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ENVIRONMENTAL SUSTAINABILITY IN ASIA:

PROGRESS, CHALLENGES AND OPPORTUNITIES IN THE IMPLEMENTATION OF THE SUSTAINABLE DEVELOPMENT GOALS

SERIES 2

CAMBODIA

KEI Korea Environment Institute

Environmental Sustainability in Asia :
Progress, Challenges and Opportunities in the Implementation of the Sustainable Development Goals
Series 2 - Cambodia

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ENVIRONMENTAL SUSTAINABILITY IN ASIA:

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SERIES 2

CAMBODIA

KEI Korea Environment Institute

In cooperation with

UN environment

Royal Academy of Cambodia - RAC

Foreword

The Environmental Sustainability in Asia publication series, published by the Korea Environment Institute (KEI), demonstrates a comprehensive picture of the progress, challenges and opportunities of the Sustainable Development Goals (SDGs) implementation in the Asian countries. Each of the chapters provide extensive scientific evidence, consultations and intergovernmental process and policy recommendations on the seven principal themes of the SGDs: 1) clean water and sanitation (SDG 6), 2) affordable and clean energy (SDG 7), 3) sustainable cities and communities (SDG 11), 4) responsible consumption and production (SDG 12), 5) climate action (SDG 13), 6) life below water (SDG 14), and 7) life on land (SDG 15). It also highlights the complexity of the interlinked challenges confronting decision makers at various levels.

The launch of the Environmental Sustainability in Asia publication series comes at a critical time as the 2030 Agenda for Sustainable Development provides a clear pathway of action for people, planet and prosperity. In particular, we are determined to protect the planet from degradation, including through sustainable consumption and production, sustainably managing its natural resources and taking urgent action on climate change, so that it can support the needs of the present and future generations (as stated in the Resolution adopted by the UN General Assembly – Transforming our world: the 2030 Agenda for Sustainable Development, 21 October 2015).

Recognizing that experience sharing can be effective development cooperation tool for its neighboring countries, KEI's Environmental Sustainability in Asia Publication Series 2 targets on the country of Cambodia. By focusing on the experiences of the government, international organizations, international development agencies, and think tanks, the Environmental Sustainability in Asia Publication Series aim to project the benefits of experience into future actions and institutional commitments to better understanding effective actions in achieving the SDGs in the developing countries in Asia. I extend an invitation to all countries and relevant stakeholders in the region to engage with this publication.

This Publication Series is an output of the project entitled “Network of Institutions for Sustainable Development (NISD)” supported by the Korea Environment Institute. I would like to extend my gratitude to all the advisory members and authors who have contributed to the publication. Special thanks to H.E. Academician Sok Touch (President of the Royal Academy of Cambodia) and colleagues in the Royal Academy of Cambodia for the planning, coordination and support of activities related to the preparation of the Environmental Sustainability in Asia–Cambodia.

Jeyong Yoon (Ph.D.)
President
Korea Environment Institute

Congratulatory Message

The Korea National Research Council for Economics, Humanities and Social Sciences (NRC) is pleased to congratulate the Korea Environment Institute (KEI) on the initiative of the Publication Series on Environmental Sustainability in Asia: Progress, Challenges and Opportunities in the Implementation of the Sustainable Development Goals. The publication will serve as a useful reference in sharing knowledge and experiences for the universal commitment to the 2030 Agenda for Sustainable Development to end poverty, protect our planet and ensure that no one is left behind. Building on from the Millennium Development Goals, the Sustainable Development Goals (SDGs) aim to "transform our world," calling for action in both developed and developing countries. Despite each of the 17 SDGs having its specific targets, no one goal can be achieved on its own. Achieving the targets set out in any of the SDGs requires an interdisciplinary and cross-sector approach.

Recognizing the responsibility for delivering the universal commitments made for the implementation of the SDGs, the NRC and its 26 affiliated research institutions specializing in each of the different areas of economics, humanities and social sciences provide a unique platform for the interdisciplinary and cross-sector research. NRC seeks to unite the national policy research institutes as a single team in order to advance towards the realization of sustainable development and strengthening global partnership for the SDGs implementation.

KEI, as one of NRC's affiliated research institution specializing in environmental policy, has been at the core of development of Korea's environmental agenda. KEI, working closely with the line ministries of the Korean government, provides policy recommendations and guidance to inform decision-making process. With the growing needs for enhanced collaboration and coordination beyond national level, KEI has extended its body of work towards regional and global levels. This publication

series is part of KEI's efforts for regional and global cooperation in understanding the progress, challenges and opportunities in the implementation of the SDGs in the developing countries in Asia.

I would like to extend my sincere congratulations and best wishes for the success of KEI's Publication Series on Environmental Sustainability in Asia and I hope it will contribute to the process of transforming our communities, countries and the world to a better future.

Kyoung Ryung Seong (Ph.D.)
Chairman
National Research Council for Economics,
Humanities and Social Sciences

Key Message

The Royal Academy of Cambodia (RAC), as collaborative partner, is proud to join Korea Environment Institute (KEI) to introduce the publication of "Environmental Sustainability in Asia : Progress, Challenges and Opportunities in the Implementation of the Sustainable Development Goals Series 2 – Cambodia." This publication is very important with the contributions from national and international occupational and environmental researchers and policy makers from various sectors sharing their work, knowledge, experiences and perspectives on UN Sustainable Development Goals (SDGs). The publication will significantly contribute to achieving the SDGs in Cambodia and in the region. Containing 17 goals, SDGs intended to drive action in critically important areas to the year 2030. These goals have been broken down into 169 targets and 232 indicators. They build on the momentum of the earlier Millennium Development Goals (MDGs) in reducing extreme poverty, and are intended to reflect a people-centered approach to development by governments and civil society across the globe. Participation in the 2030 Agenda is voluntary and actions are implemented by individual countries.

Localization of SDGs is the responsibility of each country. It requires the government to integrate the SDGs into its national development plans and then monitor progress of SDG implementation within its borders. Localization of SDGs is well underway in Cambodia, from setting goals and targets to determining how they have been implemented and using indicators to measure and monitor the progress. In addition to the 17 global SDGs, Cambodia adopted an additional goal and three targets on unexploded ordnance (UXO) and unfinished business from the MDGs. Led by the Ministry of Planning, the localized SDGs was integrated into national plans in 2018.

As the top national think tank in Cambodia under the Council of Ministers with 11 affiliated institutes, RAC has been working on various sectors including culture and fine arts, humanities and social sciences, linguistics, language policy, international relations and foreign policy, border affairs, technology and sciences, agriculture, medicine, environment and etc. Among other sectors, agriculture and environment are its priority. With strong support of the Royal Government of Cambodia, RAC has been granted the rights to managea national park named "Techo Sen Russey Treb Park of RAC" with the size of 114.35 square kilometers in order to conserve historical and cultural heritages including archaeological, historical and anthropological values, and natural resources including land, forest and wildlife at the park by establishing

a sustainable equilibrium between economic, social and environmental demands consistent with the national and global development policies in poverty reduction, sustainable development and climate change mitigation and adaptation. The park is serving as training and researching ground for national and international students and researchers in the field of agriculture and environmental protection and conservation.

RAC is honored to be part of this publication in an effort to contribute to protect and improve environment and natural resources in Cambodia and in the region. RAC is looking forward to more collaborative projects and activities with KEI as well as with other organizations and development partners in order to tackle our common environmental issues and to keep balance between the three dimensions - economic, environmental and social - of sustainable development in our region and the world.

Academician Sok Touch
President
Royal Academy of Cambodia

Key Message

It is my great pleasure to introduce this collaborative publication on reviewing the implementation of the environmental dimension of the Sustainable Development Goals (SDGs) in Cambodia. This is the second publication in a series, following the first one on Viet Nam, which was well-received by readers including policy makers and development partners for its in-depth analysis on the environmental dimension of the SDGs.

Cambodia is one of the countries that had the highest level of achievement in implementing the Millennium Development Goals (MDGs) – it had a robust economic growth averaging 7.6 per cent per year in the past two decades and its poverty rate dropped from 53 per cent in 2004 to 10 per cent in 2013, far exceeding the country's MDGs poverty target. Based on these remarkable successes, Cambodia was newly classified as a Lower-Middle Income Country in 2016.

This rapid pace of economic growth, however, has brought with it a host of environmental challenges - natural resources degradation, increasing water and air pollution, and growing amounts of solid waste in urban areas - that continue to damage the environment and harm human health. At the highest level of the Royal Government of Cambodia, there is a strong commitment to address these issues by building on its previous MDG achievements. Since the adoption of the SDGs in 2015, the Government has been actively working to contextualise and localise the global agenda for Sustainable Development. Cambodia has set a national target of 100 per cent access to improved water supply and improved sanitation by 2025 and developed an additional 18th national SDG on demining to make the country free of landmines and unexploded ordnance by 2025, which cause thousands of injuries and casualties each year.

It is anticipated that reviewing Cambodia's progress made towards achieving the environmental dimension of the SDGs up to 2018 will provide guidance to effectively plan and scale up progress towards to the SDGs in the years ahead. UN Environment stands ready to support Cambodia's endeavours for environmental sustainability and full achievement of the SDGs.

DechenTsering
Regional Director and Representative for Asia and the Pacific
United Nations Environment Programme

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Introduction of the Publication Series

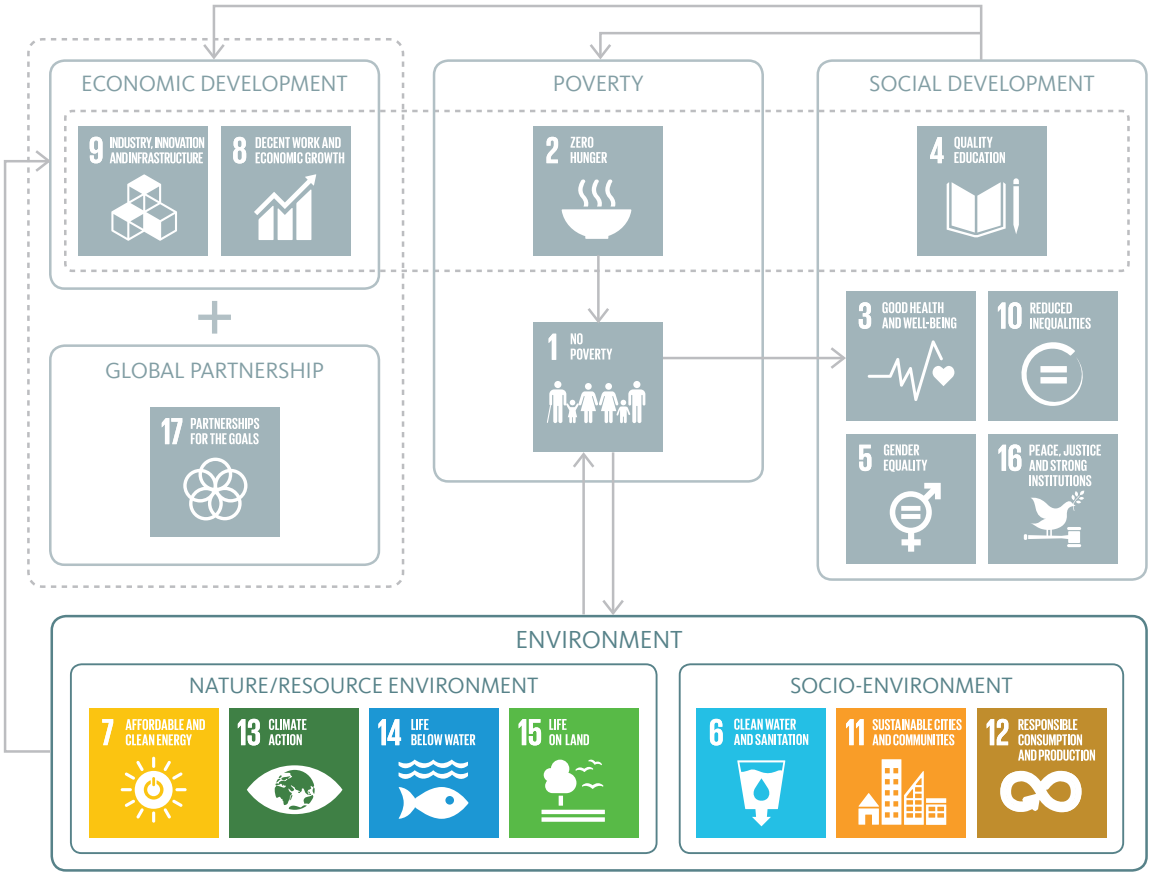
Asia-Pacific Regional Perspectives and National Integration of the SDGs

Introduction of the Publication Series

On September 25th 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development. The adoption of the Sustainable Development Agenda with 17 global goals set to end poverty, protect the planet, and ensure prosperity for all. Each of the 17 Sustainable Development Goals (SDGs) has specific targets to be achieved over the next 15 years.[1)]

Among the 17 goals of the SDGs, seven goals directly related to the environmental aspects have been clustered and were selected as the seven principal themes of the Environmental Sustainability in Asia Publication Series. The seven principal themes include ① clean water and sanitation (SDG 6), ② affordable and clean energy (SDG 7), ③ sustainable cities and communities (SDG 11), ④ responsible consumption and production (SDG 12), ⑤ climate action (SDG 13), ⑥ life below water (SDG 14), and ⑦ life on land (SDG 15).

↘ Clustering and Interlinkages in the SDGs



Source : KEI Focus 2015 (Vol.3 No.1), Implementation of UN Sustainable Development Gooals[2)]

1. United Nations General Assembly (2015), Resolution adopted by the General Assembly on 25 September 2015, Transforming our world: the 2030 Agenda for Sustainable Development, 21 October 2015.
2. KEI Focus 2015 (Vol 3, No 1), Implementation of UN Sustainable Development Goals.

Based on the seven principal themes of the Environmental Sustainability in Asia Publication Series, diverse institutions including the government, international organizations, development agencies, and think tanks, were invited to relate their work in active efforts to promote the SDGs and to advance their shared commitment to the importance of fostering sustainable development. Article commentaries of the diverse institutions draw upon experiences highlighting good practices and reflect the process and challenges on the seven principal themes.

This edition of the Environmental Sustainability in Asia Publication Series reflects the progress, challenges and opportunities of the seven principal themes in Cambodia, highlighting good practices in a wide variety of societies and disciplines. KEI recognizes experience sharing can be an effective development cooperation tool for its neighboring developing countries to fulfill their commitments to the international community and contributing responsibly to global efforts for sustainable development. By focusing on the experiences of the Cambodian government, international organizations, international development agencies, and think tanks, the Environmental Sustainability in Asia Publication Series aim to project the benefits of experience into future actions and institutional commitments to better understanding effective actions in achieving the SDGs in the developing countries in Asia.

Asia-Pacific Regional Perspectives and National Integration of the SDGs

Youngran Hur[1)]
Jinhua Zhang[2)]
Jonathan Gilman[3)]

Asia-Pacific's Solid Steps on the SDGs: Aligning National Plans with Global Agenda

Three years have passed since the adoption of the ambitious and transformational 2030 Agenda for Sustainable Development, adopted by the world leaders at the United Nations Summit in New York, 2015. Where does the region stand now on its progress on achieving the environmental dimension of the Sustainable Development Goals (SDGs)? How far have we come and how far do we have left to go? And where does Cambodia stand in the regional picture?

Regional Progress Towards Achieving the SDGs

Asia and the Pacific region shares a strong commitment in advancing the environmental dimension of the 2030 Agenda for Sustainable Development as an enabling factor to advance the entire SDGs. To this end, many processes at regional, sub-regional and national levels have been institutionalized.

At the regional level, Asia-Pacific countries adopted a Regional Road Map for Implementing the 2030 Agenda for Sustainable Development in Asia and the Pacific in the Asia Pacific Forum on Sustainable Development that took place in Bangkok, Thailand, in March 2017. The road map lays out priority areas, implementation arrangements and a process for tracking progress on the SDGs to facilitate regional level cooperation in promoting the balanced integration of the three dimensions of the SDGs (social, economic and environmental), with a focus in the areas of social development, disaster risk reduction, climate change, management of natural resources, connectivity and energy. The road map particularly highlights the importance of supporting the implementation of the SDGs by developing countries, least developed countries, landlocked developing countries, small-island developing states and other countries with special needs[4)].

At the sub-regional level, UN Environment, on behalf of the UN system and in partnership with the Association of Southeast Asian Nations (ASEAN), led the formulation of the ASEAN-UN Action Plan on Environment and Climate Change 2016-2020, of which Cambodia is a Member State, to promote cooperation and collaborative actions toward the realization of the ASEAN Declaration on ASEAN Post-2015 Environmental Sustainability and Climate Change Agenda as well as the 2030 Agenda for Sustainable Development and the 2015 Paris Agreement on Climate Change.

At the national level, Asia-Pacific countries have made solid and concrete progresses to mainstream the SDGs into national policies, plans and strategies, including submission of Voluntary National Reviews (VNR) to High-level Political Forum on Sustainable Development (HLPF). From 2016 to 2018, 20 countries from Asia-Pacific region submitted their VNRs,

1. Associate Programme Officer, UN Environment Asia and the Pacific Office
2. Regional Coordinator for Environment Under Review, UN Environment Asia and the Pacific Office
3. Programme Officer, UN Environment Asia and the Pacific Office
4. https://www.unescap.org/sites/default/files/publications/SDGs-Regional-Roadmap.pdf

and 11 additional countries will do so in 2019, including Cambodia (Table 1). As a country-led voluntary reporting process with multiple stakeholders' contribution on the SDGs implementation, the submission of VNRs by 31 out of 41 Asia-Pacific countries exemplifies the countries' strong commitment, leadership and ownership at the national level to achieve the SDGs.

↘ Table 1

List of Asia-Pacific countries submitted/ planned Voluntary National Reviews

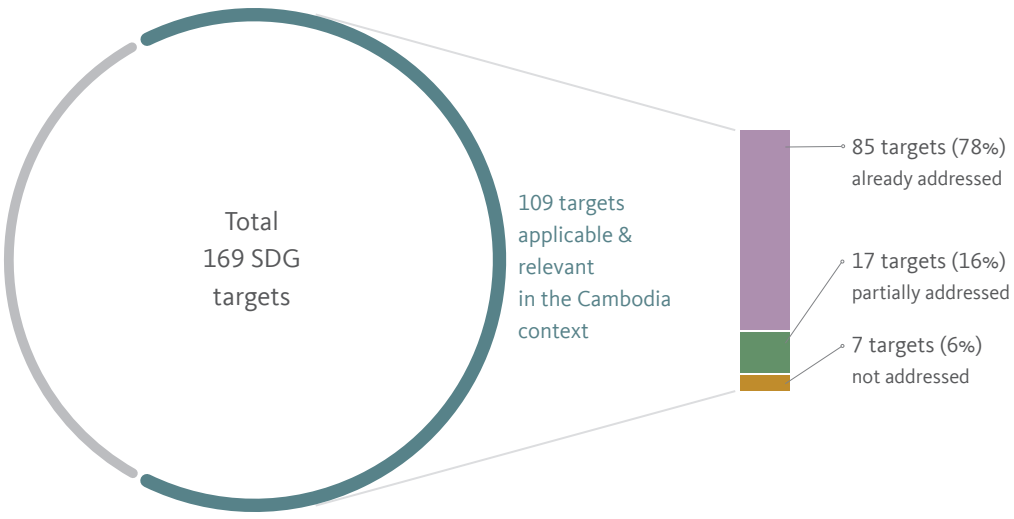
Year	Coutry				
2016	China	Philippines	Republic of Korea	Samoa	
2017	Afghanistan	Bangladesh	India	Indonesia	Japan
	Malaysia	Maldives	Nepal	Thailand	
2018	Australia	Bhutan	Kiribati	Lao PDR	Singapore
	Sri Lanka	Viet Nam			
2019	Cambodia	Fiji	Indonesia	Mongolia	Nauru
	New Zealand	Pakistan	Palau	Philippines	Timor-Leste
	Tonga				

Cambodia's Concrete Efforts towards Achieving the SDGs

Integrating the planning and implementation of the SDGs in Cambodia with its national development strategies and plans, notably the National Strategic Development Plan (NSDP) 2014-2018 was a proactive, challenging but fruitful process for the Royal Government of Cambodia. Indeed, the process for nationalizing the SDGs in Cambodia started even before the completion of the Millennium Development Goals (MDGs), with the Ministry of Planning holding a series of multi-stakeholder consultation workshops. The collaboration and partnership among civil society, government ministries and development partners in Cambodia including UN agencies not only reviewed the alignment between NSDP 2014-2018 and the SDGs targets and indicators, and identified existing gaps to be addressed, but also signaled the commitments from government, multi stakeholders and sectors.

↘ Figure 1

Status of the SDGs being addressed in Cambodia



The consultation process concluded that, of the 169 SDG targets, 109 targets were identified to be applicable and relevant in the Cambodian context. Of the 109 targets, up to 85 targets (78%) were already being addressed by national strategic planning processes and policies, 17 targets were being partially addressed, and 7 targets were not being addressed at all (refer to Figure 1). This novel approach confirmed that the SDGs are reflected in Cambodia's sectoral strategies and next NSDP 2019-2023. Despite of a strong start, the following needed areas and challenges should be addressed if Cambodia is to achieve the transformational vision of the nationalized SDGs:

Data and Information

Cambodia has specifically requested the global community for support on data availability. In the 2017 HLPF, the delegate of the Royal Government of Cambodia highlighted the need to invest in improved monitoring and information systems as a critical factor to ensuring inclusive implementation of the SDGs[5]. Also, H.E. Poch Sovanndy, Deputy Director General of Planning at the Ministry of Planning said that "the main difficulty [in reviewing Cambodia's progress against the SDGs] is the availability of data to establish the baseline and targets."

Capacity Development

Considering Cambodia's status as a least developed country since 1991, building stronger human and institutional capacity as well as better inter-sectoral and inter-ministerial coordination are critical to ensure Cambodia's effective implementation of the SDGs. In fact, "capacity building and human resource development" has been listed as one of the national development priorities in Cambodia's Rectangular Strategy 2014-2018.

Mobilizing Financial Resources

Realizing the ambitious sustainable development agenda largely depends on the availability of financial resources. Mobilizing public and private financial resources actually goes hand-in-hand with institutional capacity, as robust and capable government bodies will be able to effectively mobilize and manage a diverse range of development resources, actively engage with development actors, and coordinate and direct resources toward achieving the environmental dimension of the SDGs.

UN Environment and Cambodia

Since 2015, UN Environment Asia and the Pacific Office has implemented over 30 national and regional-level projects in Cambodia, to support its progress towards achieving the environmental dimension of the SDGs. Most of the projects have focused on three thematic areas: (1) Climate Change; (2) Ecosystem Management; and (3) Chemicals, Waste and Air Quality. These projects also address above-mentioned development challenges in Cambodia. Some best practices of UN Environment's support in promoting Cambodia's environmental dimension of the SDGs are illustrated below.

5. https://sustainabledevelopment.un.org/content/documents/25823cambodia.pdf

UN Environment supports the reform of Cambodia's Ministry of Environment

Historically, Cambodia has been constrained by weak institutional capacity and limited funding in enforcing its laws, policies, regulations and standards for environmental protection and sustainable management of natural resources. Recognizing this, in 2016, the Cambodian government decided to reform its Ministry of Environment into a more professional, modern and efficient organization and to create a completely new environmental protection and natural resources conservation legal framework with the support of UN Environment.

UN Environment, through the SWITCH-Asia Regional Policy Support Component, worked with UNDP on the reforms, by providing technical assistance to strengthen environmental policies for Sustainable Consumption and Production and formulating a new Environmental Code and Decision Support System on integrated ecosystem mapping to enable national level policymakers to adopt efficient land use decisions and sustainable natural resource management, in line with the SDG 12 on resource efficiency.

UN Environment supports on reducing short-lived climate pollutants

UN Environment, in partnership with GEF, supports Cambodia on "National Planning for Action on Short-Lived Climate Pollutants (SLCP)", with specific focus on institutional strengthening to coordinate activities related to reduction of SLCP. Information sharing mechanisms, including development of national knowledge exchange network platform on climate change and air quality, are elaborated. It has identified potential sectors and list of actions to reduce SLCP. This project contributes directly to the SDGs 11.6,13.2 and 13.3.

UN Environment supports on enhancing sustainability of protected area system

Through GEF-funded project 'Strengthening national biodiversity and forest carbon stock through landscape-based collaborative management of Cambodia's Protected Area System as demonstrated in the Eastern Plains Landscape (CAMPAS)', UN Environment has been supporting Cambodia to reduce present land-conversion trends, restore the connectivity of protected area landscapes and recover wildlife populations in the Eastern Plains Landscapes.

Achievements of this project include : conserving carbon stocks and reducing emissions (SDG 13), endorsement of the National Protected Area Strategic Management Plan (SDG 15), financing for protected area management and providing benefits to local communities. They are expected to continue to enhance the sustainability of the protected areas in Cambodia.

Way Forward

The Asia and the Pacific region enjoys a breadth of diversity in its environment, culture, economy and many more. They present the region with various challenges, but at the same time, create continuous momentum to join hands in a search for breakthroughs. Actively taking the opportunities presented by the SDGs to strengthen engagement and coordination at the national and regional levels, Cambodia and other countries in the Asia-Pacific region are well-positioned to achieve significant progress under the sustainable development agenda.

By providing a basis for a knowledge sharing and peer learning at the national level with this knowledge product, UN Environment Asia and the Pacific office will continue to extend its support to the efforts being made by Cambodia and the Asia-Pacific region toward achieving the environmental dimension of the SDGs.

I

Overview

1.

Integration of 2030 Agenda and SDGs in Cambodia

1

Tin Ponlok[1)]
Julien Chevillard[2)]
Tin Darapheak[3)]

Integration of 2030 Agenda and SDGs in Cambodia

The year 2018 in Cambodia marks the beginning of a new Government mandate and the first national planning cycle since the adoption of the Sustainable Development Goals (SDGs) in 2015. Cambodia is also at a critical stage in its development process. The country is looking to transition from a first phase of development characterized by strong economic growth and poverty reduction, to a new model that will allow it to reach upper middle-income status by 2030 and then developed country status by the middle of this century. This will require a more sustainable growth model that reduces pressure on scarce natural resources. It is therefore very timely to reflect on the best approach for integrating the global sustainable development agenda into national strategies, plans and programmes.

This paper presents a perspective from the National Council for Sustainable Development (NCSD), based on its involvement in the SDG localization process to date. The first section reviews key lessons learnt from the implementation of the Millennium Development Goals (MDGs, 2000-2015). The second section focuses on the new strategic challenges and opportunities that come with the SDGs and potential approaches in Cambodia. The third and final section looks into implementation aspects, including financing.

The key argument made in this paper is that the SDG localization process needs to be firmly grounded in local realities if Cambodia is to achieve the proposed targets. The inter-linkages and potential trade-offs between goals need to be well understood to prioritize a set of actions that will deliver maximum benefits across the economic, social and environmental dimensions of the SDGs. It is also essential to ensure that the process is not just a technocratic one, and that the prioritized actions have broad support among development stakeholders in the country. Cambodia faces significant capacity and resource constraints in this process, some of which are common to many countries, and some of which are specific to Cambodia.

Learning from Cambodia's Performance in the MDG Era

With the adoption of the Millennium Declaration in the year 2000, Cambodia has expressed full commitment to the MDGs. The eight MDGs, with the addition of a ninth goal on de-mining, make up the Cambodian Millennium Development Goals (CMDGs) which were then incorporated into the National Strategic Development Plan (NSDP). Cambodia accomplished its mission in achieving the targeted performance in some primary goals of the MDGs well ahead of the deadline, particularly in child care, maternal health, diseases and global partnership (foreign trade and

1. Secretary General, Cambodia's National Council for Sustainable Development
2. UNDP Programme Administrator, Cambodia Climate Change Alliance
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investment relations). A clear example of its achievement can be found in health, one of the principal components of sustainable development. The various health indices compiled by the World Health Organization (WHO) show significant improvement in the health of the Kingdom's population. Maternal mortality ratio (MMR) – calculated per 100,000 live births for women of reproductive age between 15-49 years old – saw a significant decline from 1020 deaths in 2000 to 161 deaths by 2015 at the annual rate of reduction hovering around 7%[4]. Life expectancy at birth also jumped by approximately 10 years for both sexes in the period of 15 years from 2000 to 2015[5].

Better overall health contributes to a stronger workforce capable of working more hours at a higher level of productivity. We can also expect the lower child mortality and morbidity rates to promote physical and mental development of children, leading to a higher growth in human capital. The impressive average GDP growth rate of 7% in the last decade (with an exception of the plummet to 0.1% growth in 2009 due to the adverse effect of the 2008 global financial crisis on the export-oriented economic growth) can be at least partially attributed to the attained level of increased healthiness for its population. Furthermore, if the strong annual average growth of 7% is sustained, the current income level of an average Cambodian can be expected to double in approximately 10 years[6]. The increase in output per capita aside, the inflow of a healthier young workforce into the labor market will contribute to a sustained high growth level for the foreseeable future.

4. http://www.who.int/gho/maternal_health/countries/khm.pdf
5. http://gamapserver.who.int/gho/interactive_charts/mbd/life_expectancy/atlas.html
6. Based on rule 72, doubling time = $\frac{72}{\text{growth rate (in percent)}}$. For smaller growth rates, changing the numerator to 70 provides a more accurate answer. The rule is derived from compounding formula.

Summary CMDG performance (at target level)

↘ Table 1

Goals	Targets	Performance
1. Eradicate Extreme Poverty and Hunger	(1a) Halve the proportion living below the nat. poverty line	Achieved
	(1b) Reduce the proportion living in hunger	Achieved
	(1c) Increase the income share of the poorest 20%	Unfinished business
	(1d) Improve nutrition & end stunting	Unfinished business
2. Achieve Universal Primary Education	(2a) Achieve 100% net enrolment at primary level	Almost Achieved
	(2b) Achieve 100% completion rate at primary level	Unfinished Business
	(2c) Achieve universal literacy of people aged 15-25	Almost Achieved
	(2d) Achieve gender parity at primary school level	Achieved
3. Promote Gender Equality and Empowering Women	(3a) Achieve gender equality in education & literacy	Achieved
	(3b) Empower women in wage employment	Unfinished Business
	(3c) Empower women in decision making	Unfinished Business
	(3d) Combat gender-based violence	No target values
4. Reduce Child Mortality	(4a) Reduce the infant mortality rate	Achieved
	(4b) Reduce under-five child mortality rate	Achieved
5. Improve Maternal Health	(5a) Reduce the maternal mortality ratio	Achieved
	(5b) Increase % of births attended by skilled personnel	Achieved

6. Combat HIV/ AIDS, Malaria and Other Disease	(6a) Cut HIV prevalence among general population	Unfinished Business
	(6b) Reduce the TB mortality rate and prevalence	Unfinished Business
	(6c) Cut the malaria mortality rate	Achieved
7. Ensure Environmental Sustainability	(7a) Sustainable development principles & reverse natural resource loss	No target values
	(7b) Achieve access to safe water & sanitation	Achieved
	(7c) Reduce dependency on wood for fuel	Unfinished Business
	(7d) Increase proportion with secure land tenure	Achieved
8. Global Partnership	No targets	Not applicable
9. Demine/ remove Explosive Remnants & Assist Victims	(9a) Reduce the number of civilian casualties	Achieved
	(9b) Clear land in contaminated areas	Achieved

Source: Reprinted from "CSDGs Framework (2016-2030)" by Ministry of Planning, 2018, p. 19.

A broader indicator on poverty also serves to demonstrate the nation's rapid progress in economic development. In 2009, poverty headcount ratio more than halved relative to the 2003 level, a drop from 50.2% to 23.9%[7]. By 2014, the poverty rate declined further to 13.5%, and the fall has continued until the present. All economic indicators point toward the right direction. The achievement for the once war-stricken nation, crippled in terms of all facets of growth, is undeniably monumental, though we should not let this distract us from the many challenges that lie ahead. While poverty at the absolute level has been considerably reduced, some persisting issues require urgent attention. At the same time, new challenges arise due to the many factors that interplay under the dynamics of changing domestic and global economic, social and political landscapes.

Progress on MDG7 on the environment has been slower. With the concept of sustainability being at the heart of the new SDGs, this remains an area that demands close attention in the coming years. The implementation of environmental solutions usually encounters various constraints, not merely limited to technical ones. Sustainable development is not feasible without a strong emphasis on contributing factors to the environmental sustainability. There is, however, potential for friction between short/medium-term economic gains and environmental priorities, especially for developing nations such as Cambodia. The short-term trade-off tends to induce resistance as achieving environmental milestones can mean foregoing economic gains in the short run while the long-term favorable outcome is often invisible or not properly internalized by decision-makers and the public alike.

For instance, there is a deep-rooted challenge as a result of poverty and how it prevents many other desirable social and environmental features from surfacing. Poverty usually prevents sizable income that enables capital accumulation. It also contributes to creating a large untaxed informal sector. Other political and social barriers aside, economic challenges

7. Data source: https://data.worldbank.org/country/cambodia

caused by poverty lead to a lower level of average education. Public education requires substantial national funding, and the untaxable sector implies lower tax revenue for the government and subsequently smaller financial package dedicated to education. At household level, poorer family lacks the ability to self-finance their children's education (especially at tertiary level). The low income and saving rate – hence, smaller capital stock – and the weak financial system to channel and lubricate domestic capital flow also implies the inability of the nation to provide loans to families or students in need. Insufficient capital investment means lower capital per worker and lower labor effectiveness, and this keeps productivity low. For many households living under or close to the poverty line, more time and members of family are thus devoted to ensuring daily subsistence. Even a small shock to the household's financial health can mean instant deterioration of livelihood. This vicious cycle traps households in poverty. With basic necessities and securities unmet, environmental projects that almost always require cooperation from the local community with respect to time and energy undoubtedly face economic challenges that undermine their efficacy. The future benefits in the long-term can take time to realize, and coupled with uncertainty, the strict economic constraints confronted by both the government and its people can cause the benefits from SDGs to be heavily discounted. Therefore, while we need to place even stronger emphasis on the environmental sustainability, it pays to consider various other complementary elements as equally significant in terms of their contributions to the success of the CSDGs, which will be discussed in the detail in the next section.

In this context, public officials and decision-makers have a key role to play to promote sustainable development solutions. Concrete and explicit strategies should be set for new approaches to promote dual objectives – environmental and economic – simultaneously instead of placing one on top of another.

This also corresponds to the rising demand for a broader definition of well-being – incorporating social, environmental and economic dimensions – coming from the middle class and a better educated population. The economic take-off that lifted many Cambodians out of the low-income status has led to more consumer awareness. Since the preference/taste of consumers is the determinant of business successes, the change in consumer attitudes affects business behavior. While adapting to market dynamics from the demand side, major players in the private sector, both domestic and foreign, have concurrently transformed into the trend or standard setters. They are on average better than other non-private entities in advertising and attracting consumers, and consequently, they serve as effective channels through which sustainable development can be achieved. Notwithstanding, deforestation, industrial waste, air and water pollutions are some of examples of how the private sector can create environmental problems. At the same time, issues such as, but not restricted to, limited policy/regulation, weak law enforcement and efficacy of governance persist. Therefore, policies that offers market incentives to change private sector behavior in investment, production, waste management, and

choices of goods and services they put on the shelves can be employed as a complement to the traditional approaches of employing just stringent regulations and legal punishment. We discuss more about this in the last sub-section on "incentives for the integration of environmental concerns in private sector investments".

Another area where progress can be made is partnerships for development. Cambodia is open to foreign direct and portfolio investment and has active partnerships with traditional and emerging donors, but coordination and alignment issues still comprise a share of the unfinished business. In addition, achieving the SDGs will require much broader partnerships among different types of actors, including public-private partnerships which are still at an early stage in Cambodia.

The Kingdom's effort thus far is worth applauding. With many accomplishments and more underway, Cambodia is progressing forward with the guiding hand of SDGs. Notwithstanding, the bigger picture remains. Cambodia still needs to combat poverty, provide more effective healthcare and education, and ensure minimized adverse environmental impacts on its development path. However, in contrast to the poorer economic and political conditions under which CMDGs were executed, drawing on its own experience from the past decades, the current Cambodia has accumulated numerous lessons learned and better insights into its own strengths and weaknesses. The structures of many fundamental components of development are now in place and functioning. Cambodia now has higher average income, more exposure to the global market, better health and education, young and increasing skilled labor force and many other changes that set a new context for the current sustainable agenda, the CSDGs. These aid development work and contribute to the higher likelihood of success while simultaneously result in new challenges that demand a paradigm shift in ways we think and approach each puzzle. There are persisting issues, and often, new solutions entail new problems. The answers at which we arrive today sometimes bring more questions for tomorrow. With old problems solved, Cambodia must look ahead to address new challenges to enable even greater improvement in the well-being of the nation and its people.

The Sustainable Development Goals: New Challenges, New Opportunities

Starting with the obvious, the 17 SDGs constitute a much broader set of goals if compared with the 8 MDGs. The 17 SDGs have a stronger focus on sustainability and environmental issues and are more explicit about some of the emerging development challenges for a country like Cambodia, including for example industrialization (SDG 9), urbanization (SDG 11) and the need for inclusive development (SDG 10). The environmental focus is a salient feature as demonstrated by the inclusion of SDG 6, 7, 12, 13, 14 and 15 explicitly in the SDGs.

Concerning SDG alignment, a narrative report from UNDP looked at SDG targets against existing government strategies (NSDP + sector strategies). Below is a summary of the assessment.

Snapshot of the UNDP's assessment on SDG alignment in Cambodia

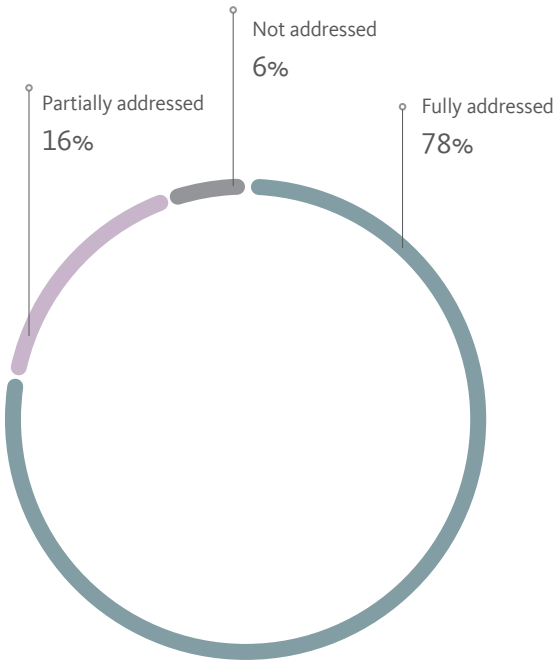
↘ Table 2

SDG targets fully addressed	85 of 109
SDG targets partially addressed	17 of 109
SDG targets not addressed	7 of 109
SDG targets not applicable	4 (SDG 10.5, 10.6, 17.2, 17.7)

Further information would be needed to assess alignment with 13 SDG targets that are part of Goal 17 on Means of Implementation. The assessment does not consider the 43 Means of Implementation SDG targets that fall under SDGs 1 to 16.

Policy alignment with the SDGs : Proportion of SDG targets addressed in national and sectoral strategies

↘ Figure 1



Source : Rapid Intergrated Assessment report, UNDP, 2017

Aligning SDGs with the national strategies is a significant step towards achieving the sustainable targets, but there are several other elements of equal importance which we should contemplate.

In the following section, we explore the opportunities and challenges of this new set of development goals for Cambodia.

The Importance of Recognizing Inter-linkages between Goals and Dimensions of Development

In adopting, localizing and pursuing SDGs, it is of paramount importance that we recognize the intricacy of the system in which sustainable development work is undertaken. Numerous variables need to be carefully considered, mainly for the relationship that any two or more variables may carry. More simply, it is necessary that parties involved in development effort are consciously aware of the positive or negative association one variable may have with another.

For instance, most of the goals mentioned are promoted either directly or indirectly through the improvement in the overall education level of the population – by-products of education. We can also safely say that there is no notable tension between environmental goals, except for the SDG7 (Affordable and clean energy) and SDG12 (Responsible consumption and production).

SDG7 – affordable and clean energy – in particular needs a special attention due to the potential inverse correlation it shares with other SDGs. Renewable energy costs with respect to capital investment and operation are decreasing (though technical issues such as, for example, the fluctuation of production for solar and wind and the seasonality of hydropower remain) but stays relatively costlier than coal and natural gas. Assuming all other variables such as education and income level are held constant, affordable energy (i.e. low-cost energy) might also lead to less responsible energy consumption. As evident in a recent study conducted on Taiwan, the finding shows an inverse causal relationship between energy consumption and energy price, though the price elasticity – how much energy consumption increases as price increases – is greater in the long-run (Chen, Yang, Lee, & Chi, 2016). An earlier study by Asafu-Adjaye (2000) from the department of economics of the University of Queensland based on time series evidence from Asian developing nations – including India, Indonesia, Philippines and Thailand – yields a similar result which points out the mutual causality between energy price and consumption. Innovative energy pricing strategy – for instance, one that charges households less for consumption of energy below a certain threshold – is therefore worth pondering as a means to bring about more responsible behavior. In the Cambodian case, differentiated electricity tariffs has already been adopted. Customers are categorized into five groups: (i) Residence, (ii) Customers paid by government budget, (iii) Embassy, (iv) Foreign residence and (v) Industrial and commercial sectors. Two of the primary goals are supporting poor households and promoting responsible consumption, thus energy saving and GHG mitigation. For example, in 2011, residence in the capital city, Phnom Penh, pays 610 Riel/kWh for monthly usage of less than or equal to 50kWh and 720 Riel/kWh for greater consumption level[8].

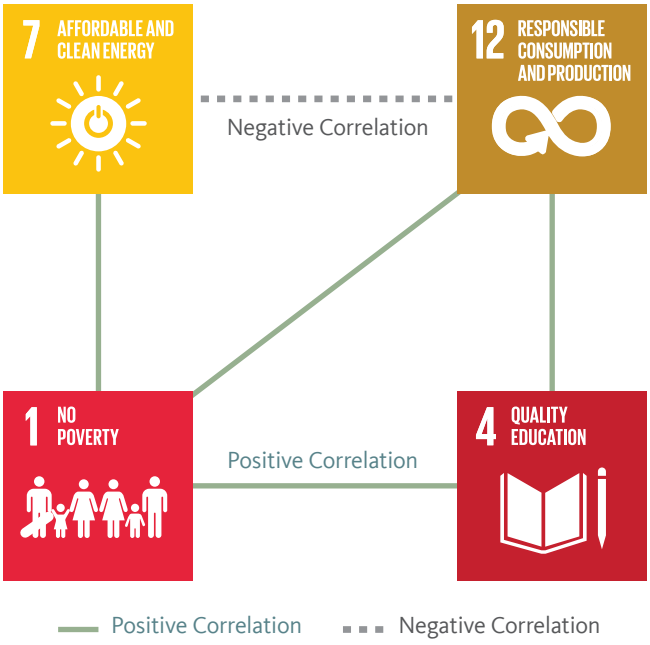
On the contrary, greater average income level seems to help bolster environmental efforts. Higher income and wealth enough to lift households well above the poverty line may make individuals and families more sensitive to other issues within their surroundings, environmental concerns included. At the aggregate level, richer countries are more capable of addressing problems other than ensuring subsistence of its citizens. These are evident in three research studies (Fairbrother, 2012; Lo, 2016; Lo & Liu, 2018). Despite the variation in dataset, scope and complexity of methodologies and details of findings, the common result remains unscratched: at least within country, better off households are more environmentally concerned and more likely to contribute to protecting the environment. Though the difference between countries (i.e., whether environmental concern is greater in richer countries) remains an area subject to argument, it should not distract us from the main finding. As an example, the urban study on Hong Kong by Lo and Liu (2018) finds that privately managed housing estates populated by better off households collected more recyclables from their residents. The relationship might also

8. Data source: http://www.cambodiainvestment.gov.kh/why-invest-in-cambodia/investment-enviroment/cost-of-doing-business/utility-cost.html

be influenced by various components such as time and education. Still, this will not change the fundamental lesson for any practitioners: some goals/targets are synergetic and some are conflicting[9].

↘ Figure 2

An illustration of how different SDGs maybe linked



Identifying the strong connection between various dimensions of development allows more organized and efficient approaches in accomplishing our goals. While CSDGs should be pursued collectively, targets with strong association with one another should be grouped into a package. Responsible institutions and focal points can then be identified and brought together for better coordination of development efforts.

As for conflicting targets, it may be necessary that involved actors work together from the planning stage to look for "win-win" options that can help meet multiples targets. For example, in the energy sector skipping new coal fired power plants to solar energy may help meet targets under many goals. Of course, credible research covering technical, environmental, economic and social aspects should be in place as the basis for making decision.

Conflicting targets ought to be equally considered. Groups of two conflicting targets ought to meet and discuss on a regular basis to find common priorities and areas of improvement. Where strong conflict arises, multiple alternatives should be considered, and among every set of solutions, groups should always consider leaving the issue to later iterations. This is not to say that they ought to do nothing, but rather, it encourages the acknowledgement of the value of time and cost effectiveness in maximizing net gain from one's effort. The subtler implication is that in striving to attain environmental sustainability, political, social and economic aspects ought to be taken into account on equal ground (i.e. evenly balancing the various dimensions by giving each identical privilege). For instance, when adaptation projects such as vaccination for livestock is implemented, economic components which include the market availability and accessibility and social

9. It appears that there is not sufficient research-based evidence in Cambodia, from which we can draw conclusion. The lack of data availability and economies of scale in R&D remain a challenge for research work. We discuss about R&D in the last section on the implementation of CSDGs. We hope, however, that this will be at least thought provoking; thus, captures interest and encourages more rigorous research in this particular area in Cambodia.

components such as health and education of the local communities should be incorporated and treated as challenges of comparable magnitudes. Is there a market for long-term supply of quality vaccination? What is the average education level and how can knowledge be passed down from former trainees to successive trainees within the local community? How will vaccination add to the cost of raising livestock when farmers confront with unstable demand from the market? These are all challenges that require cooperation, coordination, effort and funding to achieve multiple targets concurrently, or at the very least, to avoid a situation where oversight of attendant economic and/or social barriers undermines the potency of one's project. Putting it differently, it would be inadequate for a project to only teach and provide farmers with vaccination without properly addressing other parallel challenges.

A Stronger Focus on the Role of Governance for Sustainable Development

Another key characteristic of the SDGs is their added emphasis on the need for good governance, as a condition for achieving sustainable development. Cambodia has made significant progress in the past 15 years in public financial management reform and decentralization. The last mandate of the government has also seen major initiatives for public administrative reforms. Government resources, both financial and human, have greatly improved and national systems for the delivery of public services are much better established. These strengthened governance arrangements will undoubtedly be a key factor in the delivery of the sustainable development agenda.

However, it is important to recognize the challenges that still lie ahead. The Royal Government of Cambodia is aware of the need to bring services closer to the citizens, and a major effort is underway to review existing deconcentration arrangements and strengthen the local presence of government agencies, particularly at district level. District and provincial governors have also seen their role strengthened to better coordinate government services at their respective levels, and ensure the needs of the population are met.

These reforms come with significant capacity challenges, especially at the local level where most of the concrete interactions between the government and citizens occur. Stronger cooperation between local authorities and line ministries and a major capacity development effort will be required to deliver government reforms in an effective manner, particularly as the scope of these reforms become more complex to integrate social, economic and environmental aspects. Those capacity constraints should be factored in from the start, when defining CSDG targets, to avoid unrealistic expectations. One piece of good news is there has been tremendous upgrade in the technological infrastructure in Cambodia, and the rising understanding of the use of computers and other personal devices provides an additional medium through which communication, coordination, and capacity building can be channeled.

The need for effective localization, grounded in country realities

Cambodia, like other UN member states, has endorsed the sustainable development agenda in its entirety. However, strategies to reach the SDG

goals will differ from country to country. It would be impractical and inefficient to simply do a technical translation of the goals into national frameworks and expect it to deliver optimal results.

The first imperative for an effective localization of the SDGs is to ensure alignment of proposed strategies with national priorities. Beyond the technical work required to identify catalytic interventions, it is also essential to consider the political dimension of the goals. Without strong political support, the implementation of the sustainable development agenda will not gain traction. High level support to the overall goals has already been expressed by the Cambodian government, and it is now time to prioritize and identify the specific reforms and actions which are considered catalytic from a technical point of view and at the same time correspond to the highest political priorities.

In the CMDGs era, the fight to reduce poverty clearly met these two criteria. The results have been impressive and economic progress on poverty reduction has delivered co-benefits in social sectors, as highlighted above. In the CSDG era, when environmental considerations are even higher on the agenda both in the goals themselves and for the Royal Government of Cambodia, the challenge will be to find strategies that maintain strong economic and social progresses while addressing the pressing environmental needs of the country. It seems that in exploring the means of achieving SDGs, focus has been placed on the provision of resources and technology, but the lack of attention in ensuring relevant incentives by various parties should be a concern.

Hughes and Un (2011), as cited in Ou and Chheat (2015), pointed out that the success of CMDG 3, 4 and 5 were mainly due to the fact that the reforms did not generate significant resistance and were also the joint interest of the state and the donors. On the contrary, reform in some of the other studied areas have met challenges. We can therefore anticipate imbalance in terms of progress towards the different goals adopted. Goals that are aligned with the interest of both the state and its development partners are likely to be propelled onward on a smoother path and at an accelerating rate.

We have to admit that the transition process towards a modern democratic state is a gradual one, treading on a delicate balance between development reforms, governance reforms and stability. This is something that even developed countries struggled to achieve for a very long time. Hence, the pace and prioritization of the reforms required by the SDGs need to take into account this broader context, with stability as a key pre-condition for the achievement of the SDG agenda primarily because any sign of instability and insecurity in an emerging economy like Cambodia has a high chance of inviting other adverse events such as capital flight. This is unfavorable for a country with small capital stock that relies heavily on the inflow of foreign capital.

With limited time and resources and under political constraints, the priority should thus be finding convergent points of interests as this has proved to be the most effective. The efficacy of SDGs, once incentives are aligned, also rests fundamentally on the assumption (a very reasonable one) that we adopt goals that are positively linked with other goals in a way that the promotion of one goal either directly or indirectly

increases the likelihood of achieving the others as stated in the first section of part II.

Adopting and prioritizing goals and targets that are more likely to align interest and invite enthusiastic contributions from all stakeholders should constitute our first milestone in taking on the sustainable development agenda. A holistic approach should also take into account the interaction with the private sector.

Incorporating the political dimension of the goals at the country level also means addressing the potential trade-offs and facing tough choices when conflicting objectives emerge. While there could be a temptation to avoid these issues at the planning stage, they will undoubtedly come up during implementation and if not properly addressed, could compromise progresses of the sustainable development targets. It is better to explicitly weigh the various alternatives from one end of the spectrum to the other at the design stage so that win-win solutions can be promoted whenever possible, and when obstacles arise, informed and transparent decisions can be made on which objective to prioritize.

It is arguable that the primary focus of the new SDGs is on environmental concerns. As stated, the pursuit of sustainable development in accordance with the SDGs agenda is one that aims at attaining long-term prosperity. While the SDGs envisage the end goals, how they can be integrated into the NSDP of the Royal Government of Cambodia to achieve optimal outcome is debatable. Through experience and evidence from multitude of research findings, it is recommended that the environmental objectives of the SDGs be grouped on the basis of their synergy level with other goals, their feasibility and ease of implementation. There are different ways that goals can be combined and achieved through a single effort. Besides the call for attention on the alignment of local incentives and the correlations between goals, regional and global factors are not to be neglected.

Achievement of the SDGs will Require Strong Regional Cooperation and Global Commitment...

First and foremost, sustainability is achieved through a mechanism that allows for cooperation and synergy, and this hints at an inherent characteristic of sustainable development, which is aligning incentives of various parties in a manner that promotes overall growth – i.e. expanding the pie. A logical conclusion to be made here is that an essential feature of sustainable development is the absence of conflicting efforts and targets. Simply put, promoting sustainable development is tantamount to minimizing and preventing activities pertaining to a common goal that undermine each other's efficacy. Therein lies one of the most crucial factors in determining the success of the implementation of SDGs – the coordination of regional efforts.

Goals pursued by one country might either strengthen or undermine the effort of another. Hence, regional coordination is of great significance. This is particularly the case for environment-related goals, as many of these goals are closely related to global or regional exploitation of natural resources. The governance of the Mekong river is a case in point, with the recent example of the collapse of a hydroelectric dam project undertaken by Lao PDR, which impacted Cambodian communities living downstream,

leading to the mass evacuation of about 25,000 people[10]. On top of the casualties and the destruction of wealth, this puts pressure on the national budget which could have been used for other productive purposes conducive to sustainable development. The negative consequences for the countries downstream also extend to, inter alia, fish catch loss and rice production loss. Not only does it have a harmful effect on the livelihood of agriculture- and fishery- based communities, but on a broader level, this serves to undercut the strive for sustainable development of other countries.

In addition to regional coordination, we must also pay attention to the global commitment on meeting the sustainable development target worldwide. For instance, the unpredictability and low level of ODA poses an even greater financial constraint. Few countries meet the agreed 0.7% ODA/GNI target. The lack of financial capability of developing countries, the high fixed cost in clean energy research and development, and the underwhelming market incentive for many sustainable development goals to be actualized by the private sector imply that financial commitment by advanced economies play a crucial role in not just ensuring ongoing progress in all aspects in countries like Cambodia but also in setting a precedent for other emerging donors in Cambodia such as China, India and South Korea to follow. At the very least, valuable lessons learnt and feedback can be generated for future improvement. There is also the issue of gaining market access into large economies like the US and the EU. As a result of the reliance on traditional tools and techniques of production, the high cost and insufficient technology in quality control and the capacity challenge at the producer level, there are still barriers for Cambodia trying to gain access to the developed market of the west due to the high requirements for product quality and other standards for export. Consequently, this adversely affects the ability of the country to alleviate poverty and generate adequate budget to self-sustain the development effort in line with the SDGs. There are more to be done. Transfer of green technology to Cambodia, as an example, remains a challenge. Here, we select just a few issues and mention them briefly in hope that these can bring more discussion to the table.

Similarly, protectionist policies or subsidies on certain commodities by large exporting countries within the region have been seen to affect international markets, commodity prices and ultimately livelihoods in neighboring countries.

While full coordination of development policies is probably not a realistic goal, there is scope for increasing effective cooperation at least at the sub-regional level on shared goals. Relevant issues with a strong environmental component include water governance, forestry and biodiversity, and energy policies.

Because of the complexity of the issues at stake and the large number of stakeholders, support from the United Nations development system or from ASEAN may be required to identify these common goals at the regional level and facilitate the design of a coordinated response.

10. https://edition.cnn.com/2018/07/26/asia/laos-dam-collapse-intl/index.html

...and Better Coordination among Development Partners.

A related issue is the need to improve coordination among the various development partners, and align assistance with national priorities. The Cambodian government has rolled out programme budgets, which should make it easier for various developing partners to align with government programmes in a transparent manner. Development aid in the environment and climate change sectors remains very fragmented. There are however a few exceptions, where donors contribute to pooled funds managed by Government. This fragmentation leads to duplication of efforts and high transaction costs, which impact the availability of resources for achieving the goals.

Implementing the SDG Agenda in the Cambodian Context

Delivering on the challenges described above will be a formidable task for a developing nation like Cambodia.

Cambodia's Approach to Inter-ministerial Coordination

Among the challenges common to many countries is the issue of inter-ministerial coordination. While some of the goals tend to correspond in scope to specific ministries (e.g. health or education), most of the environmental goals will require an inter-ministerial response and more active cooperation with sub-national administrations.

Cambodia has established the National Council for Sustainable Development (NCSD) with a mandate to facilitate this cooperation on sustainable development issues, particularly for climate change (SDG 13), green economy (SDGs 11 and 12), biodiversity (SDGs 14 and 15), and with strong linkages to SDG 9 (for innovation and technology for sustainable development) and SDG 7 (for clean energy aspects).

As a new institution established in 2015, NCSD is still building its own capacity to engage its members (36 national level institutions and 25 provincial governors) in joint work on these issues. It also needs to coordinate with institutions in charge of overall development policy and strategies, namely the Supreme National Economic Council (SNEC), Ministry of Economy and Finance and Ministry of Planning.

Under NCSD, coordination of the climate change response is the most advanced, with an operational technical working group bringing together focal points from all concerned institutions and serving as an interface for the coordination of technical and financial assistance from development partners. Important inter-ministerial work has already been delivered, including joint work with Ministry of Economy and Finance on the economic impacts of climate change, and joint work with Ministry of Education, Youth and Sport on the integration of climate change in the education curriculum.

A technical working group on biodiversity is also operational, while others are planned for sustainable cities, sustainable energy, and responsible consumption and production. Promoting a truly inter-ministerial approach will require time. The Cambodian government, like governments in most countries, is historically structured with vertical accountability lines, through the line ministries in charge of each sector. Incentives for inter-ministerial work are not yet strong enough. In this context, building trust

and effective working relationships across ministries is a long-term endeavor, which requires strong facilitation skills on the NCSD side.

The introduction of incentives for inter-ministerial cooperation, for example by requesting ministers to report on specific inter-ministerial initiatives, or by making additional budget available for such initiatives, may help to further promote cooperation on cross-cutting national policies and programmes.

At the provincial and district levels, the coordination role falls under the governor's office, with responsibility to engage all relevant government departments and offices at their level to ensure a coordinated implementation of sustainable development solutions.

The Need for Scaled-up Investment in Knowledge, Research and Development

While the challenges mentioned above are common to many countries, Cambodia faces a particular capacity challenge. Overall education levels have spectacularly improved over the last two decades, but Cambodia still lacks a critical mass of human resources with the skills required to design and implement the new generation of sustainable development policies. A dedicated effort will be required to boost the quality and number of students in relevant science, technology, economy and social sciences curriculums, who can then actively contribute to the sustainable development agenda.

Strong international cooperation with academic institutions in developed countries will remain indispensable in the early stages, while higher education institutions in Cambodia increase their capacities to produce top-level graduates in these fields.

It will also be important to further develop and nurture a network of research institutions who can contribute their expertise and work with the government and other stakeholders on sustainable development policy.

The rapidly changing economic, political and social dynamics imply that an agenda built on past data, experience and paradigms alone might not serve us well in marching onward with SDGs. There will be a need for fresh approaches and innovation in a quickly evolving development landscape. It will also be important to monitor progress and adjust policies rapidly where needed, which may be a challenge as the lack of research-based evidence and feedback means greater uncertainty and difficulty in identifying areas for improvement and new potentials. This is where rigorous research studies come in to fill the gap and where decisions grounded on research can make a momentous difference to the growth path.

It seems, however, that in Cambodia and many other developing countries, one of the most common and least emphasized is the ability of the nations to mobilize resources, including the human factor, for self-beneficial data collection and research. The United Nations report on R&D expenditure across countries shows that the expenditure by Cambodia on R&D was a mere 0.12 percent of total GDP in 2015, a slight increase from 0.09 percent in 2012[11)].

This lack of emphasis on R&D should be expected, however, provided

11. https://www.theglobaleconomy.com/Cambodia/Research_and_development/

the current budget position of the country under which many competing needs and wants remain to be addressed by the national government.As more pressing priorities line up, the national government can only afford limited attention and discussion on R&D. But, without rigorous research results to guide the hands of policy makers, the tendency to satiate short-term needs and wants can appear more appealing and thus compete for resources from long-term investments that ensure sustainable growth. Sometimes, we see that long-term solutions come with short-term costs and a certain degree of uncertainty, and thus, the lack of more complete and accurate present information and future forecasts might preclude superior options from the grip of government and development workers.

Analogically, it is no different from individuals who have to sacrifice transient benefits in favor of long-term sustained gains. For example, household holding off purchase of a new car in order to finance the education of their offspring, or individuals undergoing strict diet for healthier lifestyle. It however hinges on the fact that precedents have been set beyond doubt that such actions will yield positive outcomes for the practitioners. But, one of the main challenges in motivating efforts to address sustainable development issues, especially at the sub-national and grass-roots levels, is the lack of tangible information and evidence of what the long-term positive outcomes are. Often, the unavailability of information also obscures the links between the present actions to be taken and the resulting future outcomes. While global evidence presents, concrete local evidence is more likely to be convincing for both the supply side and the demand side of the stakeholders. The failure to establish research-based connections between policies and outcomes also implies the difficulties in conducting monitoring and evaluation of the many past and ongoing national plans and implementations. Hence, the royal government, local and international NGOs, and development partners alike are bound to lose a huge portion of the much-needed feedback for future applications. There have been numerous studies that agree on a strong positive and statistically significant relationship between R&D and development.

A World Bank policy research working paper (Leder & Maloney, 2003) on R&D and development finds that R&D returns appear higher for developing countries. The authors further offer a few possible reasons that explain the lower level of investment despite the said effort being justified by high returns, which comprise differences in financial depth, protection of intellectual property rights, public sector's resource mobilization capability, and the quality of research institutions.

R&D here refers to the more inclusive R&D comprising both research studies in natural and social science. Although Cambodia's capacity in natural science research is limited, the need for more and higher quality social science research and natural science domains of great relevance such as environment and agriculture ought to be highly valued and promoted. Research industry as a whole is a forward link for a larger and higher quality data market. Promoting research activities is also useful for policy purposes as research findings can serve as concrete guidelines for the development of national plans and strategies. The increasing return on research also implies greater need for quality data, which in turn provides a strong incentive for larger and higher quality private and national databases. The availability and

accessibility of data then facilitates future research studies and permits more accurate and reliable findings. The greater the scope and scale of datasets expand the possibilities and opportunities for more relevant, progressive and enriching studies that improve the effectiveness and efficiency of policy formulation and implementation.

Based on existing studies on the subject, we have arrived at some recommendations for fostering R&D environment in Cambodia:

i. Tax incentive: Tax incentive for eligible private R&D projects by, for example, reducing income tax liability for profit and not-for-profit organizations investing in such projects. This still presents a challenge in implementation due to the cost of establishing public division or unit to screen various R&D projects and regularly monitor and evaluate the progress.

ii. Overcoming brain drain: Human capital is a vital contributing factor to R&D capacity in Cambodia. Large sums of money are paid each year on sending nationals to obtain higher education and training abroad either directly by the government or through external aids. However, upon returning home, most graduate students face three notable challenges – the absence of demand for their skills in the job market, the lack of well-equipped facilities, and/or the inadequacy in terms of pecuniary compensation and status. This results in higher incentive for high ability graduates to remain and seek opportunities in foreign countries instead – also known as "Brain Drain". What the government can do in this case is to establish a forward linkage that connects graduates to job prospects. Upon repatriation, further support can be provided for them to pioneer the establishment of research facilities relevant to their domains of study.

iii. Supports and funding: While financial resources remain an issue, other forms of more achievable supports do exist. Research activities should be encouraged and made more visible through public platforms such as national forum and conference with government endorsement. The government could also promote through public channels the findings from both local and international studies related to Cambodia.

iv. Cooperation: While isolated research can be expensive, research conducted in collaboration with foreign institutions at regional level can attract more attention, funding and attain greater impact. Fostering a stronger regional network is potentially a more cost-effective solution. International assistance which enables local researchers to visit and conduct their study at well-equipped foreign institutions can be an affordable short-term answer that yields high long run returns.

v. Streamlining research process: Research activities are divided into many stages. Each poses a challenge of its own. Import of research equipment, for instance, can be costly and difficult. Due to such import representing just a negligible fraction of the total import, providing tax incentive and exempting research equipment and supplies from custom duties and other restrictions would not be costly. However, the long-term benefits of the increased research and development activities to the country could be significant. The practice

has already been put into effect by the Law on Customs declared by Reach Kram No. NS. RKM. 0707. 017 dated on 20 July 2007.

Financing the Goals

A key element of the new development context for Cambodia is the evolution in the sources of development finance. The primary channels are domestic revenue collection, private sector investment, FDI inflow and ODA grants and loans.

With a national budget growing at a rate of 15 to 20% per annum in recent years (USD 6 billion in 2018) while ODA resources seem to have reached their peak in 2012 at USD 1.5 billion (Cambodia ODA database), domestic public resources have an increasingly major role to play, and official development assistance needs to be targeted in critical areas where it can have a catalytic impact.

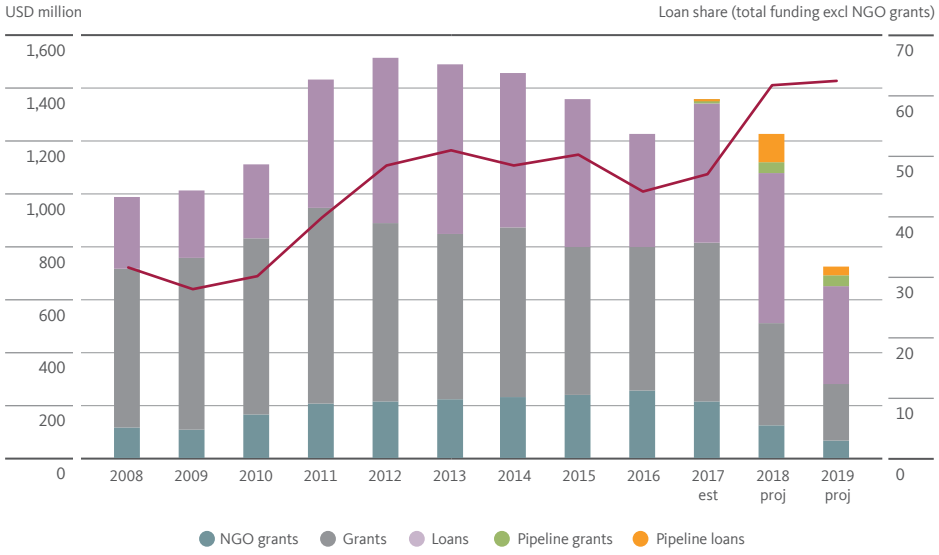
The Resource Mobilization Strategy, adopted by the government for 2014-2018 was to maintain the existing taxes and tax rates while increasing revenue through the strengthening of capacity to collect more taxes via improvement in tax administration. Public financial management reform is thus crucial and has made progress, although much remains to be done.

Efforts must be increased to better mainstream environmental priorities in the national budget, in line with the work done by NCSD and MEF in recent years for climate responsive budgeting in pilot ministries. Achievement of the environmental and climate change dimension of the SDGs will require more than the budget of Ministry of Environment. It requires environmental commitment and actual allocation of resources from a range of government institutions, from industry to agriculture, from public works to energy and municipalities, just to name a few.

On the ODA side, there has been concern that funding to Cambodia might shrink. With its status elevated to lower-middle income country, Cambodia also sees some of its donors withdraw from the scene (though with influx of emerging donors like China and India) while simultaneously, more and more financing takes the form of concessional loans rather than development grants. Concessional loans can be expected to increase due to, for instance, the establishment of Asia Infrastructure Investment Bank. Geopolitical dynamics within the region, will also give Cambodia the opportunity to attract more financial support, although it will be important to ensure the quality of aid.

↘ Figure 3

ODA Disbursement (USD million) 2008-2019



*Reprinted from "CSDGs Framework (2016-2030)" by Ministry of Planning, 2018, p. 28.
**Original source : CDC DCPR 2018

It is important to note that although overall ODA may have reached its peak, the international community has made specific commitments under multilateral environmental agreements, and Cambodia should maintain an active diplomacy to ensure that developed countries deliver on these commitments. The most prominent example of this is climate change, with a commitment to USD 100 billion a year by 2020 from developed to developing countries. Cambodia should be active to make sure that such finance – and technology transfers – benefit the most vulnerable countries, starting with Least Developed Countries (LDCs), and that a significant share is allocated to climate change adaptation.

This brings us to a new problem on the issue of financing sustainable development activities. Frequently, donors drove MDGs process to also achieve their own national interests, be it economic or political in nature. There is no reason to assume that this would not happen with SDGs. With new emerging donors and regional power play, the question is whether the new players see the sustainable development agenda in the same way. For instance, a huge portion of the financing provided by new donors such as China has been mostly related to physical infrastructure projects as opposed to projects and programmes with more environmental and social themes (health, education, water & sanitation, etc) as done by the traditional donors. As mentioned in Sato, Shiga, Kobayashi, and Kondoh (2010), certain features of emerging donors should be evaluated positively as enhancing the diversity of the aid market. Munro (2005) as cited in Sato et al. (2010) views China's focus on infrastructure as a move that allows other donors to concentrate their resources on areas they regard as having the highest comparative advantage. Nonetheless, more aid transparency and, if possible, comprehensive aid strategies are favorable for Cambodia in its formulation and implementation of the CSDGs.

Incentives for the Integration of Environmental Concerns in Private Sector Investments

There are some barriers impeding sustainable development in a market-based economy. We can reasonably assume that the private sector operating under a free-market context is the sum of profit-maximizing individuals. Profit-oriented shareholders care a lot about the cost and benefit of their planning and actions. The so-called market failure stems from this inherent behavior of the system. Among all the inefficient sub-optimal outcomes, one that significantly impacts sustainable development effort is known as externalities. Externalities arise from the failure of individuals to incorporate social costs such as pollutions and other kinds of environmental degradation into their estimation/calculation of private costs while neglecting social benefits such as the industry-wide positive impact of training workers in their estimation/calculation of private benefits. The absence of incentives to internalize environmental and social externalities causes certain socially harmful goods and services to be overproduced whereas the socially beneficial ones remain under supplied. Besides some more notable environmental costs, other resulting losses (especially, loss of potential gains) to the society are usually invisible and difficult to estimate. It is thereby of crucial importance that efforts at the institutional level, especially those of the government, are directed at measures and incentives to embed social cost into the private cost function. Carbon taxes, environmental regulations, emission caps are options in this regard. Some elements of this framework have been put in place in recent years but there is need to strengthen this tax and regulatory framework, based on solid policy research and evidence.

Another key factor is the level of environmental awareness of consumers, to impact the demand side. Awareness-raising and education are powerful instruments in the hands of the government to promote more demand for environmentally-friendly practices and products.

Private equity and debt financing have grown rapidly over the past decades. Meanwhile, the market demand for sustainable products is increasing as more and more people become aware of the existence of goods such as solar water heaters, energy efficient light bulbs, fuel saving cars and other means of transportation, just to name a few. The demand at the aggregate level will drive the market forward towards sustainable development through providing greater incentive to producers who jump on the bandwagon. While the flexibility and the invisible hand of the free market system coupled with the right incentives encourage the transformation of the society in accordance with CSDGs, the coming to existence of some goods and services are not spontaneous. Financing sustainable private projects, without effective demand to absorb the higher cost, usually face lower expected profitability. The royal government, development partners, and various local and international NGOs should thus actively seek for instruments through which private financing of sustainable development projects are encouraged. The government of Cambodia can, for instance, provide supportive supervision and tax incentive to financial institutions that provide loans to credit-worthy businesses with sustainable investment plans. While domestic private financing ought to be promoted, we cannot afford to ignore the high

level of foreign direct investment. FDI inflow is traditionally attracted by the low labour cost and generous export-oriented policies of the Cambodian government. Nonetheless, the increasing productivity and vital infrastructure in Cambodia mean that the country is now not in the same disadvantageous position as before. Though strong restrictions on FDI for environmental reasons may not be feasible in the short-run, we can look towards offering positive reinforcement or incentive for foreign investors to incorporate environmental objectives in undertaking business projects. Further tax incentive or negotiations to improve cost-cutting measures in legal and tax formalities in exchange for private foreign direct investment with better environmental standard can be a good trade for long-term prosperity and sustainability of the country and its people.

Conclusion

Cambodia is at a critical juncture in its development, and the Sustainable Development Goals offer a useful framework to think through the country's transition to a more sustainable development model. However, experience has shown that success can only be achieved if the localization process is firmly grounded in national realities, taking into account the priorities of domestic stakeholders and the inter-linkages between the goals to prioritize the most catalytic actions. Cambodia's progress has been spectacular in the last two decades, but it still faces a number of institutional and capacity challenges to plan and implement the SDG agenda. Investment in human resources, environmental education, knowledge systems, and the capacity to harness the various streams of development finance in an evolving context will be key to success.

References

Asafu-Adjaye, J. (2000). The relationship between energy consumption, energy prices and economic growth: time series evidence from Asian developing countries. Energy Economics, 615-625. doi:https://doi.org/10.1016/S0140-9883(00)00050-5

(2018). Cambodia Sustainable Development Goals Framework (2016-2030), Part 1: Framework Report and Roadmap for Integrating the CSDGs within National Planning and Delivery. Ministry of Planning (MOP).

Chen, K. H., Yang, H. Y., Lee, J. M., & Chi, C. F. (2016). The impact of energy prices on energy consumption and energy efficiency: evidence from Taiwan. Energy Efficiency, 9(6), 1329-1349. doi:https://doi.org/10.1007/s12053-016-9426-y

Fairbrother, M. (2012). Rich People, Poor People, and Environmental Concern: Evidence across Nations and Time. European Sociological Review, 29(5), 910-922. doi:10.1093/esr/jcs068

Hughes, C., & Un, K. (2011). The Political Economy of "Good Governance" Reform. In C. Hughes, & K. Un, Cambodia's Economic Transformation. Copenhagen: NIAS Press.

Lederman, D., & Maloney, W. F. (2003). R&D and Development. World Bank Policy Research Working Paper(3024). Retrieved from https://ssrn.com/abstract=402480

Lo, A. (2016). National income and environmental concern: Observations from 35 countries. Public Understanding of Science, 25(7), 873-890. doi:10.1177/0963662515581302

Lo, A., & Liu, S. (2018). Towards sustainable consumption: A socio-economic analysis of household waste recycling outcomes in Hong Kong. Journal of Environmental Management, 214, 416-425. doi:10.1016/j.jenvman.2018.03.029

Ou, S., & Chheat, S. (2015). Analysis of Cambodia's Preparedness for the Implementation of Sustainable Development Goals: Challenges, Opportunities and Financing. Cooperation Committee for Cambodia.

(2017). Rapid Integrated Assessment (RIA): Tool to facilitate mainstreaming of SDGs into national and local plans. UNDP.

Sato, J., Shiga, H., Kobayashi, T., & Kondoh, H. (2010). How do "Emerging" Donors Differ from "Traditional" Donors? An Institutional Analysis of Foreign Aid in Cambodia. JICA-RI Working Paper. Retrieved from https://www.jica.go.jp/jica-ri/publication/workingpaper/jrft3q00000022dd-att/JICA-RI_WP_No.2_2010.pdf

Vose, P., & Cervellini, A. (n.d.). Problems of scientific research in developing countries. Technical co-operation, 25(2). Retrieved from https://www.iaea.org/sites/default/files/publications/magazines/bulletin/bull25-2/25205383740.pdf

II

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Pheng Kea[1)]

Roof Harvesting - Rainwater Harvesting Formalization in Rural Cambodia

Abstract

Around the world, 663 million people still lack access to improved drinking water sources. Water is fundamental for human life and thus access to clean water is a basic human right. At the very least, one should have daily access to a minimum of 20 litres of clean water for basic needs. Both the quality and quantity of water supply must be ensured to meet people's basic needs for drinking and cooking.

Cambodia Sustainable Development Goals 6 aims to increase national access to improved water supply to 100% by 2025. In 2016, 61% of Cambodians had access to improved water supply of which 53% lived in rural areas. In order to achieve the goal, the Cambodian Ministry of Rural Development (MRD) has established the National Action Plan (NAP) to be implemented from national to sub-national levels. Under the NAP, the MRD and WASH sector havejointly developed either a provincial action plan or a district action plan for a more specific implementation in these areas.

Rainwater is in abundance in Cambodia: there is enough annual rainfall to cover both domestic water supply and irrigation needs. But for rainwater systems to be considered an improved source, the water must be stored in a single tank with a capacity of at least 3,000 litres. It also requires certain types of roofing and storage to ensure the water is clean enough to drink at all times. Rainwater systems are ideal for Cambodia, where many people already have the right types of roofing installed. However, current systems are too small to store water for the dry season and do not store the water in a safe manner.

This article combines a literature review, experience and the findings of studies undertaken by Rain Water Cambodia (RWC). The first step is to understand the government's effort to implement the national action plan on water supply. The second step is to examine the community's perception on traditional rainwater harvesting in rural Cambodia, and the third step is to investigate the sustainability of using risk-managed rainwater harvesting systems promoted by RWC in terms of physical condition, ability to maintain and user perceptions in rural Cambodia with the objective of improving access towater and make drinking water affordable, convinience and realizable in Cambodia.

1. Introduction

Global Water Supply Situation

Around the world, 663 million people still lack access to improved

1. Executive Director, RainWater Cambodia (RWC)

drinking water sources (JMP update report 2015, p4). Water is fundamental for human life, and thus access to clean water is a basic human right. At the very least, one should have daily access to a minimum of 20 litres of clean water for basic needs (Kevin Watkins, 2006). Water supply refers to large utilities with piped distribution systems, piped and non-piped community supplies including hand pumps, and individual domestic supplies (WHO 2005). Both the quality and quantity of water supply must be ensured to meet people's basic needs for drinking and cooking. Significant disparities exist between urban and rural access to improved water supplies. Aroundthe world, improved water supplies are available to 96% of urban communities and to 84% of rural communities (JMP update report 2015, p54).

Cambodian SDG 6 and Water Supply in Cambodia

In the Cambodian context for Sustainable Development Goals (SDGs), the Cambodian government sets for the country some ambitious access to water objectives: “Universal access to improved water by 2025” and “Universal access to safe water by 2030” (SEVEA 2017).

Cambodia has many alternative water resources such as Tonle Sap Great Lake, the Mekong River, and groundwater. According to data collected from the Cambodia Socio-Economic Survey, the number of households with access to improved drinking water source is 61%, of which 53% are in rural areas (CSES 2016, p13). To monitor the progress of SDGs and the National Strategic Development Plan (NSDP) 2014-2018, the Cambodia Socio Economic Survey (CSES) results are collected and used for updating the progress.

Access to an improved water supply is defined as “the availability of an improved water source within 150 metres of a house,” and an “improved” water source is one that is more likely to provide “safe” water, such as directpiped connection to the house or a borehole, (NAP, 2014). Rainwater collection is also considered as an improved water source if the rainwater catchment tank is completely closed, has a tap to withdraw water and has a capacity of at least 3,000 liters (CSES 2016, p13).

Rural Water Supply Informed Choices in Cambodia

Cambodia is considered one of the most water-abundant countries in the region, and there are two main types of water available in Cambodia: approximately 75,000 million m³ of annual surface water runoff and 17,600 million m³ of groundwater in aquifers. Precipitation varies from 1,400 ㎜ to 3,500 ㎜ annually, depending on the areas and number of rainstorms (Kyoochul Ha 2013, P.36).

The selection of the appropriate type of water supply is hence a fundamental step to ensure the reliable access to high-quantity water. There are a number of water sources, which rural areas can rely on: rainwater (different designs of tanks and jars), surface water (reservoirs, rivers, streams and others) and groundwater (dug wells and boreholes). However, each water source provides water with different quantity and quality depending on its nature (SNV-MRD 2015, p.23).

Surface water

Surface water appears either as direct runoff flowing over impermeable statured surfaces that is then collected in large reservoirs

and streams or as water flowing to the ground from surface openings. Generally, surface water is water found in lakes, streams and rivers. In Cambodia, all sources of surface water are categorized as unimproved water sources and not recommended as source for rural water supply, unless treatment is incorporated (SNV-MRD 2015).

Groundwater uses

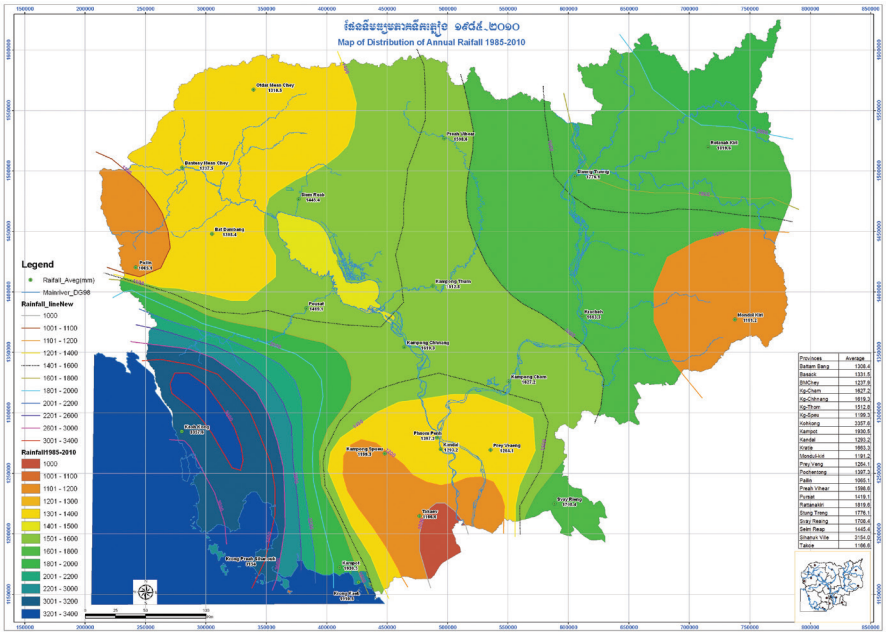
Groundwater is the water located beneath the earth's surface in porous soil spaces and in the fractures of rock formations. Shallow groundwater is generally extracted through dug wells, while deep groundwater is extracted from boreholes. Moreover, groundwater is considered as an improved source for water supply (SNV-MRD 2015, p.24). Groundwater is suitable for irrigation use, but high levels of arsenic, iron, manganese, fluoride and salt are observed in some areas; and 53% of Cambodian households drink from groundwater sources in the dry season (Kyoochul Ha 2013, p.38). However, there are areas with evidence of long-term decline in groundwater level in Cambodia that is not environmentally sustainable. Aquifers are recharged by rain at a very low rate: it was estimated that the rates are on average 1.5% of annual rainfall, between 10 and 70 millimeters per year. It is also difficult to successfully drill wells, due to complicated geology (Vouillamoz et al., 2016, p. 199-201).

Rainwater harvesting

Cambodian rainfall yield is high enough to collect water for both domestic water supply and irrigations. JICA in 2002 showed that using rainwater as a water source is a traditional practice and that 87% of the 303 villages in two provinces, Kampong Cham and Kampong Chhnang, of Cambodia used rainwater harvesting. It is common for households to have 2-3 traditional pieng jars with a capacity ranging from 800 and 1,200 litres. However, the government of Cambodia does not consider the use of rainwater as an improved source unless it is stored in a tank of over 3 m³ (World Bank -WSP 2015, service delivery assessment, p.23) and therefore estimates a lower level of access to water supply in rural Cambodia.

↘ Figure 1

Rainfall distribution map in Cambodia



Source: MoWRAM, 2011

About 97% of dwellings in 2016 had hard/permanent roof materials, and about 3% had soft/temporary roof materials. The most common roof material in the country as a whole was galvanized iron/aluminium, which constituted about 52% of the total occupied dwellings, followed by tiles, about 27%. The third most common roof material used was hard/temporary fibrous cement, which accounted for about 10% (CSES 2016, p.9). In many areas where it is difficult to get access to an alternative water supply as salty water, mountainous and arsenic affected areas, rainwater plays important roles in the provision of clean and safe drinking water solutions. The Water and Sanitation Program of the World Bank completed a study in 2011 on the options for safe water access in arsenic affected areas in Cambodia and recommended that an effort be made to focus on rainwater harvesting with year-round storage capacity for a good clean water system; and possibly a secondary focus onpiped water system (Andrew, 2011).

The alternative water access strategies that should be explored to ensure sustainable use of groundwater is to focus on increasing rainwater storage at both the household and community levels. There are two parts to increasing rainwater harvesting supply: rehabilitation of existing sources and increasing the number of storage infrastructure. At a minimum, a family of five requires 3,000-5,000 litres of water for drinking and cooking throughout the dry season (AE-WFP2016, P.24).

2. National Action Plan (NAP) on Water Supply, Sanitation and Hygiene 2014-2018

The NAP set targets of 60% improved access for rural areas and 85% of piped access for urban water supply by 2018, and the NAP 2019-2023 is being developed by reflecting the key learning from NAP 2014-18. Universal access targets to be met by 2025 have officially been adopted for rural sectors in the National Strategic Plan for Rural Water Supply, Sanitation and Hygiene (RWSSH) 2014-2025. Recently, the impact of climate change events such as floods and droughts in Cambodia has increased: in early 2016, Cambodia experienced an extreme drought that affected all 25 provinces and cities, or approximately 2.5 million people intotal (MRD/UNICEF 2016). This has led to an increased need of water with many crops and animal dying in some affected provinces, and there is a need for adaptation and increased resilience to climate change.

The NAP 2014-2018 and the National Strategic Development Plan set forth the vision of granting “Everyone in rural community sustains access to a safe water supply and sanitation services and lives in a hygienic environment by 2025”. There are five main strategic objectives of the NAP which cover (i) institutional capacity for RWSSH service delivery, (ii) increase financing for the provision of RWSSH services, (iii) promote and increase access to sustainable rural water supply service, (iv) promote and increase access to sustainable rural sanitation services, and (v) promote sustained hygiene behaviour change in relation to rural water supply and sanitation..

The Department of Rural Water Supply (DWRS) of the Ministry of Rural Development (MRD) oversees water supply in rural Cambodia. In particular, DWRS is mandated to support and facilitate development

partners involved in rural water supply; development and manage planning and allocate tasks to the sub-national level.

The Provincial Department of Rural Development (PDRD) adapted the NAP to establish its Provincial Action Plan (PAP) to be implemented at the sub-national level by working directly with district administration and commune councils. Common understanding, knowledge and willingness of local actors are key to plan implementation in target areas. The commune and district authorities have been engaged in the planning process and launching the plan for implementation. In particular, the improvement of institutional capacity for the RWSSH national action plan service delivery presentedclear expected outcomes and indicators for roles and capacity building of MRD and PDRD in implementation of national action plan from national to community levels.

The NAP calls for local governments, including district administrations and commune councils, to play increasingly active roles in identifying RWSSH priorities, and allocating investment funds towards those priorities. To assist with this process, NAP calls for selection and training of district and commune focal persons who will advocate for and support NAP/PAP at local level. PDRD and provincial working groups help oversee and support the decentralization effort which includes the delegation of governance and budgetary authority to sub-national administrative units.

3. Roof Harvesting: Community Perception of Traditional Rainwater Harvesting in Rural Cambodia

In 2016, RWC conducted a qualitative research titled “roof harvesting-community perception of traditional rainwater harvesting in rural Cambodia” as a case study of Oral district, Kampong Speu province. The researchers met a wide range of stakeholders including the government, NGOs, local authorities and community representatives to understand what they thought about traditional rainwater harvesting, uses and areas of improvement.

The rational of the study is large number of households in rural Cambodia, traditional harvesting practices are highly risky (vector-borne diseases, and inadequate water for drinking and cooking) as they use open-top small jars and other containers to harvest and store water. Littleis known about the reasons why the community still not see their risk. They may have either have no choice than drinking like that because of lack of resource to invest in safer technology, because they have other priorities in resource allocation, or because there is an acceptance of the risk associated with the water they drink. The effort made by development partners and government to promote rural water supply, in particular the promotion of rainwater program as included in the national action plan for rural water supply and sanitation, broadly present the key implementation activities and relied on the its development partners.

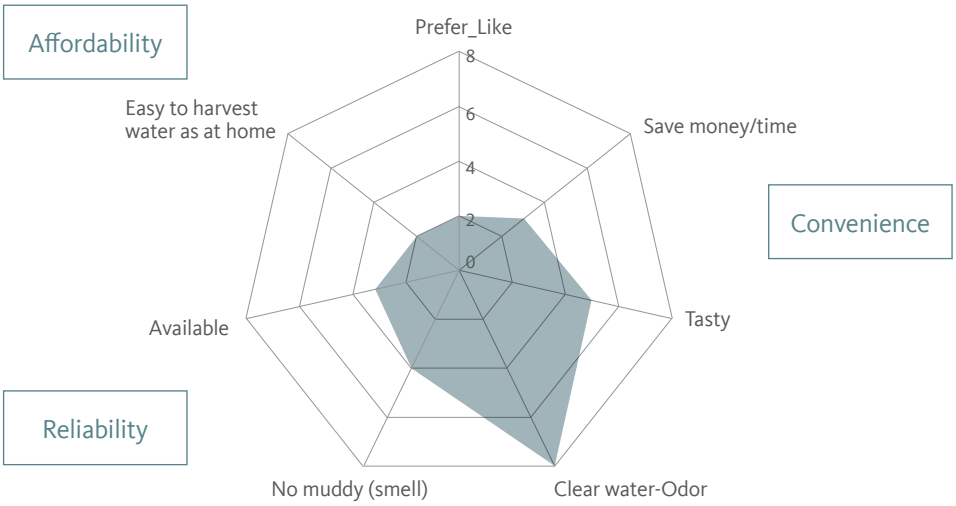
Therefore the research has explored community perceptions of harvesting and use of rainwater by adopting qualitative approach. The research analysed three main attributes of perception on Affordability, Convenience and Reliability and has defined the key factors needed to improve rainwater harvesting. Community perceptions provides RWC and its partners in development with key findings that could help tailor development of

improved rainwater promotion at scale through a joint commitment to seek funding for pilot project addressing the main concerns raise by respondents; development operation guideline, informed choice of rainwater harvesting option for improved rainwater harvesting promotion in rural Cambodia.

The study by RWC analysed three key attributes of community perception as affordability, convenience and reliability, and the results are shown in the following:

↘ Figure 2

Household perception of harvesting and using rainwater



Source : Kea Pheng, 2016

The findings presented in Figure 2 show the respondents' answers to open questions for indepth interview for 12 households in response to the three key attributes as presented. There were Eight respondents said that they were very satisfied with odour and color (clear and tasty) while two said they can harvest rainwater at home and water is available.

Affordability

The house condition of households in Kampong Speu province was found to be suitable for installing a rainwater harvesting system, and all local inhabitants owned their houses. The households that had a good economic status and a good house had the facilities to adopt rainwater harvesting. In addition, Kampong Speu province had good rainfall with an average of 1,414 ㎜ per year. Residents could easily afford rainwater harvesting, some houses could afford gutters and down pipes while some households can harvest directly from the roof by using a zinc sheet. The harvesting practices depended on the financial resources and knowledge available to the houseowner. Gutters and pipes were not available in the village or commune centre so inhabitants have to travel around 40km to provincial town or district town in order to buy these.

Convenience

Most of the respondents were satisfied with the quality of water in all three areas of odour, taste and colour. All of them confirmed they have traditionally harvested and used rainwater since older generations and most of them considered rainwateras a good source because it is pure

water that fell from the sky. The research found many respondents prefer using rainwater as it is clear, tasty and has no muddy smell. In addition, they perceived that harvesting and using rainwater would reduce their water expenditure and time collecting or buying, help them maintain good health and overall allow them to feel more at ease. The Department of Rural Water Supply perceived that Cambodians preferusing rainwater toother sources, in particular for drinking, as it was clear and tasty. In particular, the current rainwater harvesting system has potential for upgrading from the traditional to improved systems and contributing to the increased access to improved water supply targets of Cambodia.

Reliability

Rainwater is most reliable during the rainy season because most people only have small storage capacity, meaning that if there is an extended period between rains then their storage could become empty. The availability of water in each household varied with the types of usage (irrigation, drinking, cooking, etc.); and storage capacity.

During the rainy season, rainwater topped the ranking of all sources in terms of supply. The households that have storage capacity greater than 2,000 litresare able to solely rely on rainwater throughout the rainy season while households with less than 2,000 litres (having one to three jars) still require other sources. Through the visit, it was found that poor households tend to have one jar and in the rainy season they use water from tube well in their village to supplement their rainwater supply.

Government and commune focal points perceived the key factors to promote improved rainwater harvesting and reach the SDG 6 to be capacity building and raising awareness of promoters and communities, financial capacity of pilot projects and harmonization among sectors and grass root communities for program implementation. They are confident they will be able to grant access to water supply to a large number of households in rural Cambodia by promoting improved rainwater harvesting systems. Besides the research findings, there has been a continued effort made by the DRWS on the development of an informed choice on rainwater harvesting for households system in Cambodia in collaboration with RWC and the sub-group dedicated to improving drinking water quality.

4. Rainwater Harvesting Formalization in Rural Cambodia by Rain Water Cambodia

Rain Water Cambodia has designed and implemented risk-managed rainwater harvesting (RWH) systems since 2004, which were designed to capture the large rainfall in Cambodia and store enough water to last through the dry season. The risk management approach prevents contamination during storage and ensures thatwater stays safe to drink. RWC has provided RWH systems for households, schools and health centres and since 2004, over 2800 household systems and over 290 institutional systems have been installed throughout Cambodia. Beneficiaries in rural Cambodia manage the systems themselves, ensuring functionality and capability to supply water for drinking and cooking without the need for other treatment facilities, as it is drinkable. The rainwater harvesting delivery method implemented by RWC is outlined below.

Assessment and identification of beneficiaries

The situation of target areas was assessed to determine the level of access to improved water supply in reference to the technical aspects: number of water infrastructures, quality of supply, quality of water, and the distance and timing to access the water sources. Additionally, the social and environmental aspects have focused on the vulnerable, poor and arsenic-affected areas as well. The assessment has defined the current situation and proposed alternative solutionsto improve the situation. Importantly, the assessment findings will offer information in regard to the amount of water required for consumption and hence the size of tanks.

Local institution

The improvement of water supply in rural Cambodian schools was assessed by investigating schools' current water assets, water use of students and teachers, the condition of buildings and roofs, the number of students and teachers, and the schools with available water budget or ability to install arainwater harvesting system. This assessment was then summarized in a report, which is issued to the schools and used as the basis for rainwater design.

Households

For the selection of beneficiaries, a number of factors including economic status, vulnerability and access to drinking water were examined. In Cambodia, data for identifying poor households has been established and adopted inmany development programs. RWC also uses the poor households list in the selection process.

Technical Training Provided by the Local Private Sector

RWC's mission statement discusses the development and support of the local private sector in project implementation. The project financially subsidized up to 70% of the total cost for each system for the interested community representatives who invested in rainwater harvesting systems constructed by local entrepreneurs trained by RWC.

Indeed, this is an important part of RWC's work to contribute to the sustainable development of Cambodia and as such, comprehensive training programwere offered to interested entrepreneurs during projects. RWC trainings are designed to cover all the relevant aspects of building rainwater harvesting including theory sessions on the products and materials used, clearly explaining why poor-quality cheap materials result in low-quality products and safety considerations. RWC technicians then build demonstration products before the trainees are encouraged to demonstrate their abilities.

Further to technical training, entrepreneurs are also given some basic business training, including the benefits of marketing and advertising, efficiency of operations and some basic finance and accounting skills. To further ensure that construction is of good quality, construction validation visits are made during RWC projects where the construction site is visited at 80% and 100% of completion where upon subsidies are paid to the contractor if the work is of acceptable quality. This comprehensive support of the local private sector is to ensure the

beneficiaries are provided with good-quality products and to also instill in the entrepreneurs an understanding and appreciation of quality work.

Supporting Local Authorities on Project Implementation

RWC is committed to supporting the Royal Government of Cambodia's decentralization and de-concentration processes. Commune councils and local authorities selected as focal points participated in project implementation and were trained by the project team. Additionally, the support and involvement of provincial, district and communal governments in development projects is vital to the sustainable development of Cambodia, and RWC involves many levels of government in all of its projects. The Provincial Department of Rural Development (PDRD) is especially actively involved and played a vital in providing support and technical advice to RWC during projects.

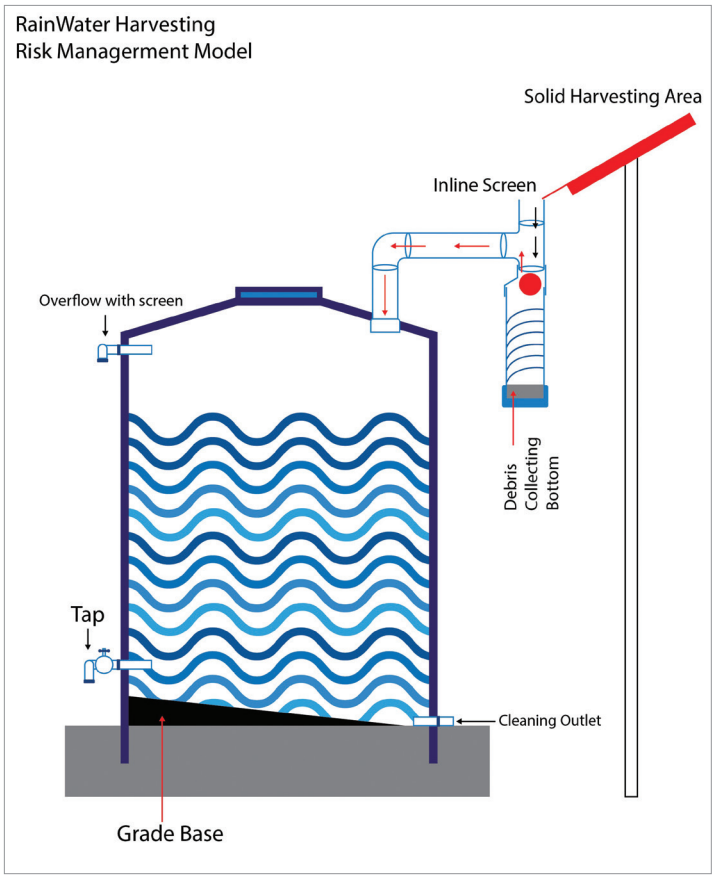
Technical Options and Construction

The risk management model focuses on the harvesting, storage and distribution parts. All parts consist of a collection system (roof, gutter, first flush system and PVC pipes), a storage system (tank) and a distribution system (PVC piping and taps).

Screens are installed at critical points to prevent animals, mosquitoes, leaves and dirt from entering the tank. A cleaning outlet at the base of the tank enables periodic flushing of the tank to clear any debris which may settle on the tank floor.

↘ Figure 3

Risk managed rainwater harvesting tank model



The first flush system is designed to divert a calculated volume of water from entering the main tank, and this ensures that the first bit of water that has collected dirt and debris from the roof and gutters is diverted to a secondary tank that is either manually or automatically emptied.

The Royal University of Phnom Penh, Penh Socheat 2009 conducted the study in Kampong Speu on rainwater harvesting with risk-managed system under Rain Water Cambodia project, which showedthat E. coli and other coliform were presentin the water ofone recipient household which removed the first flush system,and the water required further treatment options in order to be safe for drinking. The other 15 households which kept the first flush system installed were found to have good quality water whichwas directly drinkable (Penh Socheat 2009). This is a significant finding of how important it is to have a risk-managed model.

Institutional System

For larger systems, RWC's skilled technicians and engineers who have many years of experience oversee the construction, which is for the large ferro-cement tanks and other products. The cost of the system ranges from $US 1,700 to $US 4,000 depending on the size and location. The size of the tank starts from 14,000 litreand goes up to 35,000 litre. Large ferro-cement tanks are technically challenging to construct asquality materials must be used and care must be taken at every step. RWC also provides certified technical training to local masons and entrepreneurs who can then construct the tanks.

Domestic System

Domestic rainwater harvesting systems promoted by RWC include two different types of 3,000-litre tanks: the concrete ring tank and the jumbo jar.It is important to remember that other domestic rainwater harvesting technologies are available in different sizes and technical standards. Moreover, it should be emphasized that the tank is just one part of a complete domestic rainwater harvesting system and that each part plays a very important role. Within this specification of the system, the cost ranges from $US 160 for a jumbo jar to $US 250 for a concrete ring tank.

Operation and Maintenance Training

An important part of any rainwater harvesting project is operation and maintenance trainingto ensure sustainability of the system. Typically, an orientation of the different parts is given including demonstrations of how each part works, how toempty the first flush system, turn the valves on and off, clear the screens, and clean and flush the tank, and the importance of keeping the gutter free from leaves is also explained. The beneficiaries are also provided with a number of spare parts and instructions on how to repair parts of the system.

Also provided with the training is a clear easy-to-follow manual which can be kept inthe school, and posters highlighting the system are displayed in staff rooms. The manual contains contact numbers of Rain Water Cambodia, and if a local mason was involved then his contact details are also provided to the school.

(Top) Ferro-cement tank 35,000L, (Middle) Elevated tank 14,000 litres, (bottom) Concrete ring tank 20,000 litres

(Top) Concrete ring tank 3,000 litres (Bottom) Jumbo Jar 3,000 litres

Project Benefits

RWC has received positive feedbacks from all project stakeholders in regard to the project approach and the achieved outputs, and RWC is well recognised in Cambodia as being very successful in the formalization of rainwater harvesting. Besides the number of water facilities built throughout rural Cambodia, the main outcomes of the program have been defined as impact for health, social and environmental aspect also. Table 1 presents the number of rainwater harvesting systems formalized in Cambodia by RWC since 2004.

↘ Table 1

Number of rainwater harvesting systems built by RWC in rural Cambodia by 2017

Items	Domestic Systems	Institutional Systems	Beneficiaries
Household	2,802		14,010
School		273	95,550
Health Clinic		19	11,400
TOTAL	2,802	292	120,960

Health benefits

Health benefits were observed through the feedbacks from households with rainwater harvesting system as the number and frequency of vector-borne diseases have been decreased. Peter McInnisconducted a pilot study in 2008 of rainwater harvesting programs in Cambodia and the results showed that rainwater was considered to be of very high quality by both recipients and non-recipients and was thus used extensively. Both categories of participants still collected large quantities of water and although the majority of recipient households still had most of their tank water remaining, several used it all for non-essential purposes (PETER McInnis 2008).

Environmental benefit

This project has demonstrated the appropriateness of zero energy use for a water treatment before drinking. In 2016, RWC won the national Energy Globe Award – Austria 2016 in recognition of its rainwater harvesting formulization project in rural Cambodia, which contributed to promoting environmental friendly practices and health. The households with rainwater harvesting system built were able to save time and fuel costs by not collecting water from the community pond or other sources.

RWC implemented community-based climate change adaptation in which rainwater harvesting system is one available innovation for the vulnerable households and communities. The vulnerability reduction assessment (VRA) based on the model of UNDP was conducted before starting and after completion of projects to measure the level of project success in particular with respect to climate change risks like drought. The post-project VRA result is compared in Table 2, which shows a significant reduction in the risk of further climate change impact.

RWC National Award 2016 from Energy Globe Award - Austria

Climate Change Impact

↘ Table 2

Vulnerability Reduction Assessment (VRA)	Before	After	Reasons For Change
Future Climate Change Impact	4.62	3.27	Clean drinking water system installed utilising rainwater harvesting formalization to replace domestic rainwater tanks and community ponds.

Note: 1="very low ", 2="low ", 3="moderate", 4="high", and 5="very high"
Source: RWC, 2013, Post vulnerability reduction assessment

Social Benefit

This project has significantly supported the decentralization efforts of local authorities through the establishment of an operation and management committee and implementation of training on social accountability and demand for good governance. Project sustainability has been a critical focus for RWC within this project. The knowledge and resources were mobilized and absorbed by local communities, which ensured that thelocal private sector, masons and labourers have enough capacity toconstruct the rainwater harvesting system; and can be selected as a counterpart in construction for other donors and partners in Cambodia.

The project has strongly reinforced the capacity of its partners, such as government technical departments, local authorities and the private sector in regard to relevant design and construction processes for the implemented technologies.

6. Sustainability Assessment Rainwater Harvesting System

RWC conducted the sustainability assessment of household rainwater harvesting systems in four provinces of Kandal, Kampot, Kampong Speu and Kampong Chhnang in 2016. Ten rainwater harvesting systems installed between 2005 and 2016 were selected in each province. Two technical options were installed in rural communities. These were jumbo jars and concrete ring tanks with a volume of 3,000 to 5,000 litres per unit.

Three main objectives of this study were (1) to understand the current condition of rainwater harvesting systems and associated practices for households with systems implemented by RainWater Cambodia, (2) to determine the level of functionality and sustainability of those systems, and (3) to identify defects or constraints to support future decisions on implementation. The criteria for assessing sustainability were adopted from the UNDP-World Bank Water and Sanitation Program by Sara, J. and Katz (1997) which were: physical condition, operation and maintenance, budget, user satisfaction and willingness to sustain the system. The sub-indicators were scored and rated in a 10-point scale, summed up then divided by the number of total sub indicators. Then, the study identified strengths, defects and constraints from scores obtained for future improvement and implementation for sustainability.

At the time of assessment, 36 rainwater harvesting systems (90%)

were still functioning while the other 4 systems (10%) had failed in operation due to broken concrete foundation and crack on storage wall. However, the problems can be fixedby local masons. From rainwater practice findings, the majority of respondents used 'rainwater' as their main supply source of water in the rainy seasons but a much lower use of the source in dry seasonsdue to high demand, lack of rainfall and failure to separate stored rainwater for consumption.

As for the quality of rainwater stored in tanks as drinking water, 18 systems (50%) reported that they did not store other supply sources in storage tanks while the other 18 systems (50%) said they put alternative water sources into the storage tanks. Tested with the Cambodian Drinking Water Quality Standards (2015), those systems with various sources of water storage failed to meet the standards in each parameter.

Physical condition and design considerations

↘ Table 3

Type of Water Facility	Sustainability criteria					Mean of S-Score
	Physical Condition	Operation & Maintenance	O&M Budget	User Satisfaction	Willingness to Sustain	
RWH Systems	6.1	6.6	6.7	7.3	6.9	6.9

Source: (RWC 2016, Sustainability assessment)

Table 3 shows the results from the RWH systems assessment. It is classified as being 'potentially sustainable' with a score of 6.9 out of 10.0 points. The physical conditionsof the concrete foundation, concrete of storage tank and water catchment roof were all good. On the maintenance works, the respondents said they can do some repair works or replace spare parts if there was any minor error such as pipe leakage or broken pipes. For operation and maintenance budget, 78% of respondents hadthe financial capability if there wasa need for minor repair works, despite the fact that more than 50% of respondents were identified either aspoor (Poor I) orthe poorest (Poor II) according to the national poverty identification system.

All users were satisfied with rainwater in terms ofcolor, odor and taste, but the small storage capacity could not give the users enough water to last throughout the dry season. Many responses were positive on improved health (associated with water borne diseases) with fewer cases of diarrhea or typhoid in the last six months. Other benefits noted by users of the rainwater harvesting systems were reduced time in obtaining water and saving money.

7. Lessons Learnt and the Way Forward

This article presents the key opinionson how to successfully supply water in Cambodia, which is focused on increasing the effectivness of the national action plan implementation and institutional capacity building program for all relevant stakeholders from national level to grass root communities and promoting improved rainwater harvesting. DRWS and commune focal points perceived that the key factors to promote improved rainwater harvesting could help meet the sustainable development goal on clean water, by focusing on capacity building and raising awareness for promoters and communities, financial capacity ofpilot projects and

harmonization among WASH sector and grass root communities for program implementation.

In addition, the following key recommendations are more focused on improving rainwater harvesting formalization in rural Cambodia. Experts and studies reported that the effectiveness of rainwater harvesting systemscan be improved by increasing the capacity of existing storage tanks and installing new facilities. In particular, based on the sustainability assessment findings, RWC proposes the key recommendationsin Table 4 on its rainwater haresting formalization in rural Cambodia to contribute to the affordable and clean drinking water for Cambodia as the following:

Specific targets of VSDG 14

↘ Table 4

No	Situation	Recommendation
Physical condition and design considerations	- Roofs are in good condition - 64% still using first flush - 69% of insect screening still exists - Many respondents do not have enough water in dry seasons, the average household had 6 members	- Increase training on operation and maintenance, in particular the importance of the first flush system. A simplified first flush system model could be the priority as recipients found it difficult to find spare parts for insect screens in the local market. - Extra consideration should be given to installing enough storage capacity for the entire dry season. Household size and roof area should be considered in the future.
Operation and maintenance	- Most respondents (69%) understood how the RWH system works - Only 53% understood the first flush system function. - Note: in every RWH project, operation and maintenance training session was completed	- RWC will facilitate to have a clear plan for O&M through a participatory approach and improve the training strategy provided for recipient households.
Water quality	- All households with poor O&M practice had E. coli in their water. Some of the tested water also had high levels of iron, pH, and manganese, which would make the water unpleasant to drink but not affect health.	- Water contaminated with E. coli must be treated before consumption. - RWC will integrate household water treatment and safe storage in its operation and maintenance training.
RWC implementation strategy	- Currently, RWC does not assess RWH systems using the five criteria of sustainability. - On average, the RWH systems that RWC installed are potentially sustainable. - RWC is not providing follow-up training sessions or follow-up support to households.	- RWC should improve its rainwater harvesting program by specifically focusing on the five criteria of sustainability; capture the strength as found in sustainability assessment and improve the systems from potentially sustainable to sustainable. - RWC should conduct follow-up sessions to increase awareness of users on operation and maintenance, hygienic health and especially on rainwater management.

9. Conclusion

The NAP 2014-2018 clearly presented the flow of work and targets to achieve by 2018, and the second NAP 2019-2023 framework is under deveolopment. In the first mandate of the plan, the mid-term review has been conducted by MRD and its partners to define key learnings, basic strategy and planning to achieve expected outcomes.

Rainwater harvesting formalization is feasible and widely adaptod bythe communities, and many Cambodians prefer rainwater as their main source for drinking and cooking. However, the collection method needs to incorporate a risk management model. RWC has introduced the new risk management model as presented in the above section in an attempt to mitigate all risks and makethe system easy to constructfor local people. Some studies found that the rainwater harvesting program brought health, environmental and social benefits. Additionally, this technical option can be applied to the areas where alternative water sources are unavailable. From the business perspective, rainwater harvesting is not commercially viable yet as people need subsidies from donors and governments. Moreover, the system is only able to supply enough water for drinking and cooking.

The improvement of existing traditional rainwater harvesting has focused on mitigating the risk from contamination and ensuring enough water is supplied for drinking and cooking year-round by meeting the definition of access to improved water supply: (i) safe storage, (ii) storage capacity of at least 3,000 litres, and (iii) access to water through a tap. The World Food Program is carrying out a strategy to ensure access to water by promoting rainwater harvesting storage (AE-WFP 2016, p.2). There are two parts to increasing rainwater supply: rehabilitation/improvement of existing sources and installation of new facilities to increase the number of water jars or increase storage capacity up to 3,000-5,000 litres to supply water allyear round.To sustain the rainwater harvesting formalization, RWC should improve its rainwater harvesting program by specifically focusing on the five criteria of sustainability; and should capture the strength as found in sustainability assessment and improve the systems from potential sustainability to sustainability. In addition, the government of Camdodia represents by Ministry of Rural Development should put more investment in mobilization of rainwater harvesting by development of the operational guideline, demonstrate of model project and scale up. The increased effort in implementation and focused on improve traditional rainwater harvesting to an improved risk managed system either National Action Plan (NAP) or Provicial Action Plan (PAP) on water, supply, sanitation and hygiene are keys to in crease access to improve water supply.

In conclusion, rainwater harvesting formalization in rural Cambodia is an alternative and sustainable water supply solution for everyone in rural Cambodia as it is affordable, reliable and convinient.

References

AE-WFP 2016, Water Infrastructure Study: Rapid Assessment of Existing Groundwater Studies and Groundwater Use in Cambodia.

ANDREW SHANTZ & WILLIAM DANIELL 2011,Water and Sanitation Program: A Study of option for safe water access in arsenic affected community in Cambodia

CSES 2016, Cambodian Socio Economic Survey, P.9, National Institute of Statistic, The Kingdom of Cambodia.

FAO, UNICEF, WFP – 2016, Household Resilience in Cambodia, A Review of Livelihoods, Food Security and Health, Part 12015/2016 EI Nino Situation Analysis.

JICA 2002, P.8-4 The Study on Groundwater Development in Central Cambodia, Final Report.

JMP update report, WHO-UNICEF 2015, P.4, Progress on sanitation and drinking water

Kevin Watkins, 2006, P.34, Human Development Report, UNDP

Kyoochul Ha et all 2013, "Current Status and Issues of Groundwater in the Mekong River Basin", KIGAM) CCOP Technical Secretariat UNESCO Bangkok Office.

Kea Pheng 2016, roof harvesting – community perception of traditional rainwater harvesting in rural Cambodia. A final thesis for executive master in development policies and practice, at the Graduate Institute of International and Development Studies in Geneva, Switzerland.

National Strategic Development Plan 2011-2018, The Royal Government of Cambodia

National Strategy for Rural Water Supply, Sanitation and Hygiene, 2011-2025

National Action Plan 2014-2018, Rural Water Supply, Sanitation and Hygiene in Cambodia.

PETER Mclnnis 2008: Pilot study for evaluation of the impact of rainwater collection system for villagers in rural Cambodia.

Penh Socheat 2009, the study on rainwater harvesting formalization in Kampong Speu, Cambodia: A final thesis for Bachelor Degree at The Royal University of Phnom Penh, Cambodia.

RWC 2013, Climate Change Adaptation Project: Post-Vulnerability Reduction Assessment in Kampot Province.

SNV-MRD 2015, P.24, Rural Water Supply Technical Design Guideline and Construction Supervision Manual

Sara, J. and Katz, T. 1997. Making Rural Water Supply Sustainable: Report on the Impact of Project Rules. Retrieved from http://www.wsp.org/UserFiles/file/global_ruralreport.pdf. Accessed date: 10/2014.

SEVEA 2017, Access to drinking water in rural Cambodia. Current situation and development potential analysis report.

WSP 2015, p.23, service delivery assessment, Water and Sanitation Program – World Bank.

World Bank Group 2017, Sustainability Assessment of Rural Water Service Delivery Models, finding from a multi-countries reviews.

Vouillamoz, J. M., Valois, R., Lun, S., Caron, D., & Arnout, L. (2016). Can groundwater secure drinking-water supply and supplementary irrigation in new settlements of North-West Cambodia? Hydrogeology Journal, 24, No. 1 (February): 195-209.

WHO-Guideline for drinking water quality, 2008, Third Edition, p120e

WHO 2005, P.29, water safety plan, drinking water quality guideline

MRD/UNICEF, 2006, MRD WASH drought response, Drought Condition Update, 06 June 2016.

3

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Cambodia's Water Resources Observed Based on the Hydrological Conditions of the Mekong River

- Focusing on Floods and Droughts between 2000 and 2015

Abstract

This report presents the overall status of Cambodia's water resources based on hydrological conditions, by focusing on floods and droughts that occured between 2000 and 2015 in the Mekong River in Cambodia. Floods of the Mekong often develop slowly with significant lead times. Over the last 25 years, there have been a significant number of distinct drought events, which occurred in 1986-87, 1994, 1997-98, 2001, 2002, 2004, 2005, 2009, 2011, 2012, 2014, and 2015. Based on river monitoring network in 2015 of the Mekong River Commission (MRC), it was indicated that the potential changes of hydrological regime in the Lower Mekong Basin might be influenced by the reservoir operation on Mekong-Lancang in China during the dry season but not much impact during the wet season. The hydrological conditions (rainfall and flows) of the Mekong River in 2015 was characterized by very low flow, compared to its long-term average and the flood that hit Cambodia in 2000. The flow contribution from the Tonle Sap Lake to the Mekong in 2015 was lower than average as well as in 2000, which could result in lower water level in downstream areas after Phnom Penh, leaving the Mekong Delta with drought condition.

The impact of river flow hydrology depends on the flow phenomenon, including climate change (rainfall patterns and high temperatures) and hydropower operation regulations. El Niño process caused by warmer-than-average temperatures in the Pacific Ocean was also studied as it can change weather patterns (rainfall) and lead to drought in the West Pacific Countries including the Mekong Region

2. Introduction

The Mekong River flows through Cambodia for a total length of about 500 km before discharging into the Vietnamese Mekong Delta. At the Phnom Penh- Chaktomuk junction (Four Arms), the Mekong River is hydraulically connected to the Tonle Sap Great Lake by the Tonle Sap River which is 120-km long. Downstream of Phnom Penh, the Mekong splits into two rivers, namely the Lower Mekong River, which flows into the South China Sea after crossing the Vietnamese Mekong delta, and the Bassac River, which flows to the Gulf of Thailand. About 86% of Cambodia's land surface area is within the Mekong River basin, including the catchments of the Mekong River, the

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Bassac River, the Tonle Sap River, , and the tributaries of the Great Lake. The outline of the Mekong River system is illustrated in Figure 1.

The Mekong River system passes through the alluvial plain, the centre of the major cultivated land for paddy rice and upland crops in Cambodia. It plays a major role in agriculture through the maintenance of soil moisture. and utilization of colmatage is affected by the inundation, notwithstanding the insufficiencies of irrigation facilities. In addition, the river is the habitat of a variety of fish and other aquatic species that require rich nutrients for maintaining their proper living conditions. It also supports domestic water and irrigation water supplies and contributes as an important transport medium.

According to the report of the Water Environment Partnership in Asia (WEPA -Cambodia 2014), Cambodia has access to substantial surface water resources. On average, the annual inflow from upstream countries is estimated at 410 km³, with internally generates flows of 90 km³ per year (MRC, 2010). In 1995, Cambodia, Lao PDR, Thailand and Vietnam established the Mekong River Commission (MRC) as a means of collectively addressing the development problems of the Lower Mekong Basin. Since then, the Commission has focused on improving the sustainable management of the water resources in the Mekong region. Faced by the intensifying and newly emerging challenges, the capacity of the MRC to do its job is constantly being called into question and whether it is capable of addressing the core problems in the river basin effectively and competently, especially with regard to climate change, hydropower development and other uncertainty factors (El Nino process, land-use change, population growth, etc.).

↘ Figure 1

The Outline of the Mekong River System

Soure: MRC

3. Review of Floods and Droughts in Cambodia

Floods in Cambodia

Floods occur frequently and extensively in Cambodia. The source of these floods can be the Mekong River including the Tonle Sap Great Lake, tributary flash floods, urban flooding, and failure of structures such as protection levees and storages.

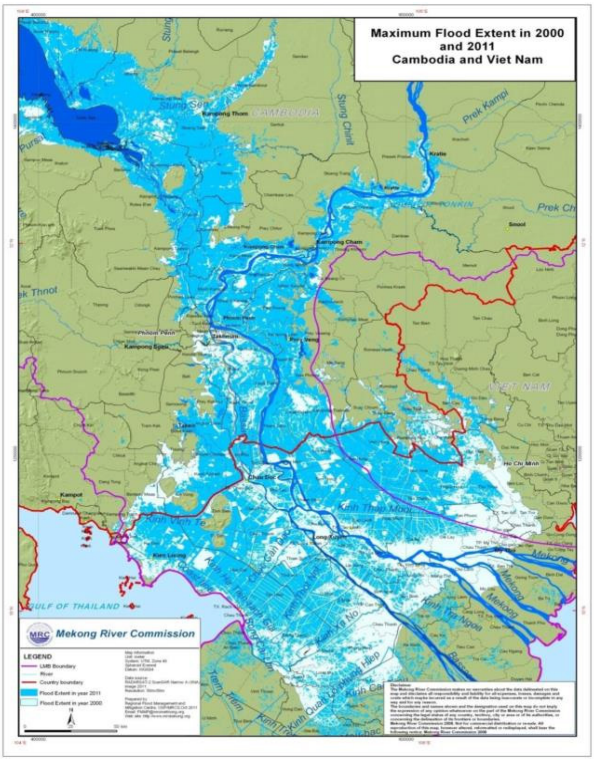
Floods of the Mekong often develop slowly with significant lead times. Recent extreme floods on the Mekong affected Cambodia in 1978, 1991, 1994, 1996, 2000, 2001, 2002, 2011, and 2013.

The 2000 flood in Cambodia caused by the Mekong was reported to be the worst in more than 70 years. It caused major disruption to the population, loss of life, and damages to infrastructure and was followed by major floods in 2001 and to a lesser degree in 2002. The official report compiled by the National Committee for Disaster Management (NCDM) dated 16 November, 2000, put the death toll resulting from the 2000 flood at 347 of whom 80 % were children. Of the 750,618 families (3,448,629 individuals) affected by the 2000 flood, some 85,000 families (387,000 individuals) had to be temporarily evacuated (NCDM. 2008).

Extreme flash floods occurred in 2007 caused by Tropical Storm Pabuk in earlier August, in 2009 caused by Tropical Storm Ketsana at the end of September, and in 2013 due to a tropical depression. Urban flooding occurred in 2010 caused by tropical depression during 10-12 October in Phnom Penh and in 2011 in Siem Reap due to a tropical depression (MoE. 2006).

Based on the statistics issued by NCDM on 3 November, 2011, the 2011 flood struck 18 cities and provinces. Kampong Thom, Battambang, Banteay Meanchey and Siem Reap were the most affected provinces. The death toll was 250, over 1,593,976 persons or 354,217 families were affected, and more than 23,000 families were evacuated to higher ground. Figure 2 shows that compared to the 2000 flood, the one in 2011 was lower in magnitude and extent. However, the flood in 2011 caused more damages than the 2000 flood (Annual Mekong flood report, 2013)

↘ Figure 2



Comparison between 2000 (white) and 2011 (light blue) max flood extent in Cambodia

Source: MRC.2010

Droughts in Cambodia

Droughts in Cambodia are usually associated with crop production as most of agricultural production comes from rain fed cropping. Over the last 25 years, there have been a significant number of distinct drought events occurring in 1986-87, 1994, 1997-98, 2001, 2002, 2004, 2005, 2009, 2011, 2012, 2014, and 2015 (ADPC. 2005).

According to drought studies (NCDM, 2006), Cambodia experienced a prolonged drought in 1997 to 1998 and had consecutive prolonged droughts in 2001, 2002, 2004, and 2005.

The term 'drought' typically refers to the situation when water availability is much reduced from the expected norm. Drought may be manifested in different forms, such as meteorological, hydrological, and agricultural drought. These different forms of drought may or may not be coincident:

- Meteorological drought occurs when rainfall over a prescribed period is significantly less than the long-term average.
- Hydrological drought occurs when water resources are significantly depleted because of meteorological conditions. For example, stream flow for a prescribed period are significantly less than the long-term average.
- Agricultural drought occurs when meteorological and/or hydrological conditions reduce crop yields and affect livestock and fisheries production.

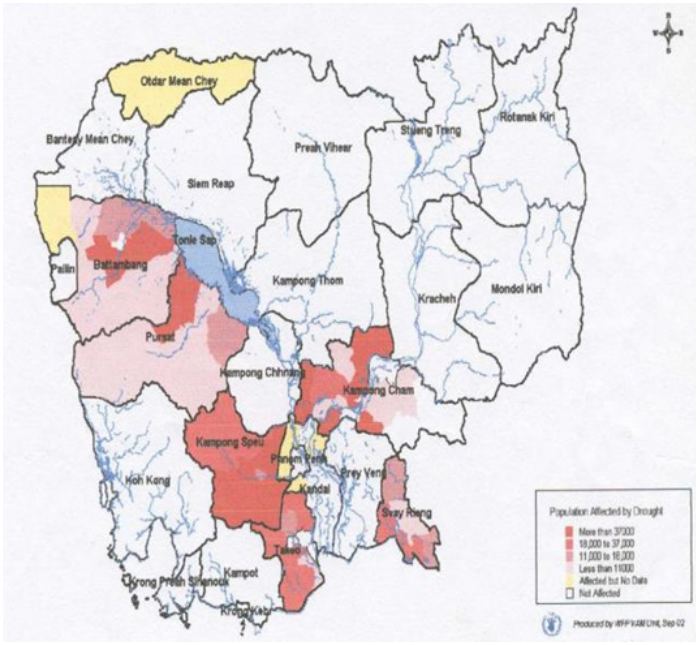
Drought originates from a lack of rainfall. A series of dry days are not usually problematic. Rather, it is the persistency of periods with lower rainfall that gives rise to a long-term rainfall deficit. The magnitude of

the rainfall deficit is related to what would normally be expected, which depends on the season and region.

According to the Ministry of Environment, the worst drought years were recorded in 2002 and 2004 (MoE. 2005). The drought in 2002 affected 43 districts in eight provinces, as presented in Figure 3.

↘ Figure 3

Provinces and population affected by the drought in 2002



Source: MoE

4. Hydrological Conditions

Based on MRC's river monitoring network in 2015, water level from upstream mostly at Stung Treng down to the Mekong Delta in Vietnam were drastically decreased due to the low rainfall and inflows from the tributaries (MRC, 2016). Water levels at each key station of the Mekong mainstream in Cambodia went even lower than their observed long-time average condition in 2015. This condition has been observed during the wet season from May to December

Low flow has been widely witnessed in the Mekong Region in 2015 and 2016. The potential climate-induced impacts on floods are considered in the context of the potential changes that may occur due to the number of large reservoir storages on the mainstream and larger changes to tributaries, and the varied rainfall patterns in the Mekong Region.

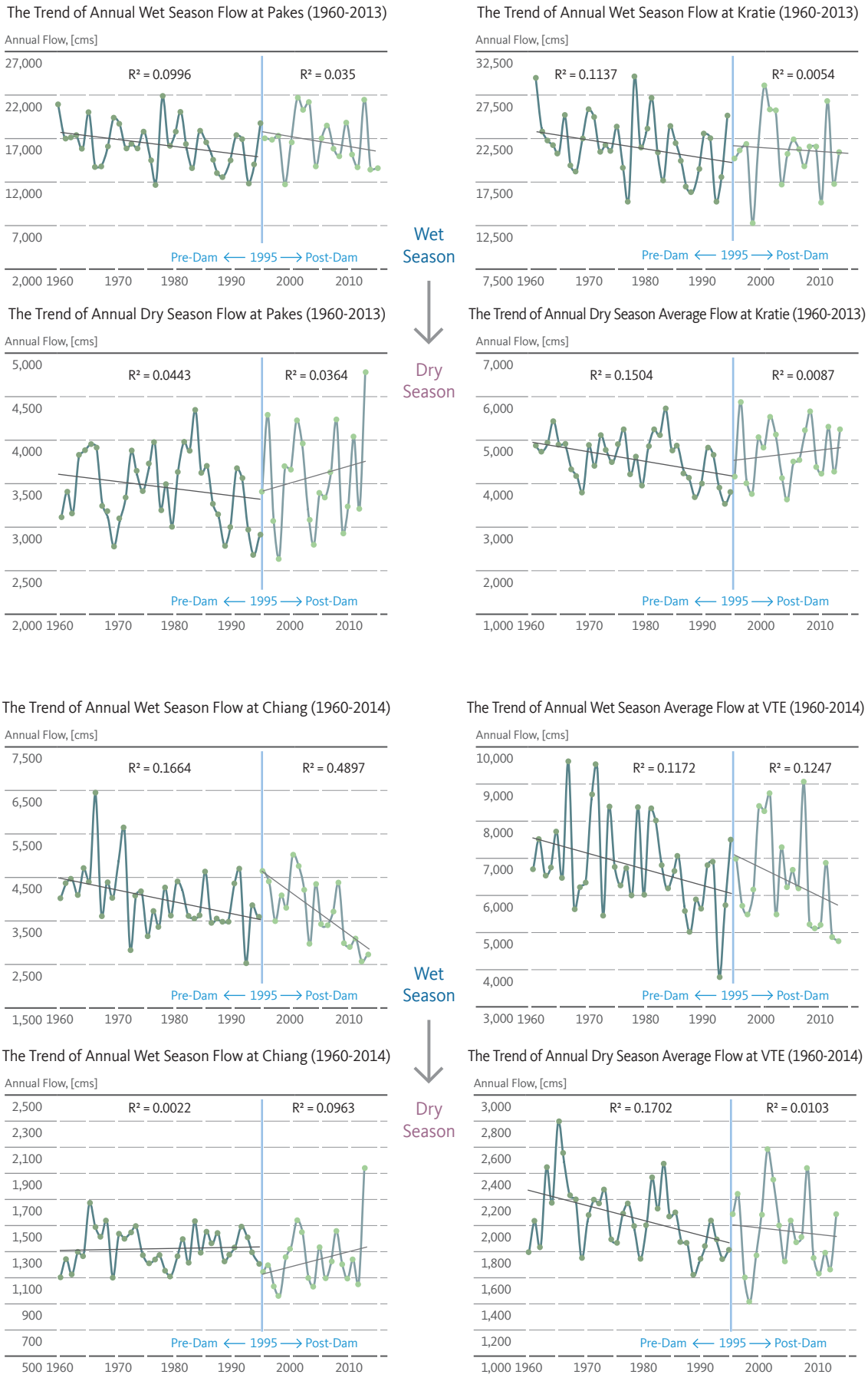
On the other hand, El Niño is known to be caused by warmer-than-average temperatures in the Pacific Ocean, causing changes in weather patterns and can also lead to flooding, rainfall in case of the Mekong region, and droughts. Based on estimates of the US National Oceanic and Atmospheric Administration, Australia's Bureau of Meteorology, Japan Meteorological Agency and NASA, rainfall in Cambodia fell short of expectations in 2015, due to the impact of the El Niño-Southern Oscillation (ENSO).

To verify the seasonal flow in the Mekong River (the section that flows through Cambodia), the analyses on hydrological process were taken into

account. The seasonal flow of the Mekong River is varied from year to year, depending on rainfall intensity in the region and inflow from upstream reaches. To describe the alteration of flow conditions in historical year in the Lower Mekong Basin from most upstream, trend analysis from 1960 to 2014 was used based on the selected stations in the upstream section. The analysis is based upon the most recent available data, which was compared to the historical hydrological and meteorological data. The seasonal flows of selected stations from Chiang Saen to Kratie were used for trend analysis made based on the historical mean flows for the wet season (May to October) and the dry season (November to April) from 1960 to 2014, as presented in Figure 3. The analysis was divided into two period conditions: before and after the construction of the Manwan Dam. The pre-Dam used flows data from 1960 to 1994 and post-Dam from 1995 to 2014 on the Lancang-Mekong mainstream (MRC. 2010). The seasonal average flows in cubic meter per second (cms = m^3/s) from 1960 to 1994 (pre-Dam) in Chiang Saen showed a statistic decline (r^2=0.16; $p \leq 0.5$), whilst from 1995 to 2014 (post-Dam) showed a drastic decrease (r^2=0.49; $p \leq 0.5$) during the wet season. In Kratie, during the wet season from 1960 to 1994, the flows slightly decreased (r^2=0.11; $p \leq 0.1$), whilst there was no visible trend for the period from 1995 to 2014 compared to Chiang Saen. For the dry season in Chiang Saen from 1960 to 1994, no statistically significant change was observed. However, from 1995 to 2014, flows showed a sharp increase (r^2=0.09, p=0.05). For Kratie the trend during the dry season before and after 1994 was not statistically significant in either direction. In summary, during the pre-Dam period, the wet season flows in Chiang Saen decreased but remained variable in Kratie. Conversely, during the pre-Dam period, the dry season flows in Chiang Saen slightly increased, while slightly decreasing in Kratie. After the dam was constructed, flows in Chiang Saen during the dry season sharply increased but was not significant changed in Kratie. There is a clear change point in their frequency in around 1994 and the commissioning of the Manwan Dam. The rate of increase remains significant in Chiang Saen, while in Kratie the change was not evident. It can be concluded that the hydrological impacts of China's reservoir operation on the flow regime of the Mekong are already manifested in the upstream of Vientiane (VTE) but not further downstream.

↘ Figure 4

Trend analyses of key stations in Chiang Saen-Vientiane (VTE) and Pakse-Kratie, based on P-values between Wet and Dry Seasons



Rainfall Conditions

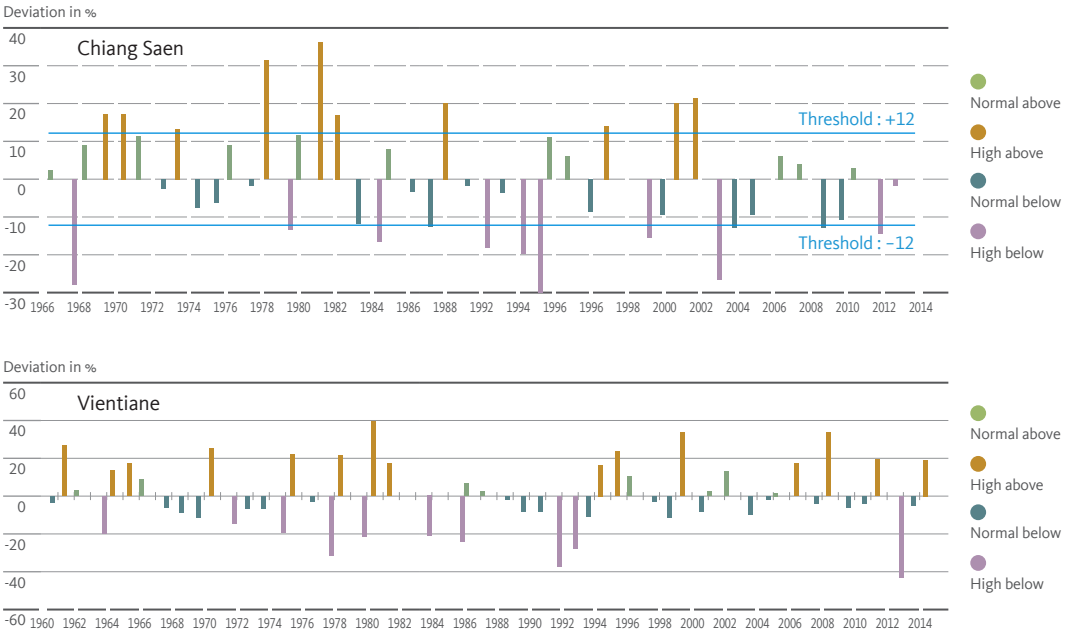
The climate of Cambodia can be characterized as a bimodal monsoon-dominated climate. The wet season is dominated by the southwest monsoon from May to November when 90% of the rainfall occurs. The remaining months spanning from March to April are hot and less humid with high potential evapotranspiration demands. The rainfall pattern is extremely variable across the country. The maximum 24-hour rainfall is in the range of 200 mm throughout the region. The maximum rainfall is often associated with convective storms. Occasionally, typhoons from the South China Sea or the Gulf of Thailand travel inland and cause widespread flooding These storms often bring strong winds and torrential rain.

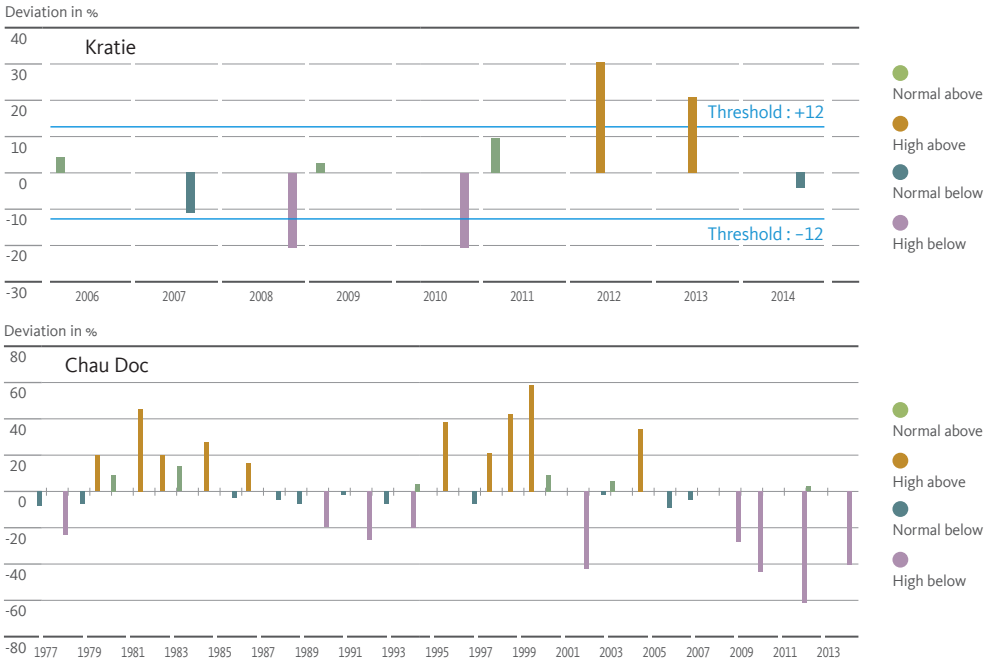
Figure 5 presents the annual rainfall at 4 selected stations. The hyetographs showed the percentage of rainfall in each historical year in above and below the long-term average and the threshold (±12%) for the historical years based on data availability at stations in Chaing Sean, Vientiane, Kratie and Chau Doc. Based on these statistical analyses, the "drier" and the "wetter" periods that highlight the normal years can be verified. In the high dry and wet years, rainfalls are above or below average by over their thresholds ±12 of the rainfall deviation in percentage (%). At the selected stations, the 2015 rainfall (up to September) is shown to be below -12% compared to its deviation in percentage. This seems to have contributed to the low flow in the mainstream of the Mekong River System. Rainfall Climate Change: The possible change in volume of stream flow and flow regime can be caused by rainfall climate change (warming in some specific areas in the world). This can be related to the following factors:

- Changes in the mean annual discharge (flow)
- Changes in the seasonal shift of rainfall which can affect flow regime in the rivers
- Changes in the flood regime and the maximum annual discharge

↘ Figure 5

Annual historical Rainfall in Percentage Deviation at Chiang Sean, Veintiane, Kratie and Chau Doc





Review of Cambodia's Wet Season

During the flood season when the flow of the Mekong River at Kampong Cham (below Kratie) exceeds about 25,000 m³/s, water spills over the banks of the Mekong River between Kampong Cham and Phnom Penh. Part of the spill on the right bank reaches the Tonle Sap Great Lake as overland flow and as such is not measured at Prek Kdam. The overland flow component contributing to the Tonle Sap Lake inflow varies from year to year depending on the flood magnitude. DHRW estimates that the overland flow varies from 2 % to 12 % of the total Tonle Sap Lake inflow volume.

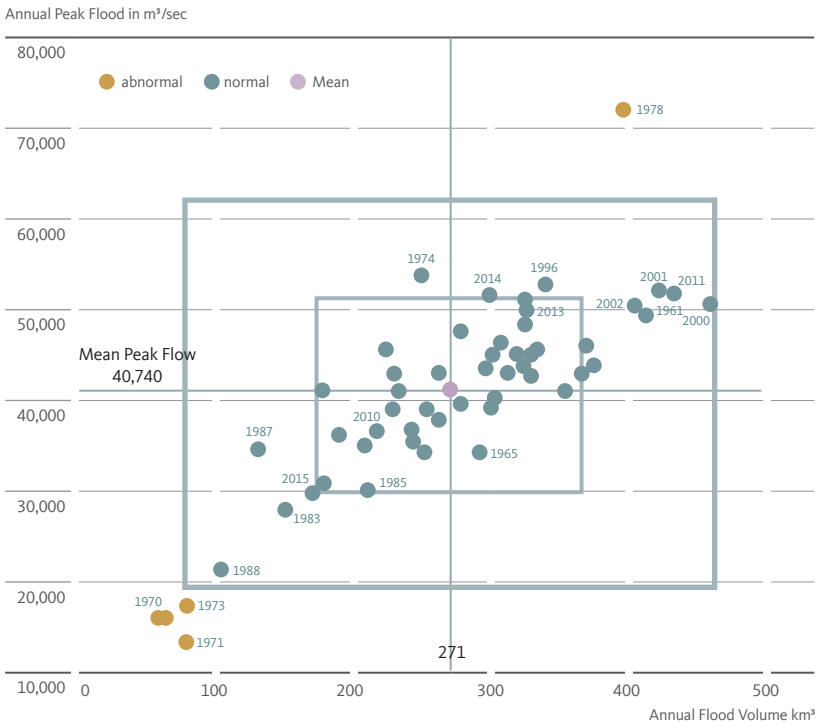
In terms of peak flow and seasonal flood volumes condition during the wet season of 2015 in Kratie, both peak flood and volume were significantly lower than average. This indicated the low water level during the wet season in Cambodia.

Figure 6 illustrates the scatter plots of the flood peak index at Kratie. The boxes indicate one (1β) and two (2β) standard deviations for each variable above and below the respective mean. Events outside the 1β box might be defined as “significant” flood years, and those outside the 2β box are defined as historically “extreme” flood years. The major over seasonal influence between the flood season flow situation and conditions during the following low flow season is not whether flood volumes during the flood season were above or below average. The over season (wet to dry) dependence in terms of flow volumes, though statistically significant, does not provide any meaningful basis for prediction.

The monsoon season regularly causes flooding in Cambodia. Figure 7 shows the observed flow hydrographs and accumulated flow volumes in Kratie over the wet season from 2000 to 2015 in Cambodia. The unprecedented peak flows in 2000 obviously caused high flow resulting from upstream inflows and heavy rainfall from sub-catchment inflows (MRC, 2015). The flood in 2000 was considered high and resulted in serious flooding across the country. However, in 2015 water levels fluctuated greatly around their long term average and even reached below its long term average level during the wet season.

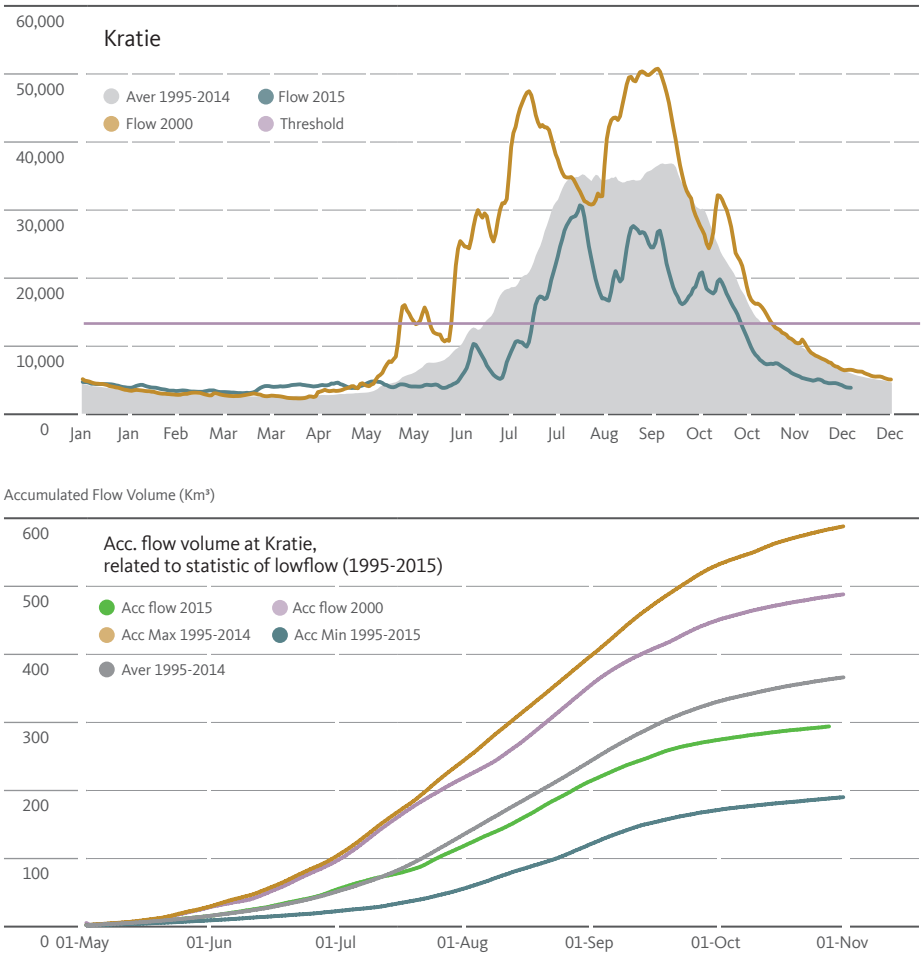
↘ Figure 6

The joint distribution of the annual maximum flood discharge in m³/second and the volume of annual flood in Kratie



↘ Figure 7

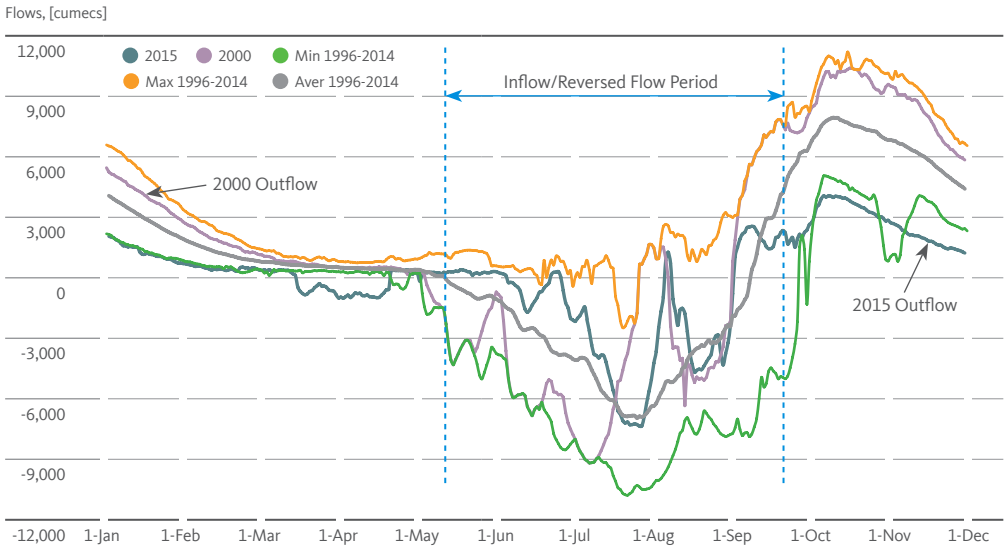
Flow Hydrograph and Accumulated Flow Volume of Wet Season in 2000 and 2015, compared to their long-term average condition and threshold



At the end of the wet season, when the flow in the Mekong begins to slow down, the flow of the Tonle Sap River is reversed. Figure 8 shows the seasonal changes of outflow/reversed flow and flow volume of the Tonle Sap Lake, in comparison with the flows between in 2000 and 2015. The high inflow from the Mekong River and the most likely highly affected rainfall in the upper sub-catchment areas of the Lake caused the outflow from the Tonle Sap Lake in 2000 to be very high. It was even higher than average condition (1996-2014) at Prekdam station. The low inflows (in the Mekong and its tributaries) in the wet season of 2015 resulted in very low flow and volume that could reach the minimum level of the Lake. This could also cause low flow condition during the dry season in 2016 from January to April. Figure 9 presents the monthly flow volume of Tonle Sap Lake, describing the high and low flow condition in 2000 and 2015. Table 1 describs the monthly change of flow volume of the Lake which identified the huge inflow in 2000 and the very low inflow in 2015.

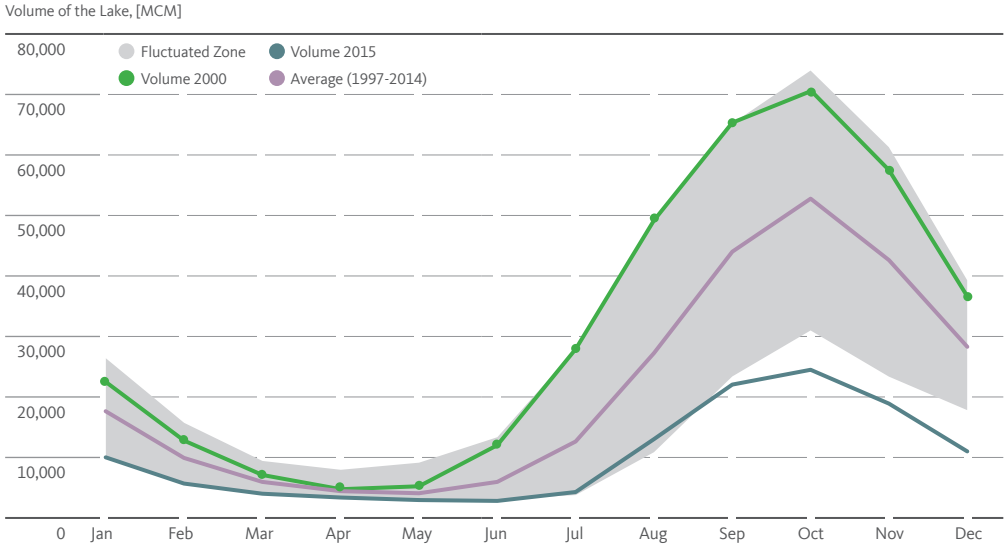
↘ Figure 8

The condition of Inflow and outflow/reversed Flows of the Tonle Sap Lake in 2000 and 2015



↘ Figure 9

The Monthly change in Flow Volumes of the Tonle Sap Lake in 2000 and 2015



↘ Table 1

The change in flow volume of the Tonle Sap Lake, compared to its average condition

Month	Average (97-14)	Volume2000	%	Volume2015	%
	[MCM] (1)	[MCM] (2)	2000	[MCM] (2)	2015
Jan	17717.27	22497.52	127%	10104.74	57.03%
Feb	10077.01	12877.20	128%	5829.33	57.85%
Mar	6209.78	7253.37	117%	4150.45	66.84%
Apr	4687.26	4906.74	105%	3558.53	75.92%
May	4320.18	5366.56	124%	3142.70	72.74%
Jun	6149.85	12108.41	197%	3008.36	48.92%
Jul	12805.48	27870.60	218%	4431.26	34.60%
Aug	27249.61	48988.62	180%	13027.83	47.81%
Sep	43833.39	65035.74	148%	21930.64	50.03%
Oct	52487.16	70396.47	134%	24317.78	46.33%
Nov	42434.51	57254.21	135%	18842.51	44.40%
Dec	28269.42	36584.17	129%	11025.15	39.00%
Average	21353.41	30928.30		10280.77	

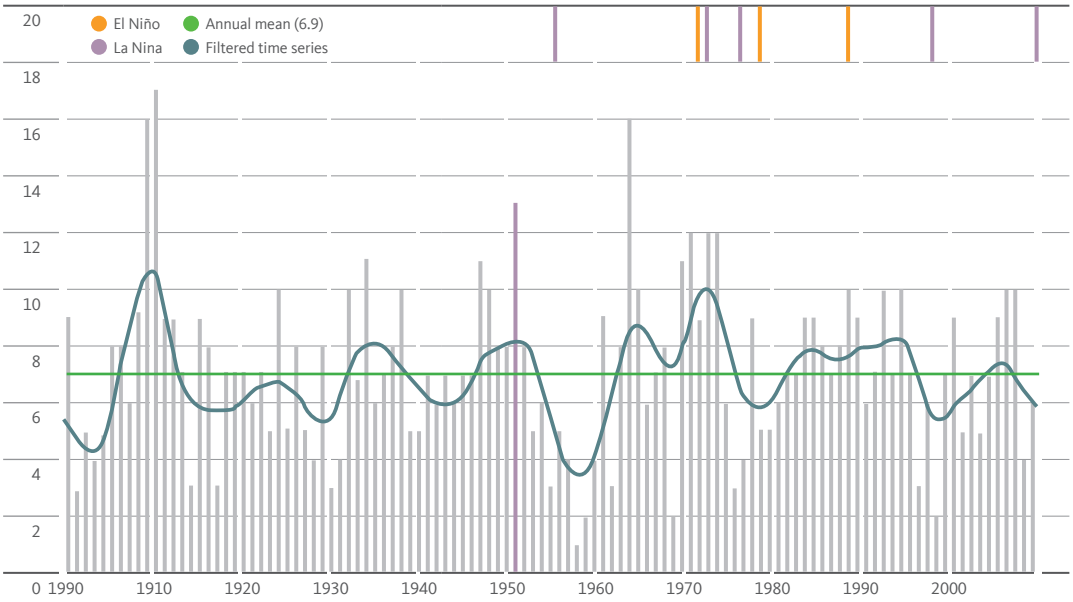
5. Impact of El Niño on the Dry Season of 2016

In addition to the hydrological conditions, the climate variability in the Mekong region in recent decades has been affected by ocean-atmosphere phenomena such as the El Niño-Southern Oscillation, which has become more variable in recent decades. El Niño affected the wet season of 2015 and prolonged to the early wet season in 2016 in the Mekong Basin.

The data plotted in Figure 9 show the annual count of storms approaching Vietnam from 1900 to date, with a mean rate of 6.9 events per year. There is no long-term systematic trend. Jan Null et al (2016) reviewed the post 1950 data from a different source and also concluded that the expected increase due to climate change was not historically evident. There were 2 storms that hit the Mekong Region in 2015: 1-Kujira from 19-24 June (with a wind speed of 85km/h) and 2- Vamco from 13-15 September (65km/h). There is no evidence to suggest that the frequency of typhoons and tropical storms is currently increasing (JMA&NASA).

↘ Figure 10

Annual number of typhoons and tropical storms

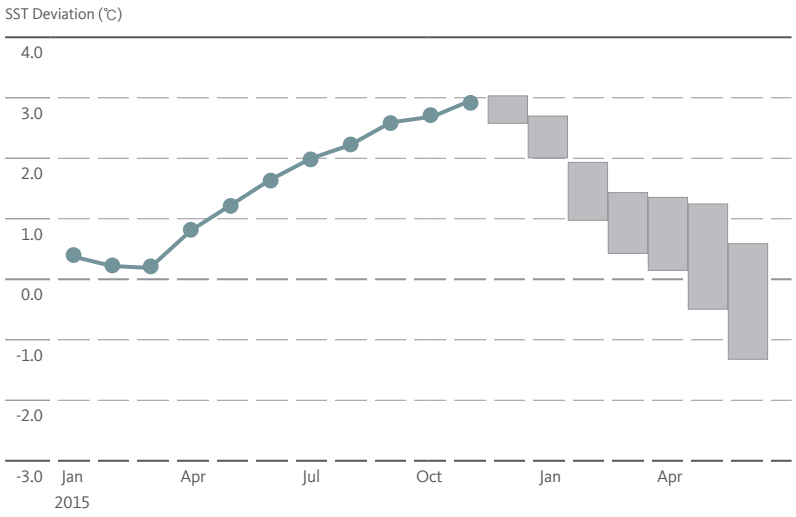


*The number of tropical storms (wind speed > 16 m/sec) and typhoons (wind speed > 33 m/sec) that approached the coast of Vietnam (specifically entering the latitude / longitude box 7.5 to 22.5° N and 105.0 to 115.0° E). The data from 1900 to 1995 are drawn from the CD-Rom Global Tropical and Extra-Tropical Cyclone Atlas, Version 2, US Navy, Department of Commerce, Washington DC. 1996

It is widely acknowledged that there is a complex relationship between ENSO events and the number of typhoons making landfall in Vietnam and Guangdong Province in China and then potentially passing into the Mekong Basin (Elsner and Liu, 2003). Fewer but more intense storms occur during strong El Niño years, but multiple occurrences have a higher probability in strong La Nina years. Because the number and intensity of storms is closely linked to sea surface temperatures, any intensification of the ENSO cycle is expected to increase the annual risk of severe tropical storms entering the Mekong region. Based on the information from the International Research Institute for Climate and Society (IRICS) and the Japan Meteorological Agency (JMA), the consensus of ENSO prediction models indicated that strong El Niño conditions will continue during the December-June 2015-2016 season. The ENSO forecast made by dynamical and statistical models for SST is presented in Fig. 11. The ASEAN Specialized Meteorological Centre (ASMC) confirmed that El Niño can still have a significant impact on the weather conditions (dryness) over the southern part of ASEAN region, in particular, the western part of the Maritime Continent. For the southern ASEAN region, the Northeast Monsoon will bring an increase in rainfall activities over most parts of the equatorial region. Over the eastern Maritime Continent and over the northern part of Southeast Asia, there are slightly higher probabilities of above normal rainfall.

↘ Figure 11

The ENSO forecast made by dynamical and statistical models for SST



Source : Japan Meteorological Agency (JMA)

6. Conclusion

Since 1995, the water flows in wet seasons from Chiang Saen to Vientiane significantly declined compared to the pre-dam period. In contrast, the dry season flow from Chiang Saen to Vientiane showed a significant increase. However, it is found that there is no significant change/effect to the flow regime from Pakse to Kratie during the wet and dry seasons. The potential changes of hydrological regime from Chiang Saen to Vientiane may be influenced by the reservoir operation on Mekong-Lancang in China. However, there was no significant influence to the further downstream of Pakse and Kratie. The rainfall essentially varied from place to place, depending on the topographical features of the watershed catchments in Cambodia and further downstream.

The hydrological conditions (rainfall and flows) of the Mekong River during 2015 was characterized as very low flow, compared to the long-term average and the flood that hit Cambodia in 2000. This caused a drastically low water level in the mainstream and many tributaries in rainfed watershed areas of the Lower Mekong Basin.

Flood conditions in the Mekong River (Cambodia) during the 2015 monsoon season were significantly below average both in terms of peak discharge and seasonal volume of runoff. The less rainfall in 2015 could affect the early dry season of 2016, which also has an impact on agriculture due to water scarcity. The flow contribution from the Tonle Sap Lake to the Mekong in 2015 was lower than average as well as in 2000, which could impact the lower level in the downstream area after Phnom Penh, leaving the Mekong Delta in drought conditions. This indicates that the outflow from the Lake influences the areas downward into the Mekong floodplain areas.

On the other hand, drought risk depends upon with the severity or 'intensity' of a drought (as measured by its likelihood of occurrence of rainfall, stream flow and soil moisture deficits). It also depends on the characteristics of drought behavior. The time of onset of a drought in relation to crop growth cycle and its duration play major roles in determining the reduction in agricultural yield. Drought risk is also highly dependent on land-use; drought-sensitive land-uses increase

drought risk. In the LMB, major land-uses adversely affected by drought include agriculture, animal husbandry, fisheries and urban settlements (typically villages). Unlike floods, droughts do not cause damage and service disruption to infrastructure and buildings.

Therefore, drought can reduce by moderating the nature of drought (through structural works, such as supplementary water supply from dams or groundwater, or by water conservation measures), reducing the population at risk (land-use controls), ensuring that land-use across flood-prone land is appropriate to the level and nature of drought risk (i.e. land-use is resilient to drought), and by increasing the drought resilience of drought-prone communities.

The decreased water levels/flows in Cambodia's wet season can cause the reduction of floodplain area and flow of nutrients from flood waters and the increase of saline intrusion in the Mekong Delta during the wet-season flows.

The impact of river flow hydrology depends on the flow phenomenon, including climate change (rainfall patterns and high temperatures) and hydropower operation regulations. The impact on reservoir operation can result in:

· Decrease in flood peak

· Delay of flood peak

· Increase in dry season flow

· Shortening of flood season

· Reduced downstream of flood duration in the floodplain and the Mekong Delta

To cope with the above situations of floods and droughts in Cambodia, the following aspects should be considered:

- The use of a combined hydrological and hydraulic modelling to simulate existing flood behaviors and possible future behaviors under climate change across Cambodia.
- Identify and implement non-structural climate change application.
- Formulate flood development scenarios based on population growth, land-use change and new floodplain infrastructure development.
- Assess possible future flood behavior under condition of climate change, upstream development (Dam) and future floodplain development.
- The effect of sediment load transport and salinity intrusion should be included in the next analyses.
- Monitor El Niño process which is caused by warmer-than-average temperatures in the Pacific Ocean that can change weather patterns (rainfall) and leads to drought in the West Pacific Countries, including the Mekong Region.

Acknowledgements

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References

ADCP (2005). Climate change and food security in SE Asia. Asian Disaster Preparedness Centre. Bangkok. Thailand.

AIACC. (2006). Vulnerability to climate change related water resource changes and extreme hydrological events in Southeast Asia. Assessment of the Impacts and Adaptations to Climate.

Arora, V.K. and G. J. Boer (2001). The effects of simulated climate change on the hydrology of large river basins. Journal of Geophysical Research. 106 (D4) 3335 -3348.

Chinvanno.S (2003). Information for sustainable development in the light of climate change in the Mekong Basin. Remote Sensing and Geographic Information Systems (GIS) Applications for Sustainable Development. Part II. SEA START. Bangkok.

James B. Elsner, and Liu, 2003. HYPERLINK "http://profs.princeton.edu/leo/journals/Atmos/ElsnerLiu-ENSOandTyphoons-ClimRes2003.pdf" Examining the ENSO– HYPERLINK "http://profs.princeton.edu/leo/journals/Atmos/ElsnerLiu-ENSO and Typhoons-ClimRes2003.pdf" typhoon hypothesis. C LIMATE RESEARCH. Clim Res Vol. 25: 43 –54, 2003 HYPERLINK "mailto:jnull@ggweather.com" Jan Null, CCM (2 016). El Niño and La Niña Years and Intensities, based on Oceanic Niño Index (ONI). HYPERLINK "http://ggweather.com/enso/oni.htm" http://ggweather.com/enso/oni.htm

Japan Meteorological Agency and NASA. HYPERLINK "http://www.jma.go.jp/en/gms/" http://www.jma.go.jp/en/gms/ .

MAFF.(1998-2007). Agricultural Statistic1984-1985. Phnom Penh: Ministry of Agriculture, Forestry and Fisheries.

Mekong River Commission. (2005). Impact of 2005 Flood. Country Report. Retrieved 13th July,2012, from HYPERLINK "http://www.mrcmekong.org/flood_report/2005/impact_cambodia1.html" \h http://www.mrcmekong.org/flood_report/2005/impact_cambodia1.html

MoE. (2005). Analysis of Policies to Address to Climate Change Impacts in Cambodia. Phnom Penh: Ministry of Environment.

MAFF. (n.d). Role and Responsibility of Ministry of Agriculture, Forestry and Fisheries Retrieved from http://www.maff.gov.kh/about/5-mission.html

MoE. (1998). National Environmental Action Plan 1988-2002. Phnom Penh: Ministry of Environment.

MoE. (2005). Analysis of Policies to Address Climate Change Impacts in Cambodia. Retrieved from Phnom Penh:

MoE. (2006). National Adaptation Programme of Action to Climate Change. Phnom Penh: Ministry of Environment.

MoWRAM. (2007). Law on Water. Phnom Penh: MoWRAM.

MoWRAM. (2012). Climate Change Strategic Plan For Water Resources and Meteorology (2013-2017). Phnom Penh: MoWRAM.

MoWRAM. (n.d). Role and Responsibility of Ministry of Water Resources and Meteorology. Retrieved from HYPERLINK "http://www.maff.gov.kh/about/5-mission.html" http://www.maff.gov.kh/about/5-mission.html .

MOWRAM, MAF (2007). National Strategy Plan for Agriculture and Water.

MRC. 2010. State of Basin Report. HYPERLINK "http://www.mrcmekong.org/" http://www.mrcmekong.org/

MRC. 2014-2015-2016. Annual Mekong Flood Report.

NCDM. (2008). Strategic National Action Plan. Phnom Penh: National Committee for Disaster Management.

NYDA C., BUNNAK P. (2012). Climate Change Impacts on Agriculture and Vulnerability as Expected Poverty of Kampong Speu Province, Cambodia. IJERD – International Journal of Environmental and Rural Development (2012) 3-2. Special Contribution on EFA and ESD

NIS. (2008). General Population Census of Cambodia 2008. Phnom Penh: Ministry of Planning. Saohorn. (Undated). Natural Disaster in Cambodia. Retrieved 22th June,2012, from HYPERLINK "http://drh.bosai.go.jp/Project/post/en/events/23_ASEAN_DRH_(IDRiM09)/4-1_ASEAN_DRH_Cambodia_Saohorn.pdf" \h http://drh.bosai.go.jp/Project/post/en/events/23_ASEAN_DRH_(IDRiM09)/4-HYPERLINK "http://drh.bosai.go.jp/Project/post/en/events/23_ASEAN_DRH_(IDRiM09)/4-1_ASEAN_DRH_Cambodia_Saohorn.pdf" \h 1_ASEAN_DRH_Cambodia_Saohorn.pdf .

The Food and Agriculture Organization (FAO) in Cambodia: HYPERLINK "http://www.fao.org/cambodia/fao-in-cambodia/en/" http://www.fao.org/cambodia/fao-in-cambodia/en/

US National Oceanic and Atmospheric Administration: available at HYPERLINK "http://www.noaa.gov/" http://www.noaa.gov/

WEPA, Cambodia (2014). State of water environmental issues. http://www.wepa-db.net/policies/state/cambodia/overview.htm

4

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Using the Freshwater Health Index to Assess Progress toward Sustainable Development Goal 6, Clean Water and Sanitation, in Cambodia

1. Introduction

SDG 6 : Clean Water and Sanitation

The Sixth Sustainable Development Goal (SDG6) seeks to ensure the availability and sustainable management of water and sanitation for all. Achieving SDG6 requires the freshwater demands of municipalities, agriculture, forestry, industry and natural ecosystems be sustainably met by 2030. The importance of SDG 6 is highlighted by the World Economic Forum (WEF) which ranked water crisis as the number one global impact risk in 2015 (World Economic Forum, 2015), and including water crisis in the top five global impact risks since 2012 (World Economic Forum, 2015). In 2014, the WEF recognized water security as a systemic global risk (World Economic Forum, 2014). A systemic risk is likely to entirely break down a system, as opposed to the isolated failure of individual components (Kaufman & Scott, 2003). Systemic risks can have modest tipping points, which may combine to produce system failure; they maybe contagious, with one failure triggering a chain of others; and, the system may be unable to recover its previous state after a shock due to a lack of resilience (World Economic Forum, 2014). Global risks to water security include floods, droughts and the impacts of water shortages on shared strategic water resources. The latter can have a systemic impact as the combination of water shortages, poverty and social instability can lead to transboundary conflicts (World Economic Forum, 2014).

As human populations grow and become wealthier the need to supply water to cities and factories, increase agricultural production and produce energy is increasing the demand for freshwater. In the 20th century, as the human population quadrupled, freshwater withdrawals increased nine fold (World Economic Forum, 2014). Competition for water is projected to rise along with increases in water withdrawals for agriculture and energy generation (World Bank, 2016). Although global gains in providing people with safe water sources have been made, dwindling supplies of safe drinking water remain a problem (World Bank, 2016), while climate change is altering the spatial and temporal distribution of exploitable water resources. This not only makes future progress difficult, but it threatens to reverse already hard-won gains.

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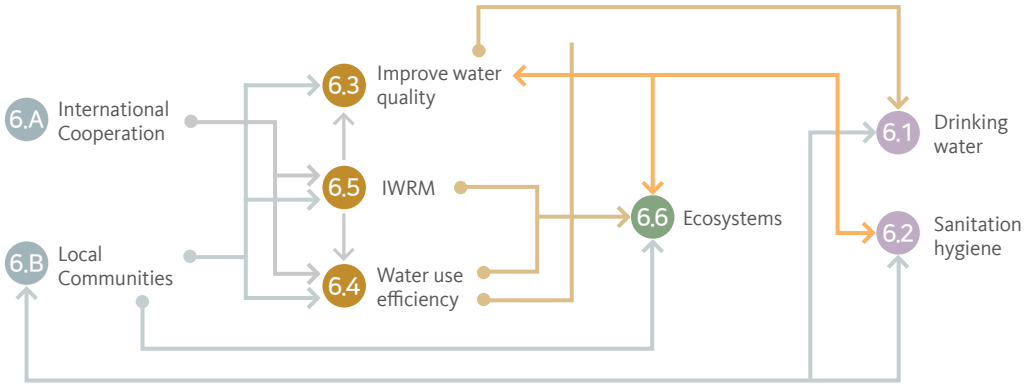
To capture this complexity, SDG 6 has eight targets and eleven indicators, which are interlinked and address the full gamut of human water use and management (Box 1). The basis of SDG 6 is the provision of an adequate supply of clean water for human use and adequate sanitation (Targets 6.1 and 6.2). To achieve these goals, pollution must be controlled (Target 6.3) and water-use efficiency increased (Target 6.4). Meeting these goals requires implementing integrated water resources management (Target 6.5) underpinned by the protection of functioning water-related ecosystems (Target 6.6). Two mechanisms are needed to achieve success: 1) expanding international cooperation and capacity building (Target 6.A) and 2) the participation of local communities in water and sanitation management (Target 6.B). In recognizing that water security is a systemic risk when addressing SDG Goal 6, we must look beyond the provision of safe water and sanitation to include the environment, human health, food security and disaster resilience. It also has been recognized that water security is a pre-condition for economic growth (World Bank, 2016). SDG 6 is a cross-cutting goal, as its achievement is a pre-requisite for achieving many of the other 16 SDGs (Regan et al., n.d.; UN-Water, 2016b).

Inter-relationships between SDG 6 targets



The eight inter-related targets of SDG 6 cannot be achieved in isolation. A simple conceptual model can help clarify important relationships between targets. Clean drinking water (6.1) and sanitation (6.2) are SDG 6's two main human outcomes (purple circles). Sanitation and hygiene have an impact on water quality and are also affected by it. Thus, poor sanitation makes improving water quality difficult, while poor water quality negatively affects hygiene. A similar relationship exists between water quality and ecosystems (6.6). Targets 6.3, 6.4 and 6.5 (brown circles) are management processes, which are directly affected by human input (6.A, 6.B; grey circles) and have an impact on human outcomes or natural processes (6.6; green circle). For example, increased water-use efficiency can make more water available for the environment while providing secure supplies of drinking water. Integrated water resource management impacts the other two management processes as well as water-dependent ecosystems, and its effectiveness can be improved through international cooperation and the input of local communities. Local communities influence all other SDG 6 targets, either through direct input (e.g., catching fish), or making management decisions. They, in turn, benefit from improved supplies of clean drinking water and adequate sanitation.

SDG 6 and Cambodia

Despite abundant water resources Cambodia has Southeast Asia's lowest National Water Security Index (NWSI) score, 37.5 out of 100 (Asian Development Bank, 2016). This classified Cambodia as "Engaged,"which generally means that more than half the population has access to modest potable water and sanitation facilities. Also, initial development of water service delivery to support economic activities, as well as some measures to improve water quality, have begun, and initial attempts have been made to address water-related risks. However, Cambodia's score was only marginally above the "Hazardous" threshold (36), which is characterized by limited water and sanitation facilities, poor infrastructure and water quality, seriously damaged aquatic ecology and poverty inducing floods and droughts (Asian Development Bank, 2016). Of the five dimensions that made up the score, economic water security was the highest (12.7 out of 20) followed by environmental water security (8), household water security (6.7), urban water security (5.6) and resilience to water-related disasters (4.5).

A UNDP assessment of Cambodia's National Strategic Development Plan (NSDP) 2014–2018 and other related plans against SDG targets revealed gaps between national goals and potential indicators that align with the SDG 6 targets (United Nations Development Programme, 2016). This assessment considered that SDG goals 6.1, 6.3, 6.5 and 6.6 were addressed, while 6.2 and 6.4 were only partially addressed by government plans. However, indicators for Targets 6.3, 6.4 and 6.5 were not included in the plans reviewed. Furthermore, the Royal Government of Cambodia has prepared a preliminary, but incomplete, list of national SDG targets.

This brief analysis shows that Cambodia faces considerable challenges in both meeting and reporting on its SDG 6 targets. The Freshwater Health Index (FHI; Vollmer et al., 2018) can help Cambodia assess and report on SDG 6. Results from an FHI assessment of the Cambodian section of the Sesan, Srepokand Sekong River basin are presented below, along with a discussion of how these results can be used to report against relevant SDG 6 targets and indicators in Cambodia.

2. The Freshwater Health Index in Cambodia

The Freshwater Health Index (Box 2) has been applied in Cambodia to the 3S River basin which comprises the Sesan, Srepok and Sekong Rivers (Figure 1) (Regan et al., n.d.). The 3S Rivers originate in Lao PDR and Vietnam, and flow through Cambodia, where they join before discharging to the Mekong River. The 3S basin is a significant source of both flow (Adamson, Rutherfurd, Peel, & Conlan, 2009; Arias et al., 2014) and sediment (Koehnken, 2012) to the Mekong and provides important migratory fish habitat (Ziv, Baran, Nam, Rodriguez-Iturbe, & Levin, 2012). The 3S River system is rapidly changing due to land clearance for industrial agriculture, climate change and hydropower dam development.

The Freshwater Health Index

ECOSYSTEM VITALITY

Water Quantity
- Deviation from natural flow regime
- Groundwater storage depletion

Water Quality
- Suspended solids
- Total nitrogen
- Total phosphorus
- Indicators of major concern

Drainage-Basin Condition
- Channel modification
- Flow connectivity
- Land cover naturalness

Biodiversity
- Species of concern
- Invasive & nuisance species

ECOSYSTEM SERVICES

Provisioning
- Water supply reliabilty relative to demand
- Biomass for consumption

Regulation & Support
- Sediment regulation
- Deviation of water quality metrics from benchmarks
- Flood regulation
- Exposure to water-associated diseases

Cultural
- Conservation/Cultural Heritage sites
- Recreation

GOVERNANCE & STAKEHOLDERS

Enabling Environmet
- Water resources management
- Right to resource use
- Incentives & regulations
- Financial capacity
- Technical capacity

Stakeholder Engagement
- Information access & knowledge
- Engagement in decision-making processes

Vision & Adaptive Governance
- Strategic planning & adaptive governance
- Monitoring & learning mechanisms

Effectiveness
- Enforcement & compliance
- Distribution of benefits
- Water-related conflict

The Freshwater Health Index (FHI) is a multi parameter index of river catchment health (Vollmer et al., 2018). The FHI defines freshwater health as the ability to deliver water-related ecosystem services, sustainably and equitably, at the drainage basin scale. It is implicit that sustainable and equitable long-term delivery of ecosystem services relies on long-term ecosystem function. The FHI is an adaptable composite indicator system that collates monitored and modeled data under three major indicators: Ecosystem Vitality, Ecosystem Services and Governance & Stakeholders. Indicators are scored from 0-100, with higher scores indicating better conditions. Using the FHI, countries can look comprehensively at the sustainability of their freshwater systems.

↘ Figure 1

Location of the Sesan, Srepok and Sekong (3S) River basin (light blue) in Southeast Asia. The dark blue portion is the section of basin located in Cambodia, dotted lines represent river basin boundaries.

The FHI assessment of the 3S River basin provides a baseline health status as of December 2016, using a combination of real and modeled data as well as stakeholder surveys. Ecosystem Vitality and Ecosystem Services scored 64 and 80, respectively, out of a possible 100, and Governance & Stakeholders scored 43 (Regan et al., n.d.). This shows that the 3S basin is providing a range of ecosystem services, but there are signs of ecological and hydrological stress, and there is limited capacity to cope with rapid change. Although the provision of Ecosystem Services is relatively high in comparison with Ecosystem Vitality, if vitality declines further, service provision may also decline.

As the previous assessment was not exclusive to Cambodia, but also included portions of Lao PDR and Vietnam, SDG 6 relevant FHI indicators were recalculated for the Cambodian section of the basin only. These results are then used to report against relevant SDG targets.

↘ Figure 2

The Sekong River basin in Cambodia

Credit : Nola Lee Kelsey, Conservation International

3. The Freshwater Health Index and the SDGs

Individual FHI components provide information that is relevant to, or directly corresponds to, indicators for measuring progress towards SDG6 (Table 1). The following section describes a suite of relevant indicators applied to the Cambodian section of the 3S River basin. Unless otherwise stated, the methods used are described in detail in FHI (2017) and Regan et al. (n.d.). Scores are presented or, if needed, recalculated for Cambodia only as per Regan et al's (n.d.) Lower Sesan II scenario, which represents the situation as of October 2017.

↘ Table 1

The relationship between relevant SDG Goal 6 Targets and Indicators and FHI indicators/sub-indicators; the FHI score for the Cambodian 3S basin and whether the SDG targets are being achieved.

SDG Target/Indicator	FHI Indicator/ sub-indicator	Relationship	FHI score	Level of achievement
6.1 Safe and affordable drinking water	Distribution of benefits from ecosystem services (GS)	Complementary indicator	41	Not achieved
6.2 Access to sanitation	Financial capacity (subset) (GS)	Complementary indicator	-	
6.3 Improve water quality	Deviation of Water Quality Parameters from Benchmarks (ES)	Alternative indicator	78	Achieved
6.3.2 : Proportion of water bodies with good ambient water quality				
6.4 Increase water-use efficiency	Water Supply Reliability Relative to Demand (ES)	Direct indicator	87	Achieved
6.4.2 : Level of water stress: freshwater withdrawal as a proportion of available freshwater resources				
6.5 Implement IWRM	Water Resource Management (GS)	Alternative indicator	59	Not achieved
6.6 Protect and restore water related ecosystems	Ecosystem vitality (EV)	Direct indicator	61	Not achieved
	Conservation/ Cultural Heritage Sites (ES)	Direct indicator	95	
	Financial capacity (subset) (GS)	Complementary indicator	-	
6.6.1 : Change in the extent of water related ecosystems	Water Resource Management (GS)	Alternative indicator	59	Not achieved
6.B Support and strengthen local community participation	Information Access and Knowledge (GS)	Complementary indicator	43	Not achieved
6.B.1 : local community participation in water and sanitation management	Engagement in Decision-making Processes (GS)	Alternative indicator	54	Not achieved

*Note : EV : EcosystemVitality / ES : Ecosystem Services / GS : Governance & Stakeholders)

Targets 6.1 and 6.2 – Safe and Affordable Drinking Water and Access to Sanitation

The FHI Governance & Stakeholders indicators provide contextual information for SDG Target 6.1: by 2030, achieve universal and equitable access to safe and affordable drinking water for all; and Target 6.2: by 2030, achieve access to adequate and equitable sanitation and hygiene for all, and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations. The Governance & Stakeholders indicators were assessed via a targeted survey based on interviewee perceptions. The results of the eight Cambodian experts who completed the survey were used to calculate a score between 0-100 for the sub indicator– Distribution of Benefits from Ecosystem Services – as this addresses access to safely-managed drinking water and sanitation services. While standard methods for calculating SDG indicators for Targets 6.1 and 6.2 already exist (UN-Water, 2016a), assessing the distribution of benefits from ecosystem services provides additional context which can help future actions aimed at meeting these two Targets.

In assessing distribution of benefits from ecosystem services, survey respondents were provided with the statement:

Equity is an important issue in water resource management, most closely associated with access to safe water and sanitation. Here we extend the concept to include all benefits from ecosystem services in the basin (water and sanitation, fisheries, flood mitigation, water quality maintenance, disease regulation, and cultural services).

Respondents were then asked to rate the following four statements on a scale of 1-5 (see Regan et al., n.d. Supplement for full category details).

1. Economically vulnerable populations benefit from ecosystem services (e.g., poor households' access to improved water supply sources at a reasonable cost, protection from inland flood risks, or rural compared to urban populations' benefits).
2. Indigenous people benefit from ecosystem services (e.g., exercising customary rights related to water, including for consumptive as well as cultural uses, or maintaining traditional fisheries).
3. Women and girls benefit from ecosystem services (e.g., amount of time collecting water for households, or provision of toilets for females).
4. Resource-dependent communities' benefit from ecosystem services (e.g., fishermen and small holder farmers' incomes compared to other economic sectors).

The average score for each of the four statements was 2.6, which meant that the share of benefits was only rarely, to sometimes (~50%), adequate. This gave a Distribution of Benefits from Ecosystem Services sub-indicator score of 41 out of 100.

Further information is also provided by the Governance & Stakeholders-Financial Capacity sub-indicator, which has three questions related to the provision of safe drinking water and sanitation. In assessing Financial Capacity, respondents were provided with the statement:

Water resource development and management is often under-financed, particularly for services that do not generate revenue, such as ecosystem

protection. Although financial capacity can be measured directly as a function of existing allocations relative to estimated budget needs, qualitative information is also useful in providing insights and identifying priorities.

Respondents were then asked to rate five statements on a scale of 1-5, of which the following three can provide complimentary information.

1. Level of investment in water supply development (e.g., financial resources for building and maintaining reservoirs or irrigation systems). Giving an average score of 2.3.
2. Level of investment in service delivery systems (e.g., financial resources for building and maintaining water distribution networks, i.e., piped supply, or household wells). Giving an average score of 2.4.
3. Level of investment in wastewater handling and treatment (e.g., financial resources for building and maintaining community toilets or treatment systems to process waste water). Giving an average score of 2.1.

These scores revealed that the financial capacity in the Cambodian 3S basin required to undertake water resources development was unsatisfactory.

These results suggest that meeting SDG Targets 6.1 and 6.2 in the Cambodian portion of the 3S River basin will be challenging. They also suggest that little progress has been made since 2011 when the Millennium Development Goal scores were calculated for both Ratanakiri and Mondulkiri provinces, which make up the majority of the 3S catchment in Cambodia (Table 2; Ministry of Planning, 2012).

↘ Table 2

Selected Cambodian Millenium Development Goal scores from Ratanakiri and Mondulkiri provinces in 2011

Cambodian Millennium Development Goal	Ratanakiri	Mondulkiri
7.3 : Percentage of families with technically designed and installed latrines	14	18
7.4 : Percentage of families using clean water	33	61
7.5 : Percentage of families using clean drinking water	27	44

Source : Ministry of Planning, 2012 *Note : Scores are out of 100

Target 6.3 – Improve Water Quality

The FHI assesses water quality against both ecological and human health standards as components of both the Ecosystem Vitality and Ecosystem Services assessments. This provides decision-makers with a standard way to assess compliance with good quality standards and will help in setting interim targets and monitoring progress toward meeting SDG Target 6.3: by 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

The FHI Ecosystem Services sub-indicator, Deviation of Water Quality Parameters from Benchmarks (DvWQ), addresses SDG Indicator 6.3.2: proportion of bodies of water with good ambient water quality. The

DvWQ sub-indicator was determined by calculating and aggregating spatial (F_1) and temporal/magnitude (F_3) aspects of water quality within the basin to produce a number between 0 (lowest water quality) and 100 (highest water quality). The DvWQ value for each parameter was combined into a DvWQ sub-indicator score by taking the geometric mean.

Twenty surface water quality parameters were used to calculate the DvWQ sub-indicator (Table 3). The parameters were collected from four Mekong River Commission monitoring stations located in the Cambodian section of the 3S basin: one on the Sekong River, two on the Sesan River and one on the Srepok River. Six-hundred and fifty-eight samples were collected during 2004-2014, monthly in most years and bimonthly in others. Protection of human health thresholds for the lower Mekong Basin were used to assess pH (6-9), Dissolved Oxygen (DO, 4 mg/L), Chemical Oxygen Demand (COD, 5 mg/L), Total Nitrite and Nitrate (NO_2 + NO_3, 5 mg/L) and Ammonia (NH_3, 0.5 mg/L), whilst the agricultural threshold was used to assess Electrical Conductivity (EC, 700 mS/m) (Ly & Larsen, 2016). The lowland rivers threshold was used for Total Nitrogen (<1.6 mg\L) (Hart, Maher, & Lawrence, 1999). Water quality data for the last five years of sampling (2010-2014) were compared against these benchmarks. For the other parameters, the protocol used to establish monthly minimum and maximum thresholds as described in Regan et al. (n.d.) was followed.

UN-Water (2016a) recommends that Indicator 6.3.2 be assessed using five parameters: Total Phosphorus, Total Nitrogen, Electrical Conductivity, Dissolved Oxygen and faecal coliform/Escherichia coli bacteria. A similar metric was calculated using the first four of these parameters (Table 3), whilst faecal coliform/Escherichia coli bacteria was excluded due to a lack of data.

↘ Table 3

Deviation of water quality metrics from benchmarks spatial (F_1), temporal/magnitude (F_3) and final sub-indicator (DvWQ) scores for 21 water quality parameters for the period of 2010-2014, collected from the Cambodian section of the 3S River basin. Parameters in italics are those recommended by UN-Water (2016a).

	F_1	F_3	DvWQ score
Total Suspended Solids (TSS)	100	10.3	67.9
Total Phosphorus (TP)	100	8.1	71.5
Total Nitrogen (TN)	50	0.6	94.4
pH	75	0.1	96.8
Electrical Conductivity (EC)	0.0	0.0	100
Dissolved Oxygen (DO)	25	0.001	99.9
Chemical Oxygen Demand (COD)	50	0.5	95.1
Total Nitrite and Nitrate (NO_2 + NO_3)	0	0.0	100
Ammonia (NH_3)	0	0.0	100
Ammonium (NH_4)	100	26.8	48.2
Calcium (Ca)	100	1.8	86.6
Magnesium (Mg)	100	4.3	79.2
Sodium (Na)	100	2.4	84.5

Potassium (K)	100	22.3	52.7
Alkalinity	100	2.3	85.0
Chloride (Cl)	100	5.8	75.8
Sulphate (SO_4)	100	4.2	79.5
Ca/Mg	100	3.6	70.5
Na/Cl	100	6.3	74.8
Na/K	100	22.8	52.2
Ca/SO_4	100	14.6	61.7

The aggregated DvWQ sub-indicator score of 78 reveals good water quality at the four Cambodian monitoring sites. Using only the four indicators recommended by UN-Water (2016a) gives a score of 91, which is also good. However, an examination of the indicators spatial component (F_1), questions the utility of global Indicator 6.3.2: proportion of bodies of water with good ambient water quality. Fourteen of the 20 metrics failed to meet the desired standard at least once per site (an F_1 value of 100; Table 3). Thus, at some time each site had poor water quality, potentially giving an 6.3.2 indicator score of zero for both the full suite of parameters and the four UN-Water (2016a) metrics (as the Total phosphorous F_1 value was 100). However, the magnitude (F_3) results show that, although many of the parameters failed across multiple sites, this was infrequent and minor in magnitude. This supports the DvWQ assessment of good water quality at the monitored sites.

The provisional Cambodian SDG indicators do not include indicator 6.3.2. There are, however, 22 water quality monitoring stations maintained by the Mekong River Commission in Cambodia, and while they do not cover the entire country, they could be used to calculate an indicator for SDG Target 6.3.

Target 6.4 – Increase Water-use Efficiency

The FHI Ecosystem Services sub-indicator- Water Supply Reliability Relative to Demand allows decision-makers to see, at a sub-basin scale, where demand is exceeding sustainable supply and where action is needed to strengthen environmental flow requirements or improve water-use efficiency. By providing a measure of Indicator 6.4.2: Level of water stress: freshwater withdrawal as a proportion of available freshwater resources, this sub-indicator directly addresses SDG Target 6.4: by 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.

Due to a lack of sectoral specific water use data, Water Supply Reliability Relative to Demand was calculated using the global 0.5° resolution self-calibrated Palmer Drought Severity Index (Osborn, Barichivich, Harris, van der Schrier, & Jones, 2016; van der Schrier,

Barichivich, Briffa, & Jones, 2013). Monthly mean values of the Index for the period 2011-2015 were compared with the full range (1901-2015) to derive the shift in spatial scope and frequency of water availability (see Regan et al. (n.d.) for full details of the methodology). Applied only to the Cambodian portion of the 3S basin, the sub-indicator gave a score of 87. This suggests that Indicator 6.4.2 is being met in the Cambodian 3S basin.

While the Water Supply Reliability Relative to Demand sub-indicator revealed a low level of water stress, it is only a coarse measure. It does not assess local scale water scarcity, which may occur due to processes such as changes in river flow or local groundwater depletion.

The provisional Cambodian SDG indicators do not include Indicator 6.4.2. The method used above and described in Regan et al. (n.d.) could be used on a national level in the absence of more comprehensive data.

Target 6.5 – Implement IWRM

The FHI Governance & Stakeholders survey assesses Integrated Water Resources Management (IWRM) through its Water Resource Management sub-indicator. The FHI helps decision-makers identify specific aspects of IWRM that need attention and, critically, where there is disagreement among decision-makers on their collective priorities or progress. The survey results can be used to measure progress toward SDG Target 6.5: by 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate. While there are standard methods for assessing Indicator 6.5.1: degree of integrated water resources management implementation (0-100) and Indicator 6.5.2: proportion of transboundary basin area with an operational arrangement for water cooperation (UN-Water, 2016a), the Water Resource Management sub-indicator provides a complementary source of data. Because it can be administered to a large sample population of decision makers, it can provide more detailed and nuanced information than the standard method.

In assessing the framework for basin management sub-indicator, survey respondents were provided with the statement:

Integrated water resources management is a guiding framework for coordinating both development and management of all resources within a basin, to maximize welfare without compromising ecological sustainability. In some cases, a single agency, such as a river basin authority, is responsible for coordinating and overseeing these functions; the questions below focus on the specific functions regardless of whether they are all carried out by the same agency.

Respondents were then asked to rate the following four statements on a scale of 1-5.

1. Policies and actions to advance water resource development and management are coordinated (e.g., if there is river basin organization or commission, how effective is it in coordinating the different agencies, levels of government – national, provincial, local – and private interests when establishing integrated development plans for the basin?). Giving an average score of 3.8.
2. Infrastructure such as dams, reservoirs, and treatment plants are centrally managed or coordinated (e.g., dam operators communicating

the timing and volume of reservoir releases, or assessing cumulative impacts of dams). Giving an average score of 3.4.

3. Financial resources are mobilized to support water resource development and management needs (e.g., cost-sharing for common projects, or collecting user fees/taxes). Giving an average score of 3.4.
4. Ecosystems conservation priorities are developed and actions implemented (e.g., protecting forested watersheds, maintaining wetland/river connectivity, or developing an aquatic species biodiversity action plan). Giving an average score of 3.

The range of scores for each individual statement showed that the functions listed were sometimes (~50%) and often satisfactory. The overall Water Resource Management sub-indicator score was 59.

This suggests that the degree to which water resources management has been implemented (Indicator 6.5.1) in the Cambodian portion of the 3S basin has been only moderately satisfactory. For Indicator 6.5.2, although not measuring a proportion of the transboundary 3S basin area, results suggest that an operational arrangement for water cooperation remains under development.

The provisional Cambodian SDG indicators do not include any indicators for SDG Target 6.5. The method demonstrated above could be implemented across the country to provide this data and be included as an alternative indicator.

Target 6.6 – Protect and Restore Water Related Ecosystems

Several FHI indicators and sub-indicators can be used to assess SDG Target 6.6: by 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes. The full suite of FHI Ecosystem Vitality metrics – Water Quantity, Water Quality, Drainage Basin Condition and Biodiversity – directly assess the Target and help set priorities for improving water-related ecosystems and setting priorities for their protection or restoration. The Ecosystem Services - Conservation/Cultural Heritage Sites sub-indicator can assess the proportion of the river network under formal protection. Questions in the Financial Capacity sub-indicator provide insight on the ability of governments to protect and restore natural systems.

Ecosystem Vitality

The Ecosystem Vitality score for the Cambodian section of the 3S basin was 61. The indicator and sub-indicator evaluations that made up this score are detailed below.

Water Quantity

The FHI Water Quantity indicator comprises two sub-indicators: Deviation from Natural Flow Regime (DvNF) and Groundwater Storage Depletion. Due to a lack of data, Groundwater Storage Depletion could not be calculated. Regan et al. (n.d.) calculated DvNF at several locations in the 3S River basin. For the Cambodian section of the 3S basin, the score at the outlet to the Mekong River, 68, was used as the water quality indicator.

Water Quality

Four surface water quality parameters: Total Suspended Solids, Total Phosphorous, Total Nitrogen and pH were used to calculate the Water Quality parameter from the same samples used for the DvWQ sub-indicator. Where appropriate, threshold values for the protection of aquatic ecosystems were used or calculated using historic data and were combined into a water quality index (see Regan et al. (n.d.) for full details). Recalculation of the Water Quality index for the four sites in Cambodia gave a score of 78.

Drainage Basin Condition

Drainage Basin Condition comprises three sub-indicators: Bank Modification, Flow Connectivity and Land Cover Naturalness. Drainage Basin Condition scored 69 based on the following sub-indicators.

Bank Modification measures the extent of unmodified river channel. The river channel can be modified by various means including inundation by reservoirs, or engineering works such as channelization and bank stabilization. As these engineering works are minor in the 3S system the extent of reservoir inundation in the Cambodian section of the 3S was determined by calculating the proportion of the river network inundated by the lower Sesan II and O Chum II dams. As this amounted to only 2.7% of the stream network, this gave a sub-indicator score of 97, which shows little change from the natural state.

Flow Connectivity was measured using the Dendritic Connectivity Index (DCI: Cote et al. 2009) which assesses river channel fragmentation caused by dams and other in stream structures. As the movements of aquatic animals are not restricted by international boundaries and the construction of dams in the 3S system is a transboundary issue, it is not appropriate to calculate the DCI for only the Cambodian portion of the catchment. Thus, the value presented in Regan et al. (n.d.) for the lower Sesan II dam scenario, 38, was used as this represents the current situation. The low value reflects the severe disruption in connectivity caused by the construction of the lower Sesan II dam.

Land Cover Naturalness (LCN) is most closely aligned with the currently recommended indicator for Target 6.6, indicator 6.6.1: change in the extent of water-related ecosystems over time. However, LCN captures not only extent, but some measure of quality, by assuming that “naturalness” exists on a gradient from completely natural to completely artificial (Angermeier, 2000). Human conversion of lands and waterways are associated with increases in pollutant loads (non-point source from agriculture, point-source from urban and industrial), changes to infiltration and runoff regimes, and losses of regulating services (flood mitigation, erosion prevention, water purification). LCN provides a proxy indicator of the degree to which these naturally-occurring functions are preserved within the basin. Regan et al. (n.d.) used 2010 dry season land cover data from the Mekong River Commission as the classification categories and temporal coverage were consistent across the 3S basin. This resulted in an LCN assessment of the entire 3S basin, and this dataset was used to calculate LCN for the Cambodian portion of the basin, for a score of 88. These data can also be used to calculate SDG Indicator 15.1.1: Forest area as a percentage of total land area.

Biodiversity

The FHI Biodiversity indicator comprises two sub-indicators: Species of Concern, and Invasive and Nuisance Species. As per the method outlined in Regan et al. (n.d.), the Species of Concern sub-indictor for the Cambodian portion of the 3S was calculated using IUCN Red List spatial data (http://www.iucnredlist.org/technical-documents/spatial-data) for amphibians, terrestrial mammals, reptiles and the freshwater polygon groups for fish, molluscs, plants, Odonata, shrimps, crayfish and crabs, and water bird data from Birdlife International (http://datazone.birdlife.org/home). The number of Invasive and Nuisance Species was determined through a literature review and interviews with regional experts.

Four-hundred and ninety-two aquatic species present in the Cambodian section of the 3S basin were assessed for the Species of Concern indicator. Of these, nine were critically endangered, 14 endangered and 34 vulnerable. Of the nine critically endangered species, six were fish. This gave a Species of Concern score of 32. As the nine invasive species present in the whole 3S basin are also believed to be present in the Cambodian section, the Invasive and Nuisance Species score was calculated as 46. This gave an overall biodiversity sub-indicator score of 39, which is reflective of the high proportion of threatened species and large number of invasive species.

Conservation/Cultural Heritage Sites

The FHI Ecosystem Services - Cultural/aesthetic indicator includes a Conservation/Cultural Heritage Sites sub-indicator. This sub-indicator was calculated as a weighted proportion of stream length, within, or on the boundary of, protected areas (see Regan et al. (n.d.) for full methods). The proportion score for the Cambodian section was 75, as following the creation of an extensive biodiversity corridor network, much of the Cambodian section of the 3S basin is contained within protected areas. This gave a sub-indicator score of 95. This indicator can also be used to report against SGD Indicator 15.1.3: percentage of important sites for terrestrial and freshwater biodiversity that are covered by protected areas and fisheries conservation areas, by ecosystem type.

Governance & Stakeholders Financial Capacity

The Governance & Stakeholders - Financial Capacity sub-indicator had two further questions which can provide complimentary information regarding SDG Target 6.6.

1. Level of investment in ecosystem conservation and rehabilitation (e.g., financial resources for protecting wetlands to mitigate flood risk, remediating impaired streams, or rehabilitating fish stocks). Gave an average score of 2.5.
2. Level of investment in monitoring and enforcement (e.g., financial resources for evaluating Environmental Impact Assessments, collecting environmental data, inspecting facilities, and enforcing regulations). Gave an average score of 2.4.

Both revealed an unsatisfactory level of financial investment in conservation, rehabilitation, monitoring and enforcement.

Assessing Target 6.6

The Ecosystem Vitality score of 61 suggests that the water-related ecosystems in the Cambodian section of the 3S basin are functioning but showing signs of stress. On this basis the SDG Goal 6.6 is not being met in the Cambodian 3S basin. The results also point to the need for restoration. This is despite a large proportion of the 3S's rivers being either entirely in, or on the border of, protected areas. Options for restoration include providing environmental flows and the construction of viable fish passage over the lower Sesan II dam (Shaad, Souter, Farrell, Vollmer, & Regan, 2018). It also shows that further infrastructure development or land clearance within the 3S basin will reduce the score and may compromise ecosystem function. Financing restoration may prove difficult due to the low levels of investment in ecosystem conservation and rehabilitation, as well as monitoring and enforcement. These results also suggest that resourcing Target 15.1: by 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and dry lands, in line with obligations under international agreements, may prove to be challenging.

SDG Target 6.6 has one global indicator - Indicator 6.6.1: change in the extent of water-related ecosystems over time. UN-Water (2016a) divides this into three components for assessment, for which there are corresponding FHI indicator/sub-indicators (Table 4). The three UN-Water components correspond to LCN, DvNF and Ecosystem Vitality. However, these three scores cannot simply be combined into a single metric as LCN and DvNF are included in the calculation of the Ecosystem Vitality score. However, if LCN and DvNF are removed from the Ecosystem Vitality (Reduced Ecosystem Vitality) score and recombined as equal components (using the geometric mean) this gives an FHI derived SDG 6.6.1 indicator score of 70. This, in contrast to the full Ecosystem Vitality indicator score, suggests that Target. 6.6 is being met in the Cambodian section of the 3S basin.

↘ Table 4

Assessment of SDG Indicator 6.6.1 using FHI indicators and sub-indicators in the Cambodian portion of the 3S basin. The Ecosystem Vitality score has been calculated without the Land Cover Naturalness or Deviation from Natural Flow Regime indicator.

Indicator assessment (UN-Water, 2016a)	FHI indicator/ sub indicator	Cambodian 3S basin score, out of 100.
Spatial extent of water-related ecosystems (wetlands, forests and drylands)	Land Cover Naturalness sub-indicator	88
Quantity of water in ecosystems (rivers, lakes and groundwater)	Deviation from Natural Flow Regime sub-indicator	68
Resulting ecosystem health	Reduced Ecosystem Vitality	57

The provisional Cambodian SDG indicators do not include any for SDG Target 6.6. The full suite, or at least a sub-set, of the FHI Ecosystem Vitality measures could be calculated for the whole of Cambodia using pre-existing data to measure progress toward Target 6.6. This should be achievable as at least some of the data that needs to be collected for indicators listed under SDG Target 15 can also be used to assess SDG Target 6.6.

Target 6.B – Support and Strengthen Local Community Participation

The FHI Governance & Stakeholders survey has two sub-indicators that can report against SDG Target 6.B: support and strengthen the participation of local communities in improving water and sanitation management. The first is Information Access and Knowledge, as sound water governance requires information on a range of topics from many sources. Even in cases where data and information are abundant, if they are not made accessible (across agencies, to citizens, etc.), they are unlikely aid wise decision-making. The second is Engagement in Decision-making Processes. Stakeholder engagement is the process by which any person or group with an interest in a water-related topic can be involved in decision-making and implementation. It is associated with improved information transfer, better targeted and more equitable plans and policies, improved transparency and accountability, and reduced conflict.

In assessing Information Access and Knowledge, respondents were asked to rate the following statements:

1. Information is accessible to interested stakeholders (e.g., reports are made freely available through a website, or data is available upon request to the agency with the information). Giving an average score of 2.5.
2. Information meets expected quality standards, in terms of frequency, level of detail, and subjects of interest to stakeholders (e.g., time series data on stream flow, water levels, or water quality for specific locations within the basin). Giving an average score of 2.6.
3. Information is transparently sourced (e.g., methods used to collect data are documented, or authors (source) of these data are clearly identified). Giving an average score of 2.9.
4. All available, sound and relevant information is routinely applied in decision-making (e.g., modifying an infrastructure project based on EIA results, or adjusting fisheries management guidelines based on fish catch data). Giving an average score of 2.9.

The range of scores for each individual statement meant that Information Access and Knowledge was only rarely or sometimes (~50%) satisfactory. This gave an overall Information Access and Knowledge score of 43.

In assessing Engagement in Decision-making Processes, respondents were asked to rate the following:

1. All relevant stakeholders have been identified and notified when considering major decisions (e.g., mapping and notifying stakeholders affected by a proposed water supply infrastructure project, such as construction of a water supply dam). Giving an average score of 3.3.
2. Stakeholders are able to provide comments prior to major decisions being taken (e.g., consultation meetings or an information gathering period where stakeholders may provide input regarding a policy or project). Giving an average score of 3.3.
3. Decisions are responsive to stakeholders' participation (e.g., processes for reaching joint agreements among a group of

stakeholders prior to approval of a major policy or project, or projects being revised subsequent to stakeholder feedback). Giving an average score of 3.

The range of scores for each individual statement meant that decision-making processes occurred sometimes (~50%) or often. The overall score for Engagement in Decision-making Processes was 54.

These results suggest that while there has been a degree of local participation in decision-making, the level of participation needs to be improved, as does the flow of information to communities.

SDG target 6.B has a single global indicator 6.B.1: proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management. However, neither this nor a national Cambodian indicator has been adopted. Whilst the FHI does not measure the proportion of administrative units, it provides a measure of the current level of community engagement in water resource management. In the Cambodian portion of the 3S basin these results show that community engagement needs to be improved before Target 6.B can be met.

4. Conclusion and Future Directions

The FHI contains a range of indicators that, at either the international or national level, can measure and report on progress toward a range of SDG 6 targets (Table 1). Results from calculating these FHI indicators suggest that, if the SDG 6 targets are to be met in the rapidly developing 3S basin:

- Additional resources are required to ensure safe and affordable drinking water and access to sanitation (Targets 6.1 and 6.2).
- All future development needs to ensure that water quality remains good (Target 6.3), and that water is used efficiently (Target 6.4).
- The current good progress toward implementing basin wide (including transboundary) water management continues (Target 6.5).
- Future development does not further degrade water-related ecosystems and that restoration and protection of important components (e.g., fish passage and threatened species conservation) is undertaken (Target 6.6).
- These goals can only be achieved with a greater level of local community participation (Target 6.B).

Given the systemic risk associated with water systems, meeting all SDG 6 goals is essential to reduce the likelihood of system collapse. Of the indicators listed above, the Ecosystem Vitality score of 61 is especially concerning, given the rapid development of the 3S basin. Meeting Target 6.6 is crucial to meeting SDG 6 (Regan et al., n.d.) and avoiding system collapse. As most Cambodians living in the 3S basin are dependent on natural resources, including fisheries, for their daily survival, any failure of the natural systems they rely on could have catastrophic consequences.

In many cases, the indicators proposed above can be readily calculated for the rest of Cambodia using pre-existing data. As shown above, this can be achieved using well-developed methods and at minimal cost. Thus, the FHI presents a range of indicators that can be adopted by the Royal Government of Cambodia to supplement their provisional SDG indicator list and allow them to report on their SDG commitments.

References

Adamson, P. T., Rutherfurd, I. D., Peel, M. C., & Conlan, I. A. (2009). The Hydrology of the Mekong River. In I. C. Campbell (Ed.), TheMekong: biophysical environment of an international river basin (1st ed., pp. 53–76). Amsterdam, Netherlands: Elsevier. https://doi.org/10.1016/B978-0-12-374026-7.00004-8

Angermeier, P. L. (2000). The natural imperative for biological conservation. Conservation Biology, 14(2), 373–381. https://doi.org/10.1046/j.1523-1739.2000.98362.x

Arias, M. E., Cochrane, T. A., Kummu, M., Lauri, H., Holtgrieve, G. W., Koponen, J., & Piman, T. (2014). Impacts of hydropower and climate change on drivers of ecological productivity of Southeast Asia's most important wetland. Ecological Modelling, 272, 252–263. https://doi.org/10.1016/j.ecolmodel.2013.10.015

Asian Development Bank. (2016). Asian Water Development Outlook 2016: Strengthening Water Security in Asia and the Pacific. Manila, Philippines: Asian Development Bank.

Cote, D., Kehler, D. G., Bourne, C., & Wiersma, Y. F. (2009). A new measure of longitudinal connectivity for stream networks. Landscape Ecology, 24, 101–113. https://doi.org/10.1007/s10980-008-9283-y

FHI. (2017). Freshwater Health Index User Manual. Version 1.1. Retrieved from http://www.freshwaterhealthindex.org/resources

Hart, B. T., Maher, B., & Lawrence, I. (1999). New generation water quality guidelines for ecosystem protection. Freshwater Biology, 41(2), 347–359. https://doi.org/10.1046/j.1365-2427.1999.00435.x

Kaufman, G. G., & Scott, K. E. (2003). What is systemic risk, and do bank regulators retard or contribute to it? The Independent Review, 3(3), 371. https://doi.org/10.2307/24562449

Koehnken, L. (2012). IKMP Discharge and Sediment Monitoring Programme Review, Recommendations and Data Analysis, Parts 1 & 2. Vientiane, Lao PDR. Mekong River Commission

Ly, K., & Larsen, H. (2016). 2014 Lower Mekong regional water quality monitoring report. Vientiane, Lao PDR. Mekong River Commission

Ministry of Planning. (2012). Scorecard of the implementation of Cambodia Millennium Development Goals (CMDG) at sub-national levels by Capital , Provinces, Municipalities, Districts, Khans in Year 2012. Phnom Penh, Cambodia. Retrieved from http://www.kh.undp.org/content/cambodia/en/home/library/mdg/cambodia-mdgs-2012.html

Regan, H. M., Souter, N. J., MacDonald, G. M., Dudgeon, D., McCartney, M. P., Andelman, S. J., … Dalton, J. (n.d.). Sustaining fresh water for people and nature: a new framework to guide policy.

Shaad, K., Souter, N. J., Farrell, T., Vollmer, D., & Regan, H. M. (2018). Evaluating the sensitivity of dendritic connectivity to fish pass efficiency for the Sesan, Srepok and Sekong tributaries of the Lower Mekong. Ecological Indicators, 91, 570–574. https://doi.org/10.1016/j.ecolind.2018.04.034

UN-Water. (2016a). Integrated Monitoring Guide for SDG 6: Targets and global indicators. Retrieved from http://www.unwater.org/app/uploads/2017/03/SDG-6-targets-and-global-indicators_2016-07-19.pdf

UN-Water. (2016b). Water and sanitation interlinkages across the 2030 Agenda for Sustainable Development. Geneva, Switzerland. Retrieved from www.unwater.org/app/uploads/2016/08/Water-and-Sanitation-Interlinkages.pdf

United Nations Development Programme. (2016). Rapid Integrated Assessment – Cambodia SDG Profile. Retrieved from http://kh.one.un.org/content/dam/unct/cambodia/docs/RIA_Cambodia_Analysis_07Oct2016.pdf

Vollmer, D., Shaad, K., Souter, N. J., Farrell, T., Dudgeon, D., Sullivan, C. A., … Regan, H. M. (2018). Integrating the social, hydrological and ecological dimensions of freshwater health: The Freshwater Health Index. Science of The Total Environment, 627, 304–313. https://doi.org/10.1016/j.scitotenv.2018.01.040

World Bank. (2016). World Development Indicators 2016. Washington D.C., USA: The World Bank. Retrieved from https://doi.org/10.1596/978-1-4648-0683-4

World Economic Forum. (2014). Global Risks 2014, Ninth Edition. Geneva, Switzerland: World Economic Forum.

World Economic Forum. (2015). Global Risks 2015, 10th Edition (10th ed.). Geneva, Switzerland World Economic Forum.

Ziv, G., Baran, E., Nam, S., Rodriguez-Iturbe, I., & Levin, S. A. (2012). Trading-off fish biodiversity, food security, and hydropower in the Mekong River Basin. Proceedings of the National Academy of Sciences, 109(15), 5609–5614. https://doi.org/10.1073/pnas.1201423109

5

Environmental Degradation of the Tonle Sap Lake and Capacity Building to Recover its Sustainability

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1. Introduction

Tonle Sap Lake (TSL) is the largest freshwater lake in Southeast Asia, and it is the seventh largest lake in the world in terms of size in the wet season (ILEC, 2005). The lake is known for its rich biodiversity and extraordinary hydrological phenomenon characterized by a huge seasonal variation in term of both water level and inundation area. The lake size varies from approximately 160 km long and 35 km wide (250,000-300,000 ha) during the dry season (Somony and Schmidt, 2004) to 250 km long and 100 km wide (1.0-1.3 million ha) during the peak wet season(Campbell et al., 2009, 2006). The Tonle Sap River (TSR) connects the lake to the Mekong River. TSL absorbs a huge volume of water from the Mekong River during rainy season through the TSR. This dynamics of the lake is also referred as the "flood pulse", which causes the lake to swell 5-6 times larger, with water depth increasing from 1.5 m in the dry season to 9-10 m in the wet season (Kummu et al., 2006). The "flood pulse" transforms both the physical and the human landscape of the Lower Mekong and TSL. This helps to reduce excessive flooding in the Mekong River floodplains downstream while maintaining beneficial inundation. In dry season, the TSR flows into normal direction that helps to maintain vital flow in the Mekong River and prevent salt intrusion into the Mekong Delta. As the water level of TSL recedes, it exposes the areas naturally fertilized by sedimentation, including nutrients, fostering vegetation growth and agriculture and serving as home to a number of terrestrial species.

As one of the most productive freshwater fisheries in the world, the lake annually yields 230,000 tons of fish; it has been estimated that approximately a half of the country's population benefits, either directly or indirectly, from this lake's productivity (Van, Zalinge, et al., 2000). Consequently, the ecosystem services of the lake is vital for the food security, to support the nation's livelihood, and help sustain socio-cultural, economic, and environmental condition of the country.

Unfortunately, over the last few decades, a number of human-induced drivers and climate change impacts have led to the significant disruption of TSL's environmental and the flow of ecosystem services. The cascade of hydropower dams developed along the Mekong River is one of the distinct interventions to the TSL's unique flood pulse system. The socio-economic context of TSL is another main driver affecting the lake environmental

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condition. The unsustainable resource exploitation, the expansion of floating villages, and dumpingof wastes and pollutants into the lake have severely affected the lake environment. The deterioration of the environmental conditions of TSL is detrimental on the livelihoods of communities who are directly relying on fishing, farming and other resources of TSL.

This situation in Cambodia has placed a big challenge to the country to achieve the relevant targets set in Sustainable Development Goals (SDGs). Among the goals, the environmental management of TSL is closely related to improvement of water quality and sanitation (SDG Targets 6.2 and 6.3), conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services (SDG Target 6.6 and 15.1), and enhancement of capacity-building supports to developing countries (SDG Target 17.9). An insightful understanding of drivers and impacts on the lake's water quality and quantity is critical for the sustainable management of the lake and its basins.

Given this background, a five-year (2016-2021) Science and Technology Research Partnership for Sustainable Development Project (SATREPS) for "Establishment of Environmental Conservation Platform of Tonle Sap Lake" is being implemented with the financial support from Japan International Cooperation Agency (JICA) and Japan Science and Technology Agency (JST). Two main expected outcomes of the project are: (1) development of water environment analytical tool of Tonle Sap Lake, and (2) establish an environmental conservation platform through the elucidation of the lake and the tool development. In the long term, it aims to contribute in the establishment of an international standard research structure and facilities in Institute of Technology Cambodia (ITC) and assist relevant agencies in Cambodia, such as the Tonle Sap Authority, to introduce science-based management to the lake and its basins. The proposed Tonle Sap Water Environmental Platform (TSWEP) is expected to serve as an information hub to promote environmental management and governance of TSL and its basins. The platform will be the basis for enhanced scientific-based knowledge and information sharing system. Besides, the platform at its core, the project aims at capacity building for human resources as well as research and development targeting Cambodian researchers and governmental officials through direct engagement in the project implementation and various opportunities for training and studies. The project was designed to facilitate the cooperation among several leading universities and policy research institutions both in Cambodia and Japan for joint research and capacity building activities.

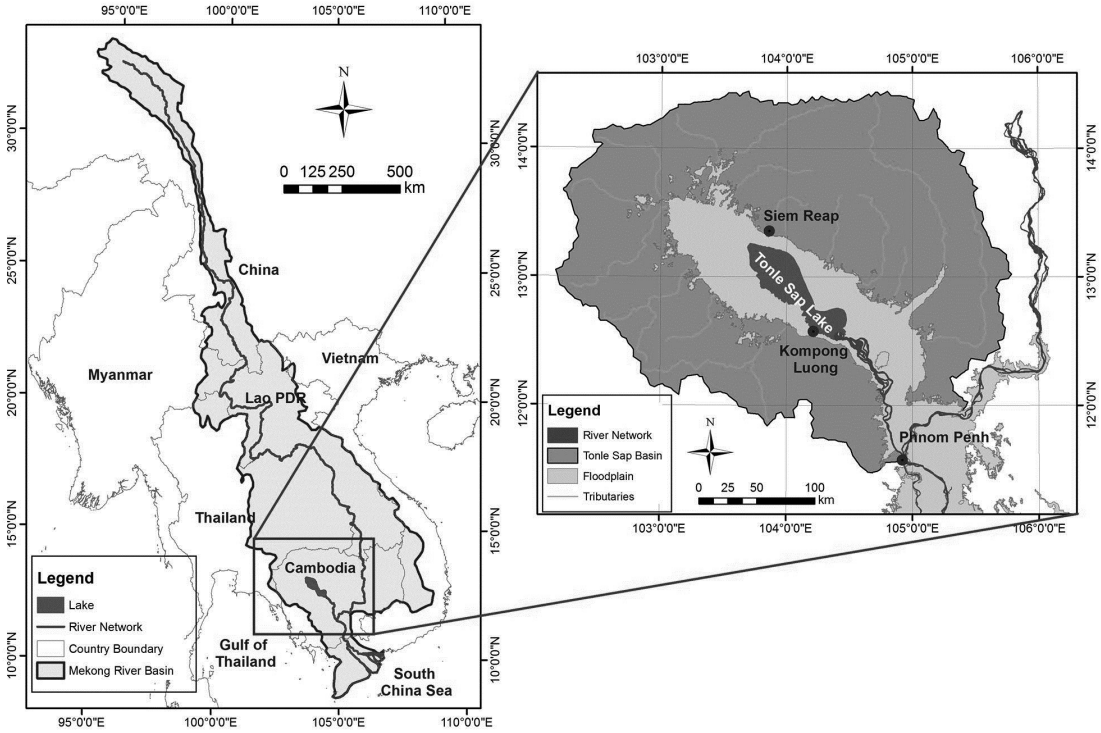
In this chapter, the authors provide a comprehensive understanding on: (i) the current status of TSL water environment, (ii) human-induced and global environmental change impacts on the livelihoods of local communities on and around TSL, and (iii) the expected contribution of the SATREPS project to address these challenges through capacity building on scientific research.

2. Overview of the Tonle Sap Lake (TSL)

Geography and Geology

TSL is a shallow lake lying in a north-west–south-east direction (Figure 1). The maximum depth of TSL seasonally fluctuates between an average of 0.5 m to 9 m and corresponding increase in the lake volume from approximately 1.3 km³ in the dry season to a maximum of about 80 km³ in the wet season, respectively (Kummu & Koponen, 2003). TSL basin is covered mainly by alluvial deposits overlaying older bedrock, composed of unconsolidated silt, sand and gravel. The clay minerals in the bottom sediments of TSL are derived from the surface soils of its own basin's alluvial deposits, as well as the rock bodies in the Mekong River basin (Tsukawaki, Okawara,Lao, & Tada, 1994). Based on the presence of marine creatures such as marine diatoms, sponges and fishes in bottom sediments of the lake, Tsukawaki et al. (1994) concluded that TSL was once connected with the sea during the last global sea-level high stand (Uk et al., 2018).

↘ Figure 1

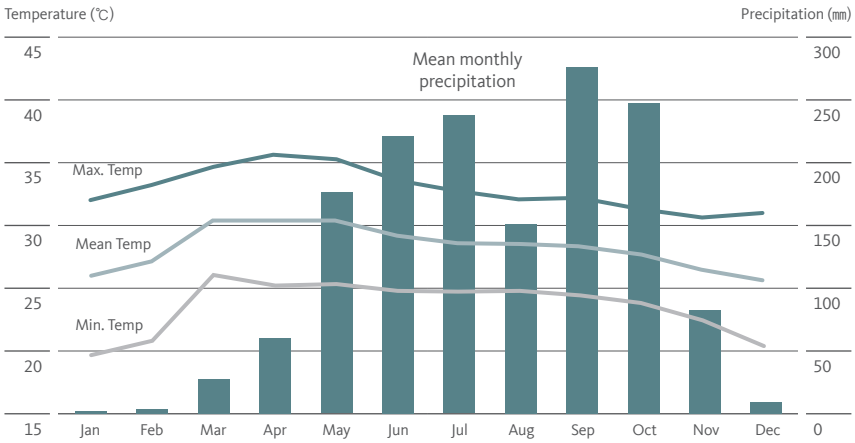


Location of Tonle Sap Lake in Cambodia (adopted from Uk et al. 2018)

Climate

The climate in this region is predominantly governed by two distinct seasons, namely the rainy season (May–October) and dry season (December–April). In the wet season, the south-west monsoon brings heavy rains and high humidity during mid-May to early October. In the dry season, the north-east monsoon lasts from early November to March that brings drier and cooler air (The World Bank Group 2011). The mean daily air temperature at Siem Reap varies between 20°C in January and 36°C in April (World Meteorological Organization 2016), while the water temperature of the lake varies between 28 and 33°C (Sarkkula et al., 2003). The mean monthly rainfall at Siem Reap exceeds 100 ㎜ in the rainy season (Figure 2; World Meteorological Organization 2016).

↘ Figure2



Mean and maximum monthly temperature (°C) and precipitation (mm) in Tonle Sap Lake region observed at Seam Reap (adopted from Uk et al. 2018)

Hydrology

The Tonle Sap River changes its flow direction twice a year. Substantial floodwater from the Mekong River flows into the lake when the water level in the Mekong River is higher than that in the lake, starting in early June. The lake then discharges water back into the Mekong River when the water level in the lake reaches its peak in October. TSL receives water from three major sources, including 53.5% from the Mekong mainstream, 34% from the lake's tributaries and 12.5% from precipitation, whereas it discharges around 88.5% of its total outflow to the Mekong, and 11.5% evaporates directly from the lake surface (Kummu et al., 2014; Uk et al., 2018). This estimate does not include the potential contribution of groundwater, which may account for approximately 13% of the input to TSL (Burnett et al., 2013; Uk et al., 2018).

Sediment

Approximately 72% of the sediment flux into TSL and its floodplain is derived from the Mekong River, while the rest comes from the lake's own tributaries (Kummu et al., 2008). The sediment input is 5.1 million tons (Mt) per year from the the Mekong River and 2.0 Mt/year from the lake basins' tributaries. About only a fraction (1.4 Mt/year) of sediments is released back to the Mekong River on average (Kummu et al., 2008). As a result of accumulation of sediments, the long-term sedimentation rates have been reported less than 1 ㎜/year (Kummu et al., 2008; Penny, Cook, & Sok, 2005; Tsukawaki, 1997). The sedimentation rate in the lake area during the dry season is very low, estimated to be approximately 0.1–0.16 ㎜/year (Tsukawaki, 1997). According to Siev et al. (2018), the resuspension rate accounted for 306.7 g/m²/day, almost 90% of the settling flux indicating that sedimentation and resuspension of sediment are almost in balance. Total suspended solids (TSS) in TSL ecosystem exhibited a clear difference between the open lake and the floodplain (Sarkkula et al., 2003). TSS values for the open lake typically vary from 5 to 20 mg/L during the high-water period to over 1,000 mg/L during the low-water period, while the variation in TSS in the floodplain is 1–10 mg/L and 100–200 mg/L during the high-and low-waterperiods, respectively (Sarkkula et al., 2003). The sediment of TSL and the floodplain was mainly composed of silt (4–63 μm), which is favorable for resuspension (Siev et al. 2018). The sediment appears to provide a

substantial amount of nutrients, which are vital for sustaining the floodplain productivity (Kummuet al., 2008; Uk et al., 2018).

Nutrient

Nutrient concentrations in TSL change seasonally, with both phosphorus and nitrogen concentrations peaking during the low-water level period (usually during late dry season, March–May; Figure 3) (Uk et al., 2018). Observation at Kampong Loung found the seasonal TP concentration in TSL ranged from 0.001 mg/L to 0.99 mg/L (mean of 0.095 mg/L), while the concentration of nitrate and nitrite nitrogen varies between 0.001 mg/L and 2.1 (mean of 0.21 mg/L) (Uk et al., 2018). The limiting nutrient for primary production is yet to be confirmed, light could be a significant factor for algae growth in TSL (Holtgrieve et al., 2013). Although the annual floodwater from the Mekong River and the tributaries to TSL are undoubtedly important nutrient sources for TSL, nutrient dynamics in the lake are dominated by internal loading during the low-water period (Campbell et al., 2009). Mixing processes in shallow lakes, where frequent resuspension of deposited sediments, play an important role in nutrient release from sediments (especially phosphorus; Søndergaard, Jensen, & Jeppesen, 2003; Søndergaard, Kristensen, & Jeppesen, 1992). However, the nutrient released from the sediment is more significant in low water period as the sediment resuspension process become more dominant (Khanal et al., 2018; Siev et al., 2018; Uk et al., 2017). Sediment resuspension in TSL is caused by wind and wave-induced currents in the dry season when the water level is as shallow as 1 m (Kummu et al., 2008). The currents by the incoming flood waters through the TSR in the rainy season also causes resuspension (Kummu et al., 2008).

Ecosystem Productivity and Biodiversity

Primary production in TSL ecosystem depends on phytoplankton and floodplain vegetation (Lamberts, 2001). TSS concentrations in the lake generally peak in April–June. Light is more likely to be a limiting factor for the pelagic primary production inTSL due to high turbidity. When the water is very turbid, phytoplankton growth is concentrated in the topmost few centimeters of the surface water, presumably caused by the positively buoyant Anabaena species (Sarkkula et al., 2003). Most of the phytoplankton biomass in TSL is produced during the high-water level period (Sarkkula et al., 2004). Aulacoseira diatoms and copepods dominate the pelagic trophic structure of TSL during the high water level periods. The flood pulse drives the expansion of the lake area and extensive inundation of the floodplain for several months. The flood pulse shapes a mosaic of natural and agricultural habitats and nutrient replenishment from the Mekong (Arias, Cochrane, Norton, et al., 2013) and help sustain primary productivity and breeding of fish and aquatic species.

The ecosystem of the TSL basin could be distinguished into at least eight subsystems. They are: the permanent waterbody, tributaries, seasonally inundated forests, scrublands, and grasslands ecosystems, receding and floating rice fields, seasonally flooded crop fields, and marsh swamps. These ecosystem functions provide TSL with exceptionally high biodiversity. Overall, it is home to more than 370 plant species, 197 phytoplankton species, 46 zooplankton species, 57 reptile species, 225 bird species, 46

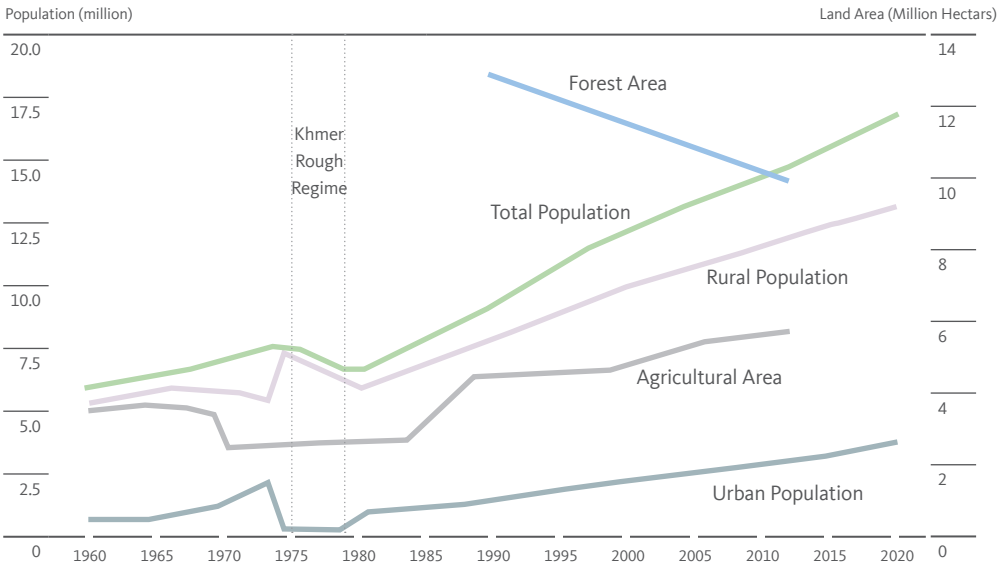
mammal species and 42 reptile species. At least 44 species are classified as threatened or endangered species (MRC 2010; Uk et al., 2018).

3. Drivers and Pressures on the TSL

Population

TSL ecosystem has experienced major changes over the past decades as a result of anthropogenic activities both inside and outside of its basin. After the collapse of the Khmer Rouge regime, Cambodia's total population doubled within less than four decades from approximately seven million in 1979 to more than 15 million in 2015 (Figure 3). The population in Cambodia is predicted to reach 22.5 million by 2050 with 62% of the people expected to live in rural areas. TSL is surrounded by the most densely populated region of Cambodia (Hortle, 2007), with approximately one third (i.e., 5 million) people living around the lake (Ministry of Planning 2013).

↘ Figure3



Population and land use trends in Tonle Sap region (adopted from Uk et al. 2018)

Unsustainable Fish Harvest

The population growth has resulted in increased food demands and pressures on the lake's natural resources (Bonheur & Lane, 2002). TSL ecosystem is one of the largest scale indiscriminate fishing locations in the world (McCann et al., 2015). Migratory fishes entering the lake from the Mekong River are indiscriminately harvested using rows of barge-mounteddrift nets and the barrage system of river spanning fences, allowing low escapement of the fish (Cooperman et al., 2012).

Deforestation and Land Use Changes

Deforestation and land use changes in TSL basin and inundation area are substantial and detrimental for the breeding of the aquatic species. Once there used to be approximately one million ha of flooded forest around the lake. The flooded forest areas had subsequently been reduced to about 614,000 ha by the 1960s, 362,000 ha by 1991 and 350,000 ha by 1997 (ADB 2005). Land use changes are equally significant in the upland area of TSL basin. Annual deforestation in TSL

basin is worse than in any other areas in Cambodia (Senevirathne et al., 2010). In less than 20 years' time forest cover in the lake basin decreased by 43%, from 20,170 km² in 1990 to 11,436 km² in 2009, while the total agricultural land area in the basin increased by 30%, from 14,076 km² in 1990 to 18,858 km² in 2009 (Senevirathne et al., 2010). The area affected by deforestation in TSL basin is equal to 15% of the basin total land area. Higher sediment loads into TSL and its floodplain is anticipated from soil erosion and nutrient runoffs from the deforested and agricultural areas in the basin (UK et al., 2018).

Development of Hydropower Dams along the Mekong River

Biodiversity and ecosystem production in TSL have also been severely threatened in recent times (Bonheur & Lane, 2002; Campbell et al., 2009). Alterations to the hydrology in TSL system resulting from water infrastructure development (Arias, Cochrane, et al., 2014; Arias, Piman, Lauri, Cochrane, & Kummu, 2014; Kummu, Lu, Wang, & Varis, 2010) has raised concerns about their adverse effects on the floodplain habitats and fish production, plant communities and nutrient exchange processes between terrestrial and aquatic food webs in TSL ecosystem (Arias et al., 2012; Arias, Cochrane, & Elliott, 2013; Arias, Cochrane, Norton, et al., 2013; Arias, Cochrane, et al., 2014; Arias, Piman, et al., 2014; MRC 2010). The number of commissioned hydropower stations between 2000 and 2010 increased by 183%, and the total water-holding capacity has increased fourfold compared to that of the 1990s (Lin & Qi, 2017). Although the Mekong River was largely undeveloped prior to 1990, it is currently undergoing a rapid dam construction period, with seven dams under construction on the mainstream in China, and 133 proposed for the Lower Mekong River and tributaries (Kondolf, Rubin, & Minear, 2014), with the situation becoming even worse after 2010 (Lin & Qi, 2017). Because the occurrence of such intense pressure on water resources in the Mekong is coincident with the loss of the phenology of TSL, construction of hydropower dams is believed to be a primary reason for the degradation of TSL ecosystem (Lin & Qi, 2017).

In fact, fish production in TSL is influenced by several factors, including water level, flood extent and duration, timing of the floods, regularity of flooding and characteristics of the flooded zone (Halls et al.,2013). Hydrological structures (e.g., dams) would also block seasonal fish migration between the Mekong River and TSL (Campbell et al.,2009). Fish migrate down the river to breed in the Mekong River during the low-flow period, with their larvae being washed back upthe river in the following wet season to grow in the shallow waters around the lake (Campbell et al., 2009). At peak migration periods, more than 50,000 fish per minute swim pass a given point from TSL to the Mekong River (MRC 2003a). Thus, any disturbance to theTSL ecosystem implies negative impacts on fisheries in the entire Mekong River system. The lake could also be considered a pollution hotspot (Chea et al.,2016), with TSL water quality being influenced by both internal (e.g., lake sediments) and external nutrient sources (e.g., tributary point and non-point sources; groundwater; Burnett et al., 2017; Uk et al., 2018).

Pollution and Health Impacts

Pollution from agricultural chemicals is substantial in TSL basins, although it is difficult to determine its level because of inadequate monitoring. A study in six provinces surrounding TSL indicated that prohibited pesticides are still traded in high level despite the 1998 Sub-Decreeon Standards and Management of Agricultural Materials (Yang Saing, 2001), with 59% of the pesticides widely used in Cambodia being categorized by the World Health Organization as Class I + II (highly to extremely hazardous; Jensen, Konradsen, Jørs, Petersen, & Dalsgaard, 2011). In the case of TSL basins, it has been found that 67% of farmers in TSL region used pesticides for agricultural activities (Cambodia Centerfor Study and Development in Agriculture 2001). Although no dataon the exact volume of chemical pesticides used in Cambodia have been recorded, it was estimated that about 3,570 t were used in2007 (Preap & Sareth, 2015). Such hazardous pesticides are increasingly used not only to increase agricultural productivity in the TSL basins but also to illegally catch and kill fish, as well as protect dried fish from insects, endangering fish and other aquatic life in the lake as well as migratory water birds that feed on contaminated fish and drink the water (The World Bank 2003; Uk et al., 2018).

Further, people live directly on the lake in 170 floating villages (Nuorteva et al., 2010). TSL water pollution has threatened the drinking water supply for local people, while eutrophication has resulted in an explosive development of harmful invasive plant species such as water hyacinth (Kuenzer, 2013; Uk et al., 2018).

4. Impacts of Environmental Changes on the Livelihoods of People on and around Tonle Sap Lake

Background

In order to understand the impacts environmental as well as socio-economic changes on the livelihoods of local people, particularly fishing communities, a study team from this project (Group 7) employed both qualitative and quantitative methods for data collection and analysis from both primary and secondary sources. The secondary data relies on published literature and statistical data (e.g. Cambodia Socio-Economic Survey 2014, 2015; Cambodia Inter-Census Population Survey 2013). Primary data were collected using following qualitative approaches in land-based, land-water based and water based (floating village) communities: (a) ethnographic-type fieldwork, in particular, participant observations in the selected study sites; and (b) semi-structured interviews with local residents; and (c) focus group discussion with local NGOs and communities, and village chiefs.

Before conducting household interviews in each studied site, a Focus Group Discussion (FGD) was carried out targeting local residents, fishers, local NGOs and village chiefs, in order to get general understanding of the village and its livelihood situations. Totally, 3 FGDs have been conducted. In addition, altogether 253 interviewing samples have been carried out at households in 4 studied villages located in 4 major provinces around TSL, namely Rohal Suong (land-based village)

in Battambang Province, Muk Wat (water-land based village) in Siem Reap, Kampong Luong (water-based village) in Pursat, and Chhnok Trou (water-based village) in Kampong Chhnang Province (Fig. 4). The interviews were conducted using a semi-structured questionnaire. Main issues discussed in the interviews included household characteristics; geographical landscape of the community; linkages between TSL and their livelihoods; household income; farming and fisheries and their impacts on the livelihoods; access, availability and uses of water; changes in socio-economic conditions, living standards and surrounding environment during the past decade.

↘ Figure 4

Towns and villages selected for the interviews and questionnaire surveys.

Condition of the Communities Living around the Lake

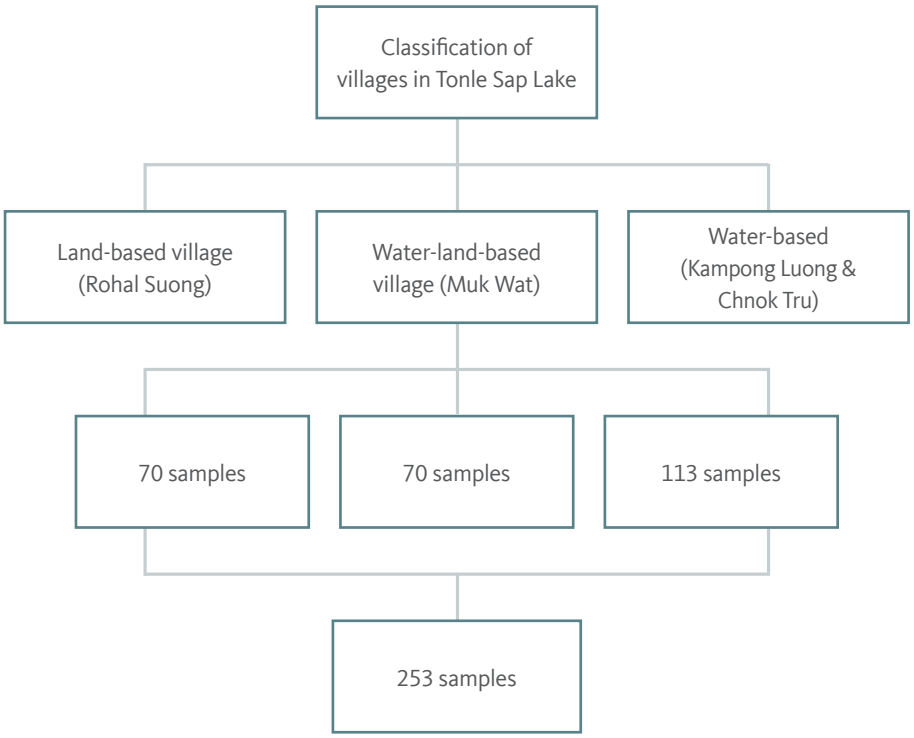
It is estimated that about 1.7 million people were living in 1037 villages of TSL and surrounding floodplains (Sithirith 2011). The people have learned to adapt to the hydrological changes and live in close relation with the environment. Fishing villages in TSL are organized into three different groups situated in three different ecological zones, namely land-based village (948 villages), water-based village (53 villages), and water-land based village (36 villages) (Sithirith, 2011). In land-based villages, people are primarily engaged in farming with occasional fishing activities depending on water level. In water-based villages, often referred to as floating villages, local people are primarily relied upon fishing, which is an important activity for local livelihoods since they have little or mostly no access to land. Meanwhile, in water-land based villages, people often spend approximately six months of the year on land and six months in water. In the wet season, the water floods the area around the village and surrounds the houses, which are built 6-8 meters above ground. Although fishing is a primary occupation for local livelihoods, villagers also supplement their incomes through small-scale farming.

These villages are in the ecological zone mostly affected by seasonal water level changes. The livelihood setting of TSL area is well adapted to its flood pulsing system and are deeply dependent on the resources and services that the lake and its floodplains provide such as agricultural products, fish and

other aquatic animals, and plants. As a result, these people are also the most vulnerable from the negative pressures on the lake resources and resulting changes.

↘ Figure 5

Sample size for household questionnaire surveys



Declining Fish Catch and Socio-economic Impacts

From the surveys conducted under this project, fisheries in all surveyed communities are crucial and forms their primary or secondary income sources. (Kampong Luong and Chhnok Trou; Muk Wat). For example, in Chhnok Trou, 74% of households heavily rely on small-scale fishing as the main income source. The income is directly dependent of daily fish catch which is equivalent to 3-20 US$/day. For most households, it is the only revenue to support household expenditure. Meanwhile, in land-based and water-land based villages, besides small-scale fishing as the secondary income source, rice cultivation is the main livelihood and source of income for majority of households living there. Rapid fall in the fish catch (both quantity and quality) is one of the critical issues identified from the surveys. Fishermen are finding it hard to support essential households' expenses only by selling fishes. Fish catch has not improved despite an intensification of fishing efforts at the household level. Intensification in fishing and low fish catch also means waste in added time, financial and energy expenditures, and opportunity costs. According to the local communities, the decline in fish catch can be attributable to several factors. Use of illegal fishing methods, lack of control of fishing gear, unequal access to fishing grounds, an increase in the number of fishers, deterioration of fish habitat, and hydrological changes in the flood pulse (mainly inadequate flood water entering the lake during the wet season). Although the communicates are not fully aware of the root causes on the fluctuation

of water level in wet season, the construction of cascade of hydropower dams on the upstream countries as well as impact of climate change is believed to alter hydrological cycle affecting seasonal inundation of the lake, sedimentation and nutrient transport. It is quite evident that continuation of disruption in the hydrological cycle and declining fish catch is increasing vulnerability of fishing communities, who have low assets base and rely on income from daily fish catch.

The Impacts of Environmental Changes

The findings from the interviews showed that the most recent environmental changes is the deterioration of water quality in both TSL and Tonle Sap River. The main causes of water quality decline are discharge of untreated wastewater and disposal of solid waste into the lake basins' tributaries, runoff of agro-chemicals, and poor water, sanitation and hygiene (WASH) and waste disposal in the floating village areas. Houses in floating villages discharge effluents from toilets directly into the lake. Due to the nature of housing and lifestyle, people come under frequent direct contact with polluted water such as through washing raw food and fish, bath, hand wash and swimming. The polluted water increases the risk of microbial health risks. Due to primary and secondary contamination paths, at least some family members, especially children, had water borne illness and need to visit doctor frequently.

Climate Change and Low Adaptive Capacity of Fishing Communities

The local livelihoods and people's lives in and around TSL could be directly affected by the impacts caused by climate change, especially, through disruption on the hydrological cycle of TSL. Number of extreme weather or unexpected events such as heavy storms causing high waves, severe floods (e.g. the flood events in 2000 and 2011) and droughts seem to occur more frequently and have huge economic impacts particularly to the poor households. This is highly critical for a large population dependent on the resources and services of TSL basin (Grundy-Warr and Sithirith, 2016), agriculture and food security, terrestrial and freshwater ecosystems, and human health. Among the three types of surveyed villages under this project, the water-based communities (Kampong Luong and Muk Wat village) as such are physically less affected than those living in land. However, coping with high waves caused by heavy storms is becoming a challenge for small-scale fishing activities. Meanwhile, severe water pollutioncan happenedduring low water level periods affecting to fish population. As a result the communities have to travel afar in search of better fishing ground. It means adding fuel cost of the fishing boats, extra physical labor, and risk of accidents.

Findings from this study team indicated that in order to improve the resilience and to cope with unexpected environmental and climate change, diversification of income sources is one of the common options adopted by the households such as seasonal migration to cities, industrial estates for jobs, part-time or short-term workers or helpers in other villages or provinces, off-farm business (groceries). Improve and strengthen their housing structures, either using bamboo or woods, is another coping measure against rising tides and storms. The study found that micro-credits with low interest rate is also an important factor that help local

communities to finance/invest supplementary livelihood sources and for buying new fishing gears.

↘ Figure 6

Water-based and water-land basedcommunities along Tonle Sap Lake

5. Addressing the Problems through the Establishment of Environmental Conservation Platform of Tonle Sap Lake

Overview of the SATREPS Project

Science and Technology Research Partnership for Sustainable Development (SATREPS) is a Japanese Government overseas development assistance project funded through Japan Science and Technology (JST) and Japan International Cooperation Agency (JICA) for the international collaborative research in issues of global concern (JICA, 2018). SATREPS principally focus on scientific evidence-based research and capacity development in partner countries. Establishment of Environmental Conservation Platform of Tonle Sap Lake (ECP-TSL) is one of the SATREPS projects stationed at Institute of Technology of Cambodia and led by a consortium of research organization and universities from Japan and Cambodia for the period of April 2016 – March 2021. ECP-TSL project aims to develop a water environment analytical tool for Tonle Sap Lake (TSL) through elucidation of the lake and the tool development. The ECP-TSL projectal so aims at the capacity building for Cambodia partners by i) establishing state-of-the-art research-oriented structures and facilities in ITC, ii) promoting science-based management to the government of Cambodia, and iii) assisting to develop the Tonle Sap Water Environmental Platform (TSWEP) and make it one of the benchmarks in freshwater ecology and management studies in Southeast Asia. Since the project is on half-way of its implementation, that project members are intensively involved in regular monitoring of TSL water environment, strengthening of analytical laboratories, meeting, workshops and lecture, and technical capacity development objectives.

The project integrates seven areas consisting of hydrology and hydrodynamics, sediment and water quality, chemical and microbial pollutants, model integration, risk assessment, and social implementation (Fig. 5). Multiple problems and scenarios are being

analyzed to find integrated solutions and support decision making. The framework for environmental conservation consists of a close integration of capacity building with co-design of methodological and analytical framework among researchers and key stakeholders.

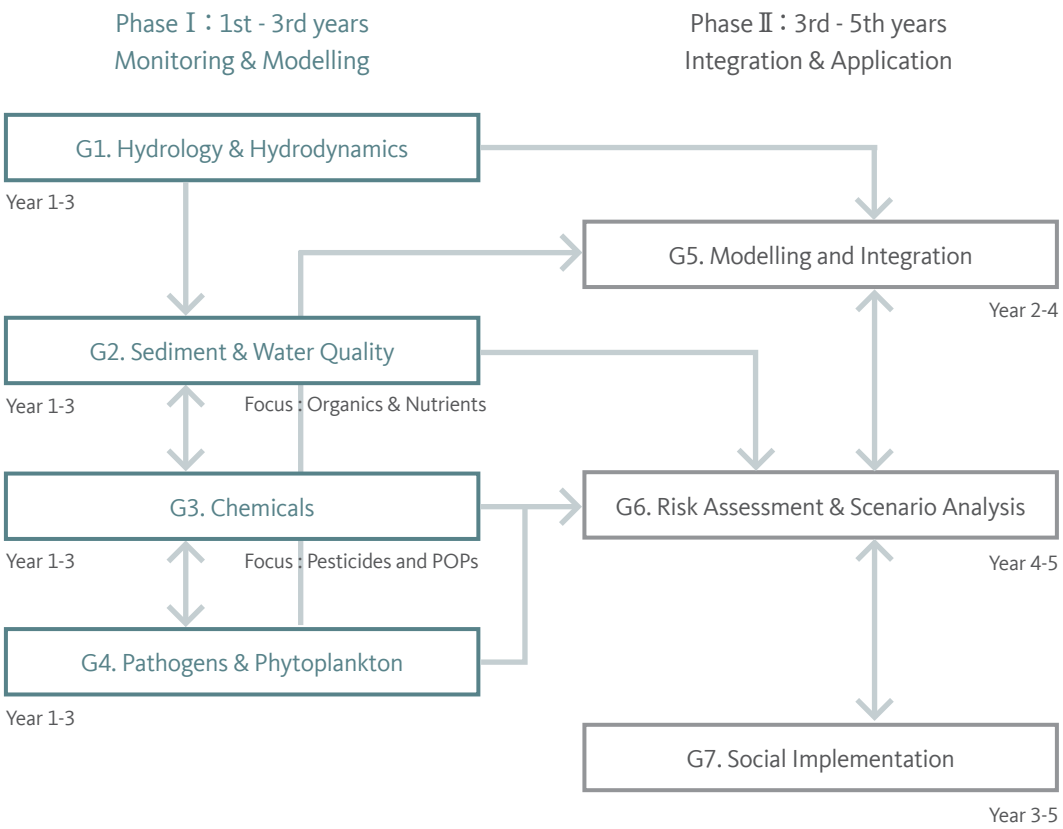
Strategy for Capacity Building on the Integrated Management of TLS and its Basins

Urbanization, population growth, human resources and political stability plays an important role in the policy formulation for environmental conservation. These factors are also critical for setting priorities for implementation of the SATREPS project and achieve capacity building objectives. SATREPS being a research collaboration project, the key strategy is to transfer the state-of-the art research support facilities and infrastructures (setting of water quality labs with latest analytical equipment) in Cambodia. Researcher from leading universities and research institutes from Japan will directly work with relevant expertise from universities and agencies in Cambodia. This approach of co-designing and co-implementation of research activities between researchers in Japan and Cambodia is crucial for the effective transfer of scientific research capabilities in Cambodia and its sustenance. It is hoped that enhancing the capacity to conduct scientific assessment of the environmental problems is necessary for evidence-based discussion and devise appropriate solutions. The project is in its middle of implementation, below contents elaborate the outline of the project and key experiences so far.

A general outline of the project and work packages with time frame is shown in Fig. 7.

↘ Figure 7

Major work packages and timeframe of the SATREPS project.



More than 25 and 21 PhDs graduated in Japan and Cambodia are involved in this project, respectively. Transdisciplinary research team is formed by academic institutions (In Japan - Tokyo Institute of Technology; Yamagata University; In Cambodia – Institute of Technology of Cambodia; Royal University of Phnom Penh), Public institution (Institute for Global Environmental Strategies, Japan), Government (In Cambodia – Tonle Sap Authority, Ministry of Education Youth and Sports, Ministry of Environment, Ministry of Water Resources and Meteorology). Each working group develops a plan for intensive monitoring as a basic for database creation and also to support other working group in comprehensive research environment. Training and workshop for members of working group in Cambodia is organized on a regular basis (Table 1). In addition, institutional capacity building is achieved by major investment in monitoring equipment, including Acoustic Doppler Current Profile (ADCP) for bathymetric measurement, sediment and water quality sensors, advanced laboratory equipment for food and water analysis, and modelling. In addition, an environment for internal competition is also created by providing opportunities of training in Japan for those who are actively involved in research. Communication outreach is being achieved by peer reviewed journal publication, domestic and international conferences, collaboration in Southeast Asia and beyond. In addition, special workshops are also being organized the special need of government agencies for the capacity development of bureaucrats.

Technical cooperation in personal and institutional capacity development

↘ Table 1

No	Particulars	Activities	Remarks
1	Dispatch of Japanese experts	Contemporary issues like- environmental leadership, water Governance, lab safety, water quality, modelling	Target trainees: Graduate students, researchers, bureaucrats, public
2	Training in Japan	Laboratory analysis, hydrology and hydrodynamics, data analysis, publication, land use land cover	Operation of advanced equipment and advanced modelling
3	Technical capabilities	Weather stations, Real time water quality monitoring, advanced laboratory equipment like, GC-MS/MS, HPLC, particle analyzer, ultra-pure water	Institutional capacity development
4	Monitoring	Sediment and water quality, chemical pollutants and pathogens, nutrients, bathymetric, risk assessment	Creation of databank
5	Networking and communication	Symposium, workshop, joint seminar, lectures	International collaboration, results dissemination

*Note : GC-MS = Gas Chromatography-Mass spectrometry; HPLC= High Performance Liquid Chromatography

Major Outcomes of Capacity Building and Future Prospects

A number of personal and institutional capacity development programs has been implemented since the establishment of the project (Table 1). In brief, these programs include, dispatch of Japanese experts to Cambodia for research support, setting up advanced bathymetric measurement of TSL and tributaries, setting up of workstations, trainings for advanced modelling (1D-MIKE 11, 2D-LIE, 3D-TITech-WARM, GBHM), and setting up of weather stations, real time water quality monitoring, and advanced laboratory equipment (e.g., GC-MS/MS, HPLC, particle analyzer, ultra-pure water, and so on). The project has also established the effective method for intensive regular monitoring on sediment, water quality, chemical pollutants, and pathogens in the lake. The collected data will help in the assessment of chemical and microbial risk. Eventually, the data and results of analysis will be integrated for building water environmental analytical tool and transfer to the target areas and communities for social integration.

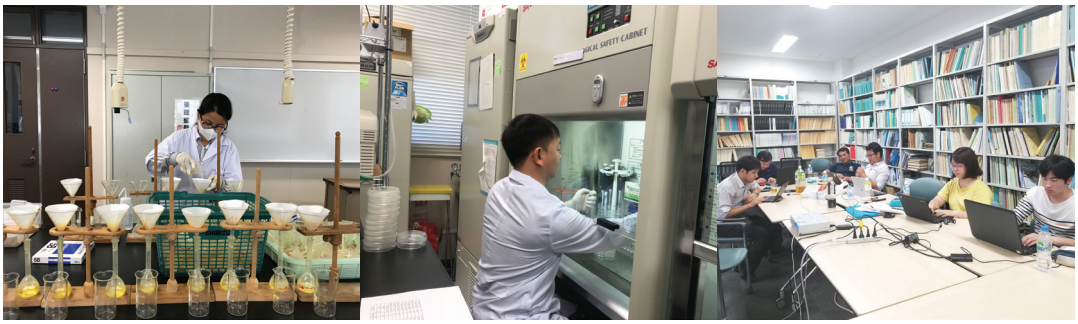
Regarding human resource development, the project has provided a wide variety of training programs both in Cambodia and Japan. Those activities include lecture, workshop, technical training in field and lab, supervision in each small team, collaborative research, participation to several symposia and academic conference as well as meetings with external experts. One of the most promising outcomes from such capacity development is that some departments at Institute of Technology of Cambodia (ITC) have set up full time graduate programs for master and PhD degrees there and are waiting for students enrolling from 2018.

It is also strongly believed that not only the members involved in this project, but also other people are benefiting directly or indirectly with the contribution from this project. For example, students at ITC are now having access to state-of-the-art laboratory facilities for the environmental analysis such as GC-MS. The collaboration with governmental institutions (Tonle Sap Authority, Ministry of Water Resources and Meteorology, and Ministry of Environment) also support them to develop their capacity for environmental management by exposing them with practical challenges in the field.

The project is also developing an integrated tool for the environmental management for Tonle Sap Lake and its basins by consolidating all data, analytical methods, and finding for the evidence based decision making and policy formulation. The platform will work as an information hub of such human resources, relevant institution, environmental information, and technical tools.

For long-term, the project hopes the outcomes will lead to establishment of a system and protocols for surveillance and monitoring of water and

↘ Figure 8



Researchers at ITC performing water quality analysis and attending the capacity building programs.

sediment quality. We expect the ongoing monitoring scheme to continue even after the completion of the project. In addition, a methodology for the quantitative chemical and microbial risk assessment will be developed. All the relevant data, presentations, technical notes, conference papers and journal publications will be maintained by ITC in a central database that would be easily available to concerned stakeholders. These databases can be utilized by government agencies, researchers, general public, non-governmental agencies and academicians for further analyses, according to their need and they can formulate policy and research plans ahead. The project strongly believe that research assistance to Cambodia support an idea to establish an international research center at ITC focusing freshwater ecosystems and water environmental management.

Tonle Sap Water Environmental Platform (TSWEP) envisions the participatory approach of information generation and sharing while respecting diversity of all the involved stakeholders. With the emergence of stringent regulation in cultural preservation, priority of economic development, ethics in research, and inelastic terms and conditions of donor agencies, conservation of TSL cannot be achieved without valuing diversity of local residents, academicians, governmental agencies, and donors (Martín-López and Montes, 2015).

One of the challenges in transdisciplinary research consisting of multiple stakeholders is technology, knowledge transfers for coordination and action oriented goals, and implication of scientific knowledge to political and societal decision-making (Pregernig, 2014). Scientific research should not merely identify the problem but should propose realistic solutions as well. This transformation of scientific knowledge can be achieved by setting agendas relevant to socio-economic standard, handling of dissent, management of uncertainty, peer review, operational transparency and dialogues amongst various stakeholders (Cornell et al., 2013). Goal of conservation of TSL can be maximized, as pointed out by Campbell et al., (2015), when all the involved stakeholders shared the common goal, retained the skilled human resources, maintained the advanced equipment, respect diversity and pluralism, trust, and flexibility in operation.

Another major challenge of capacity development in developing countries is the dependency threat, whereby partner institute commitments on sustainability after the completion of the project is restricted by the limited support on maintenance of the advanced instruments and retention of the skilled human resources. Hence, before the overseas development assistance (ODA) commences, a framework is to be established to ensure sustainability after the completion of the project. In addition, without an indicator for measurement of sustainability, it would be vulnerable that the system is classed as sustainable even when it is not. So, development of sustainability indicators would be equally crucial to assess sustainability with respect to the diversity and self-actualization of individual and an organization. Development of indicator in terms of existing system's food, energy, economy, biodiversity and socio-cultural values is truly desirable (Gerbens-Leenes et al., 2003).

References

ADB (2005). The Tonle Sap Basin strategy. Manila, Philippines: ADB.

Arias, M. E., Cochrane, T. A., Norton, D., Killeen, T. J., & Khon, P. (2013). The flood pulse as the underlying driver of vegetation in the largest wetland and fishery of the Mekong basin. Ambio, 42(7), 864–876. https://doi.org/10.1007/s13280-013-0424-4

Arias, M. E., Piman, T., Lauri, H., Cochrane, T. A., & Kummu, M. (2014). Dams on Mekong tributaries as significant contributors of hydrological alterations to the Tonle Sap Floodplain in Cambodia. Hydrology and Earth System Sciences, 18, 5303–5315. https://doi.org/10.5194/hess-18-5303-2014

Bonheur, N., & Lane, B. D. (2002). Natural resources management for human security in Cambodia's Tonle Sap Biosphere Reserve. Environmental Science & Policy, 5(1), 33–41. https://doi.org/10.1016/S1462-9011(02)00024-2

Burnett, W. C., Wattayakorn, G., Supcharoen, R., Sioudom, K., Kum, V., Chanyotha, S., & Kritsananuwat, R. (2017). Groundwater discharge and phosphorus dynamics in a flood-pulse system: Tonle Sap Lake, Cambodia. Journal of Hydrology, 549, 79–91. https://doi.org/10.1016/j.jhydrol.2017.03.049

Burnett, W., Wattayakorn, G., Kum, V., & Sioudom, K. (2013). Assessing the impact of climate change and development pressures on nutrient inputs into the Mekong River and Tonle Sap, FL, USA.

Cambodia Center for Study and Development in Agriculture (2001). The situation of pesticide use in the Tonle Sap Catchment. Phnom Penh, Cambodia: Cambodia Center for Study and Development in Agriculture.

Campbell, C.A., Lefroy, E.C., Caddy-Retalic, S., Bax, N., Doherty, P.J., Douglas, M.M., Johnson, D., Possingham, H.P., Specht, A., Tarte, D. and West, J. (2015). Designing environmental research for impact. Science of the Total Environment, 534, 4-13.

Campbell, I.C., Poole, C., Giesen, W., Valbo-Jorgensen, J. (2006). Species diversity and ecology of Tonle Sap Great Lake, Cambodia. Aquat. Sci. 68, 355–373.

Campbell, I.C., Say, S., Beardall, J., (2009). Tonle Sap Lake, the Heart of the Lower Mekong, in: The Mekong. Elsevier Inc., USA, pp. 251–272. https://doi.org/10.1016/B978-0-12-374026-7.00010-3

Chea, R., Grenouillet, G., & Lek, S. (2016). Evidence of water quality degradation in Lower Mekong Basin revealed by self-organizing map. PLoS ONE, 11(1), 1–19. https://doi.org/10.1371/journal.pone.0145527

Cooperman, M. S., So, N., Arias, M., Cochrane, T. A., Hand, T., Hannah, L. … Kirk, O. (2012). A watershed moment for the Mekong: Newly announced community use and conservation areas for the Tonle Sap Lake may boost sustainability of the world's largest inland fishery. Cambodian Journal of Natural History, 20, 101–106.

Cornell, S., Berkhout, F., Tuinstra, W., Tàbara, J.D., Jäger, J., Chabay, I., de Wit, B., Langlais, R., Mills, D., Moll, P. and Otto, I.M. (2013). Opening up knowledge systems for better responses to global environmental change. Environmental Science & Policy, 28, 60-70.

Gerbens-Leenes, P. W., Moll, H. C., & Uiterkamp, A. S. (2003). Design and development of a measuring method for environmental sustainability in food production systems. Ecological Economics, 46(2), 231- 248.

Grundy-Warr, C. and Sithirith, M. (2016). Threats and challenges to the "floating lives" of the Tonle Sap. In "Land, Indigenous Peoples and Conflict. Edited by Alan C. Tidwell and barry Scott Zellen. Published by Routledge Taylor &Francis Group, London and New York.

Halls, A. S., Paxton, B. R., Hall, N., Ngor, P. B., Lieng, S., Ngor, P. B., & So, N. (2013). The stationary trawl (Dai) fishery of the Tonle Sap Great Lake System, Cambodia. MRC Technical Paper. Phnom Penh, Cambodia, (MRC Technical Paper No. 32), p. 168.

Holtgrieve, G. W., Arias, M. E., Irvine, K. N., Lamberts, D., Ward, E. J., Kummu, M., … Richey, J. E. (2013). Patterns of ecosystem metabolism in the Tonle Sap Lake, Cambodia with links to capture fisheries. PLoS ONE, 8(8), https://doi.org/10.1371/journal.pone.0071395

Hortle, K. (2007). Consumption and the yield of fish and other aquatic animals from the Lower Mekong Basin. MRC Technical Paper. No. 16, p. 87.

International Lake Environment Committee (ILEC). (2005). Managing Lakes and Their Basins for Sustainable Use: A Report for Lake Basin Managers and Stakeholders. Kusatsu, Japan: International Lake Environment Committee Foundation.

Jensen, H. K., Konradsen, F., Jørs, E., Petersen, J. H., & Dalsgaard, A. (2011). Pesticide use and self-reported symptoms of acute pesticide poisoning among aquatic farmers in Phnom Penh, Cambodia. Journal of Toxicology, 2011, 8. https://doi.org/10.1155/2011/639814

Khanal, R., Siev, S., Uk, S., Kodikara, D., Yoshimura, C. (2018). Impact Of Water Level Fluctuation On Nutrient And Sediment Dynamics In A Shallow Lake: A Case Of Tonle Sap Lake, Cambodia, in: International Symposium on Ecohydraulics. International Association for Hydro-Environment Engineering and Research (IAHR) and International Society for River Science (ISRS), Tokyo.

Kondolf, G. M., Rubin, Z. K., & Minear, J. T. (2014). Dams on the Mekong: Cumulative sediment starvation. Water Resources Research, 50(6), 5158–5169. https://doi.org/10.1002/2013WR014651

Kuenzer, C. (2013). Threatening Tonle Sap: Challenges for Southeast Asia's largest Freshwater Lake. Pacific Geography, 40(August), 29–31.

Kummu, et al. (2014). Water balance analysis for the Tonle Sap Lake-floodplain system. Hydrological Processes, 28(4), 1722–1733. https://doi.org/10.1002/hyp.9718

Kummu, M., & Koponen, J. (2003). Modelling flood, sedimentation processes, and water quality for environmental impact assessment and management support in the Tonle. Paper to ICGRHWE 2003 conference in Three Gorges Dam (September), 1–14.

Kummu, M., Penny, D., Sarkkula, J., & Koponen, J. (2008). Sediment: Curse or blessing for Tonle Sap Lake? Ambio, 37(3), 158–163. https://doi.org/10.1579/0044-7447(2008)37[158:SCOBFT]2.0.CO;2

Kummu, M., Sarkkula, J., Koponen, J., and Nikula, J. (2006). Ecosystem Management of the Tonle Sap Lake: An Integrated Modelling Approach, Water Res. Dev. 22 (3): 497-519.

Lamberts, D. (2001). Tonle Sap fisheries: A case study on floodplain gillnet fisheries. Bangkok, Thailand: RAP Publication.

Lin, Z., & Qi, J. (2017). Hydro-dam – A nature-based solution or an ecological problem: The fate of the Tonlé Sap Lake. Environmental Research, 158(May), 24–32. https://doi.org/10.1016/j.envres.2017.05.016

Martín-López, B., & Montes, C. (2015). Restoring the human capacity for conserving biodiversity: a social–ecological approach. Sustainability Science, 10(4), 699-706.

McCann, K. S., Gellner, G., McMeans, B. C., Deenik, T., Holtgrieve, G., Rooney, N. … Giacomini, H. (2015). Food webs and the sustainability of indiscriminate fisheries. Canadian Journal of Fisheries and Aquatic Sciences, 665, 656–665. https://doi.org/10.1139/cjfas-2015-0044

Ministry of Planning (2013). Cambodia Inter-censual Population Survey 2013: Spatial distribution and growth of population. Cambodia, Phnom Penh.

MRC (2010). Assessment of Basin-wide development scenarios: Impacts on the Tonle Sap Ecosystem. Basin Development Plan Program, Phase 2. 10. Vientien, Lao PDR.

Nuorteva, P., Keskinen, M., & Varis, O. (2010). Water, livelihoods and climate change adaptation in the Tonle sap lake area, Cambodia: Learning from the past to understand the future. Journal of Water and Climate Change, 1(1), 87–101. https://doi.org/10.2166/ wcc.2010.010

Penny, D., Cook, G., & Im, S. S. (2005). Long-term rates of sediment accumulation in the Tonle Sap, Cambodia: A threat to ecosystem health? Journal of Paleolimnology, 33(1), 95–103. https://doi.org/10.1007/s10933-004-1323-2

Preap, V., & Sareth, K. (2015). Current use of pesticides in the agricultural; products of Cambodia. Submitted for the FFTC-KU International Workshop on Risk Management on Agrochemicals through Novel Technologies for Food Safety in Asia, November 10–14. Nakorn Pathom, Thailand.

Pregernig, M. (2014). Framings of science-policy interactions and their discursive and institutional effects: examples from conservation and environmental policy. Biodiversity and conservation, 23(14), 3615-3639.

Sarkkula, J., Baran, E., Chheng, P., Keskinen, M., Koponen, J., Penh, P., … Lake, S. (2004). Tonle Sap pulsing system and fisheries productivity. In XXIXe International Congress of Limnology (SIL 2004). Lahti, Finland.

Sarkkula, J., Kiirikki, M., Koponen, J., & Kummu, M. (2003). Ecosystem processes of the Tonle Sap Lake. In 1st Workshop of Ecotone Phase II. Phnom Penh, Cambodia (pp. 1–14).

SATREPS, 2018. Interview with the Principal Investigator. SATREPS Newsl.

Senevirathne, N., Mony, K., Samarakoon, L., & Hazarika, M. K. (2010). Land use/land cover change detection of Tonle Sap Watershed, Cambodia. In 31st Asian Conference on Remote Sensing 2010, ACRS 2010 (pp. 852–857).

Siev, S., Yang, H., Sok, T., Uk, S., Song, L., Kodikara, D., Oeurng, C., Hul, S., Yoshimura, C., 2018. Sediment dynamics in a large shallow lake characterized by seasonal flood pulse in Southeast Asia. Sci. Total Environ. 631–632, 597–607. https://doi.org/10.1016/j.scitotenv.2018.03.066

Sithirith, M.(2011). Political Geography of the Tonle Sap: Power, Space and Resources. Ph.D. dissertation, National University of Singapore.

Somony, T., and Schmidt, U. (2004). Aquatic Resource Management: Tonle Sap Great Lake. Phnom Penh: Department of Fisheries.

Søndergaard, M., Jensen, J. P., & Jeppesen, E. (2003). Role of sediment and internal loading of phosphorus in shallow lakes. Hydrobiology, 506–509, 135–145. https://doi.org/10.1023/B:HYDR.0000008611.12704.dd

The World Bank (2003). Cambodia environment monitor 2003. Washington, DC: The World Bank.

The World Bank Group (2011). Climate risk and adaptation country profile: Vulnerability, risk reduction, and adaptation to climate change, Cambodia. Washington, DC: The World Bank Group.

Tsukawaki, S. (1997). Lithological features of cored sediments from the northern part of The Tonle Sap Lake, Cambodia. In International conference on Stratigraphy and Tectonic Evolution of Southeast Asia and the South Pacific. Bangkok, Thailand (pp. 232–239).

Tsukawaki, S., Okawara, M., Lao, K., & Tada, M. (1994). Lake Tonle Sap, Cambodia. Journal of Geography, 103(6), Plate3–Plate4.

Uk, et al. (2018). Tonle Sap Lake: Current status and important research directions for environmental management. Lakes & Reserv. 00:1– 13. https://doi.org/10.1111/lre.12222

Uk, S., Kodikara, D., Yoshimura, C., Yang, H., Siev, S., Sato, M., Sok, T., Song, L., Oeurng, C., 2017. Phosphorus fractions in sediments and its potential exchange with water column in Tonle Sap Lake, in: The 2nd International Symposium on Conservation and Managment of Tropical Lakes,. Siem Reap, Cambodia, p. 119.

Van, Zalinge, N., Thouk, N., Touch, S. T., and Deap. L. (2000). Where There is Water, There is Fish?" In Common Property in the Mekong Issues of Sustainability and Subsistence, 37-50.

World Meteorological Organization (2016). World Meteorological Organization. Retrieved from http://www.worldweather.org/en/city.html?cityId=347. Accessed 21 September 2016.

Yang Saing, K. (2001). Pesticide use in Tonle Sap region. Phnom Penh, Cambodia.

III

Affordable and Clean Energy

6.
Cambodia's Progress Towards the Sustainable Development Goal on Clean and Affordable Energy

6

Andrew Williamson[1)]

Cambodia's Progress Towards the Sustainable Development Goal on Clean and Affordable Energy

1. Introduction

Cambodia finds itself at an extraordinary point in history. It has achieved 20 years of record economic growth while re-building the country from one of the worst periods of human destruction on record (McKinsey, 2018). The Royal Government of Cambodia (RGC), recently re-appointed, expects to graduate from its classification as least developed to lower-middle income country in the next few years, and now has its sights set on becoming an upper-middle income country by 2030 (RGC, 2018c). However some commentators have observed the spectacular growth has only been achieved at significant social and environmental cost, and is not sustainable (Sivhuoch & Sreang, 2015).

Just three years ago Cambodia committed, along with 192 other countries, to achieving the UN's Sustainable Development Goals (SDG). These 17 ambitious goals, along with 169 targets and 230 measurement indicators present a significant challenge for any nation, and especially a least developed nation with a recent history such as Cambodia's. A number of the 17 SDG are relevant to the cleaner generation and consumption of energy, such as SDG 1 on poverty reduction, SDG 8 on economic growth, SDG 12 on responsible consumption and production and SDG 13 on climate action. However SDG 7 is concerned directly with affordable and clean energy and is the focus of this analysis. This goal is detailed in three main targets to be achieved by the year 2030, as indicated in Table 1.

1. Consultant in Sustainable Energy projects, businesses and policy in South East Asia

↘ Table 1

Definitions of targets and indicators for SDG 7

SDG7 Targets	Indicators
7.1 : By 2030 ensure universal access to affordable, reliable and modern energy services (the indicators track electrification and cooking fuels progress separately)	Proportion of population with access to electricity
	Proportion of population with primary reliance on clean fuels and technologies
7.2 : By 2030 increase substantially the share of renewable energy in the global energy mix	Renewable energy share in total final energy consumption
7.3 : By 2030 double the global rate of improvement in energy efficiency	Energy intensity measured in terms of primary energy and GDP

Source : World Bank, 2018c

This paper starts with an overview of the energy sector in Cambodia today, and a snapshot of the initiatives of a wide range of stakeholders to make it more sustainable. It then reviews the evidence regarding the progress, challenges and opportunities presented by Cambodia's efforts to achieve SDG 7 by the year 2030. While the challenges are clear, this paper will argue that significant progress has been made in certain areas, and that in fact the RGC is faced with a unique window of opportunity to adjust Cambodia's energy sector onto a more sustainable path that will not only help achieve SDG 7, but go a long way to ensuring the country's impressive economic growth can be continued, to everyone's benefit.

2. Cambodia's Energy Sector Today

Policy

Cambodia's socio-economic development over the past twenty-five years has been guided by a series of 5-year socio-economic development plans and strategy documents. The first of these in 1993 was titled the National Programme to Rehabilitate and Develop Cambodia, followed shortly afterwards by the first five-year Socio-Economic Development Plan. These documents presented the Government's vision that prioritised macroeconomic stability, social development, and poverty reduction. These plans and strategies have been regularly updated with revised priorities and targets. The current versions of these documents are the National Strategic Development Plan 2014-2018 and the Rectangular Strategy Phase III (2013-2018). The documents make it clear that Cambodia aims to graduate to being classified as an "upper middle income" country by 2030, and a developed country by 2050 (RGC, 2014).

These over-arching development plans and strategies focus on electricity and do not mention thermal energy for household cooking or industry, which is mainly supplied by fuelwood and charcoal. However the Ministry of Mines and Energy's Cambodia Wood and Biomass Strategy and Action Plan (2015), and the Ministry of Environment's National Biodiversity Strategy and Action Plan (2016) go into much more detail (RGC, 2016). The latter document proposes an inspiring vision for Cambodia's energy sector:

..."that by 2030 Cambodia has rich renewable energy resources such as biomass, biogas, hydropower, solar and wind energy resources which are used in an efficient and environmentally sustainable way in order to fulfill all people's and sectors' needs of energy services, using a demand side management approach; and an important target is to achieve, by 2020, a widespread use of renewable energy, including up to 30% of biogas in urban and rural areas instead of fuelwood and charcoal use." (RGC, 2016)

In each of the national plans and strategies the electricity sector features as one of the essential public infrastructure services required for economic development. There are three areas of focus with respect to electricity: to further expand the electricity supply coverage, to lower the electricity tariffs and to strengthen institutional mechanisms and management capacity.

The Electricity Law was first promulgated in 2001 and established the framework for the electricity sector in Cambodia, including the generation, transmission, distribution and sale of electricity. This document assigned the responsibility for planning and policy development to the Ministry of Mines and Energy (MME) and also established the Electricity Authority of Cambodia (EAC) as the independent regulator. Electricite du Cambodge (EDC) has existed in Cambodia, in various forms, since 1958. In 1996 it was converted to a limited liability company owned jointly by the Ministry of Mines and Energy (MME) and the Ministry of Economy and Finance (MEF). The Electricity Law assigned EDC exclusive rights for the generation, distribution and transmission of power in Phnom Penh and 12 other major provincial centres plus four regions bordering Vietnam (EDC, 2016). Outside these areas power is distributed and sold by 348 Provincial Electricity Companies (PECs) and Rural Electricity Enterprises (REEs), and generated by Independent Power Producers (IPPs). All are licensed and regulated by EAC (EAC, 2018).

MME regularly produces a Power Development Plan (PDP) that describes how the power sector will be developed. This incorporates the RGC's three high-level goals for electricity: reducing reliance on power imports, reducing costs to consumers and ensuring that grid-quality electricity is available to all villages by 2020 and 70% of households by 2030 (de Ferranti, Fullbrook, McGinley, & Higgins, 2016). These goals are directly relevant to SDG 7 regarding the availability of affordable and reliable electricity. The current PDP, updated in 2015, does not specifically prioritise clean or renewable electricity. Rather it is based on the conventional approach of large centralised generation from fossil fuels and large hydro generation supplying a growing national grid network. The Asian Development Bank (ADB) is engaging a consulting team to work on the next update of the Power Development Plan over a 21 month period, starting in April 2019. The terms of reference for the assignment clearly require that renewable energy (solar, wind and biomass) and quick-responding gas-fired generation be considered for inclusion in Cambodia's future generation mix (ADB, 2018). The use of renewable energy specifically for the task of rural electrification was the focus of an action plan, national policy and master plan that were developed between 2002 and 2006. These were developed initially with the support of the World Bank, who also funded the establishment of the Rural Electrification Fund (REF) to promote and subsidise rural electrification, through renewable and conventional means. The Japan International Cooperation Agency (JICA) produced a Master Plan for Rural Electrification by Renewable Energy in 2006 (JICA, 2006).

In 2013 the Cambodia Climate Change Alliance supported the RGC to develop a suite of national policy documents to encourage a more inclusive and "greener" form of economic growth. They were the Cambodian Climate Change Strategic Plan 2014-2023, the National Policy for Green Growth 2013-2030 and the National Strategic Plan for Green Growth 2013-2030. These included recommended actions in the energy sector such as increasing renewable energy sources, encouraging the financial sector to support sustainable energy projects and improving residential and industrial energy efficiency (RGC, 2013).

These green policies provided some foundation for Cambodia's Intended

Nationally Determined Contribution (INDC) document that was submitted to the twenty-first Conference of the Parties (COP21) in Paris in 2015 (UN, 2015). Cambodia committed to reducing greenhouse gas emissions, with its energy sector contributing 16% out of the total target of 27% reduction by 2030 on business as usual levels. The priority actions to achieve this were identified as having a national grid with connected renewable energy generation, connecting decentralised renewable generation to the grid, residential off-grid electricity generators such as solar home systems and hydro (pico, mini and micro), and promoting energy efficiency by end users (WWF, 2016).

The Electricity Authority of Cambodia (EAC) announced a new regulation in early 2018 regarding the connection of solar power systems to the national grid network. This document only allows for large power consumers (with grid connections rated at medium or high voltage) to use their own solar power system while connected to the grid. The customers must use a different tariff schedule and systems must comply with a number of criteria, including a maximum output rating of 50% of the site's consumption. Even after complying with all this, they are forbidden from exporting excess power generation into the grid network (RGC, 2018b). While the new solar tariffs are attractive for some businesses, the inability to export unused solar power will significantly reduce the viability of solar power for many sites. This is an unfortunate disincentive for private investment in distributed generation that could be a flexible and cost-effective source of renewable energy in the grid.

By contrast, draft versions of the Environment and Natural Resources Code were much more supportive of solar power systems. The tenth draft of the code, released in February 2018, proposed a number of initiatives to encourage private investment in solar power systems (RGC, 2018a). These include formalising the right of any consumer to connect a complying solar power system to the grid, using a net-metering system, and a one-year pilot of a feed-in-tariff system that would pay consumers for any electricity that they export to the grid. It also proposed a reduction in profit taxes of up to 20% for any company generating at least 20% of its own energy through sustainable sources. However, there is no guarantee that these pro-renewables provisions will achieve approval of all the relevant ministries to remain in the final version (Tilleke & Gibbons, 2018).

The proliferation of Government policy documents in Cambodia has been assisted, and in some cases driven, by the numerous and generous foreign donor programs that identified the energy sector as a worthy focus of development assistance. The Cambodian Prime Minister acknowledged and thanked the "development partners" for their contributions to the country's development in the foreword to the National Strategic Development Plan 2014-2018 (RGC, 2014). Development of energy and environmental policy can be an attractive target for donor funding as it is a pre-requisite for effective sector development, and offers a clear project outcome that can be achieved within a reasonable time frame. Effective implementation of that policy, of course, is often a much more complex and difficult task.

Biomass Energy for Households and Industry

There is very little accurate and current data on the production and use of biomass energy (such as fuelwood and charcoal) in Cambodia. The most recent estimate by the International Energy Agency (IEA) states that conventional biomass energy sources provided around 56% of Cambodia's total energy needs in 2016, including transport fuels. This was down from 70% in 2012, due to increased imports of oil and coal (IEA, 2016). The pioneering "Flowood" study by GERES, a French NGO, in 2014 involved extensive field surveys to try to understand and quantify the flow of biomass through Cambodia's supply chains. This study estimated that at that time domestic cooking represented over 70% of the demand for biomass (Romain, 2015). This was mainly consumed by households as fuelwood or charcoal in cookstoves. Since then there has been significant industrial growth in Cambodia that has increased demand for fuelwood used in steam boilers and brick kilns. A recent study on industrial biomass use by GERES found that garment factories and brick kilns are responsible for most of the industrial biomass consumption. It further estimated, based on field surveys, that 77% of the wood used in garment factories is from forests and the rest is waste wood from managed sources such as rubber or cashew plantations. In brick kilns, the relative proportions are reversed, with 61% of wood being sourced from rubber and cashew plantations, and 39% from forests (Buysman, 2018).

A number of organisations have devoted great time, effort and funds to trying to reduce the pressure on Cambodia's forests from the country's growing demand for energy. Some of these efforts have focused on the supply of biomass, while others intervene in the conversion technologies being used by consumers. On the supply side, some organisations have tried establishing "energy plantations" that sustainably harvest fuelwood using fast-growing species that can be regularly harvested. One of the first was a small community-owned Rural Electricity Enterprise (REE) established in Battambang in 2005 that used a biomass gasifier fuelled by a combination of wood harvested from its own plantation of Leucaena Glyricidia and waste corn cobs to offset diesel consumption in its generator (JICA, 2006).

Two local organisations have developed the supply of a high-quality sustainable cooking fuel source in the form of charcoal briquettes made from sustainable biomass. Sustainable Green Fuel Enterprise (SGFE) is a social enterprise that was established in 2008 to commercialise the supply of sustainable biomass for households. They convert waste coconut and rice husks into charcoal briquettes designed to directly replace traditional charcoal or fuelwood in cook stoves. These briquettes comply with international quality standards and are promoted for their superior energy content and lack of smoke, smell or mess. SGFE estimates that each kilogram of their briquettes offsets 6.6 kilograms of forest wood. SGFE was initially started by GERES and then converted to a social enterprise (SEVEA, 2013). More recently, GERES has started a new sustainable charcoal project, known as Kjuon Go, sourcing wood biomass from sustainably managed community forests in Kompong Thom (GERES, 2018).

The most successful demand-side interventions have been a series of programs to promote improved cook stoves implemented since 1997 by GERES and SNV, a Dutch development organisation (USAID, 2013). These programs have been remarkably effective in terms of market penetration,

to the point that the high-efficiency models are widely available throughout the country and often preferred by consumers. By 2013, the project celebrated the sale of its two millionth improved cook stove (GERES, 2013).

Since then there have been a number of initiatives to promote further-improved cookstove designs. SNV, GIZ (the German development agency) and C-Quest Capital created The Stove Auction, which is an innovative online clearing house for investment, promotion and procurement of improved cookstoves (SNV, 2018). The ACE-1 and Mimi-moto are examples of new stoves with enhanced combustion chambers, some with fan-forced induction and a solar panel that can also charge mobile phones (E4C, 2017).

Household biodigesters have been promoted in Cambodia for over 15 years as a way for households to process manure from livestock to generate biogas, which is then used as a clean fuel in a low-pressure gas stove and for applications such as lighting. A by-product from the biodigester is bioslurry that is a safe and effective fertilizer for crops. In 2006, SNV started what is now the National Biodigester Program (NBP) in Cambodia. The NBP has claimed responsibility for a total of just over 25,000 biodigesters installed around the country since then. Others have also had some success, including ATEC, a social enterprise with a biodigester made of blow-moulded PVC. These are relatively quick and easy to install without skilled masons, unlike traditional designs made from bricks and mortar. The ATEC design also claims to perform well in flood-prone areas, and can be moved if necessary (ATEC, 2018). Program experience in many developing countries has shown domestic biodigester technology to have great potential as a clean and renewable energy option for households with the required minimum number of livestock, and sufficient yard space, in order to be viable (World Bank, 2015).

As mentioned already, the two main industrial uses of biomass energy in Cambodia are for direct firing in brick kilns and in wood-fired steam boilers for various manufacturing, mainly garments (Buysman, 2018). Agricultural wastes, consisting mainly of rice husk, are also used for heat and power generation but in limited volumes. Over the past 15 years, commentators, including this author, have held high expectations for the viability of agricultural residues as a source of renewable energy. However, operators in Cambodia report that supply of biomass at a viable price cannot be secured due to high demand from biomass-fired operations in Thailand and Vietnam. These buyers inflate the price of large and convenient volumes of biomass, for example rice husk at a large rice mill or corn cobs at a large maize processor. Smaller dispersed sources, such as at small mills or crop residue left in the field, are often not viable due to the high cost of collecting and transporting the material (Nam, Minh, & Van De Steene, 2015).

Brick manufacturing is a booming industry in Cambodia due to the construction growth across the country, particularly in Phnom Penh and Sihanoukville. The price of bricks has more than doubled in less than a year due to excess demand, and builders report difficulty in obtaining bricks at any price during some periods (Hor, 2018). A recent study by GERES estimated that there are 876 brick factories in Cambodia and they are fuelled mainly by wood (58%) and rice husk (39%). Most of the

wood (61%) comes from rubber and cashew plantations, with the remainder from forests. Traditionally Cambodian brick factories have used the "boat kiln" design. This is a relatively inefficient design as most of its heat is lost when it is opened and cooled to remove each completed batch of bricks. GERES reports that since 2014 many factories have changed to more efficient kiln designs so that by 2018 it is estimated that over half the kilns are a rotary design and these are used for over 77% of Cambodia's annual brick production. This rotary design is around three times more efficient than the traditional boat kiln design (Buysman, 2018). It is important to note here that there is no evidence of external intervention in the upgrading of the kilns to more efficient designs. The demand, technology and investment appear to have come from the kiln owners. The lack of external intervention may be partly due to concern from international donors about reports of poor working conditions and labour practices in the industry (Brickell, Parsons, Natarajan, & Chann, 2018).

Clearly, significant efforts have been made over more than 20 years to reduce the deforestation caused by Cambodia's heavy reliance on biomass for household cooking and industrial heat. There have been some notable successes, such as the introduction of improved cookstoves and the adoption of more efficient brick kilns. However, the problem of providing low-income rural households and industry with access to clean, affordable and sustainable sources of thermal energy remains arguably Cambodia's toughest barrier in this area.

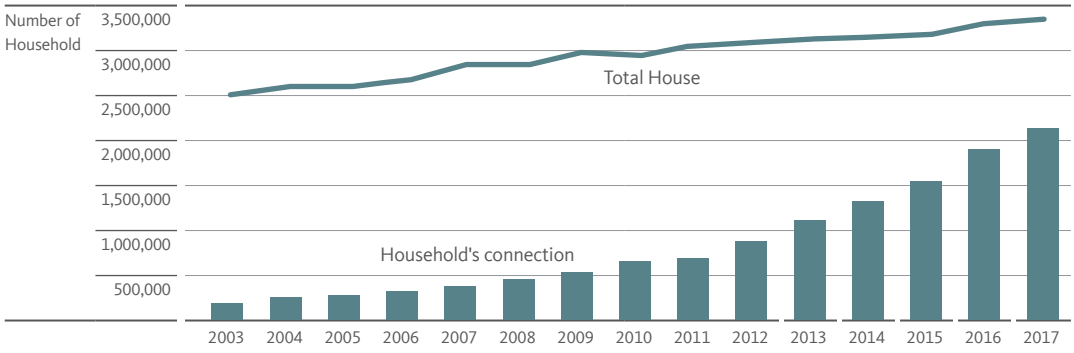
Power Demand

Cambodia's demand for electricity has grown at an average rate of over 19% per year from 2003 to 2017. The peak load on Cambodia's grid reached an all-time peak of 2,283 MW in 2017, which was a big increase from the total load of 205 MW back in 2003. The total energy supplied in 2017 reached 7,966 GWh (EAC, 2018).

Cambodia appears to have achieved significant improvements in the rates of electrification across the country. EAC reports that 69% of Cambodian households were connected to a power grid by the end of 2017, which is up from just 9% in 2003. This is illustrated in Figure 1 below (EAC, 2018). The Ministry of Mines and Energy has stated that by the end of 2018, some 75% of all households and 88% of all villages will be electrified (Chea, 2018).

↘ Figure 1

Growth of household connections to the grid



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total Household (M)	2.50	2.57	2.60	2.67	2.80	2.83	2.94	2.94	3.04	3.08	3.12	3.16	3.18	3.28	3.38
# of Household's connection	0.23	0.27	0.30	0.35	0.41	0.48	0.55	0.67	0.81	0.99	1.19	1.35	1.57	1.91	2.32
% of Household's connection	9.28	10.61	11.78	13.42	14.83	17.22	18.79	22.88	24.17	29.25	38.14	42.72	49.37	58.23	68.64

Source : EAC, 2018

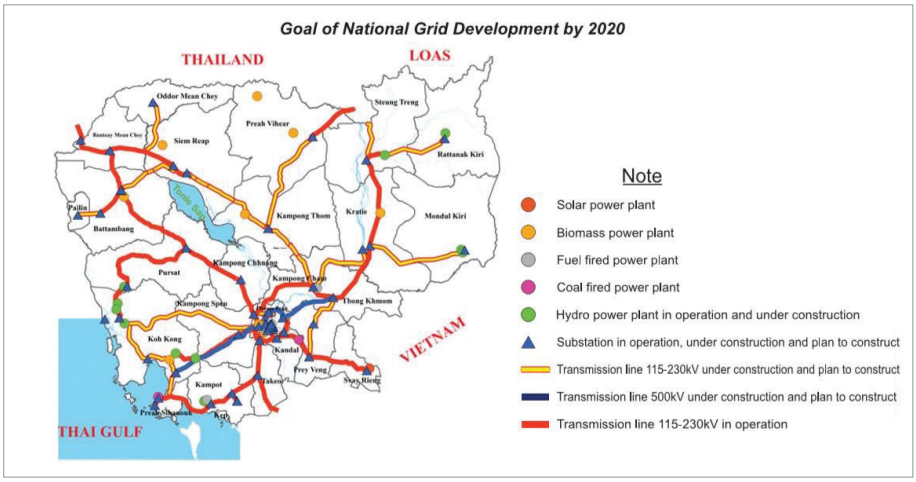
According to a comprehensive survey of households by the World Bank, 98% of households have access to at least one source of electricity: 71.5% on the grid and 26.1% off the grid. However, 70% of households reported frequent power shortages and over 9% said they cannot pay the high cost for electricity (World Bank, 2018a).

Fifteen years ago, the task of providing electricity to rural communities was largely being performed by private entrepreneurs. These Rural Electricity Entrepreneurs (REE), as they became known, would operate in remote rural areas throughout the country and respond to each community's demand for electricity by building their own mini-grid, in lieu of any Government service. Generation was usually an old diesel truck engine and alternator, and the distribution network consisted of wires connecting customers' houses as required. By 2003, these REEs had formed their own association to lobby the Government for fair treatment as the rural electrification market was regulated and the grid was expanded into their areas (Coren, 2003). Today, there are 348 private companies supplying electricity to rural areas under licence to EAC (EAC, 2018).

There is now a national grid network that reaches 21 of Cambodia's 25 provinces. This includes around 2000 km of high voltage transmission line (115kV – 230kV) with over 30 substations. EAC reports that projects currently being planned and implemented will add another 1600 km of transmission line and 19 substations to improve the access and quality of power to a further 25 towns (EAC, 2018). Figure 2 illustrates the existing national grid network and planned expansions.

↘ Figure 2

Planned development of national grid



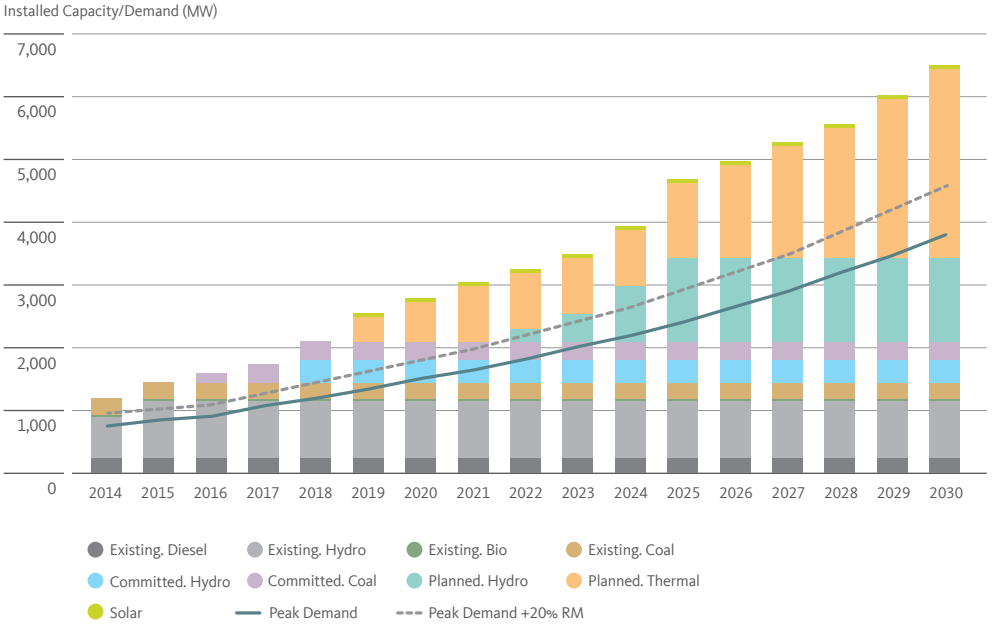
Source : EAC, 2018

Conventional Power Generation

Cambodia's energy planners, regulators and investors have succeeded in the challenge of supplying the country's fast-growing demand for electricity over the past 15 years. As discussed earlier, this has been achieved with a conventional strategy of developing fossil fuel and large hydro generation sources and an extensive transmission network. Interconnectors with Vietnam, Thailand and Lao PDR allow the import of power to supplement local supply. Figure 3 indicates that conventional power will form the majority of the country's energy planning for the foreseeable future, with negligible contribution from renewable energy sources.

↘ Figure 3

Planned expansion of power generation



Source : Pradeep, 2018

EAC reports that Cambodia currently relies on coal-fired power stations and large hydro generators for over 90% of delivered energy, with the balance being imported apart from a small fraction generated by diesel or heavy fuel oil and renewables. A new 350 MW hydropower station in Stung Treng is expected to be commissioned in 2018, while a new 150 MW coal-fired power station in Sihanoukville is expected to be commissioned in 2019 (VDB Loi, 2018b). The Ministry of Mines and Energy has reported that construction will start on two more coal fired power stations, rated at 350 MW each, and expected to be commissioned in 2023 and 2024 (Niseiy, 2018).

Power imports have provided a useful buffer during periods when the development of new local generation lagged behind demand growth. Imports rose significantly from 2007 to 2014, and peaked at around 65% of total demand in 2011. Imports have declined sharply since then and now represent less than 20% of the total supply (Kvammen, 2018). This is consistent with the Government's stated intention to improve self-sufficiency with respect to electricity. The interconnectors may provide an opportunity to export power in the future, particularly given ASEAN's recent commitments to sharing regional energy infrastructure (ASEAN Secretariat, 2016).

Renewable Electricity Generation

Renewable Energy currently represents less than 1% of Cambodia's mix of electricity generation sources, not including large hydro[2]. EAC reported a total of 84 MW of renewable energy power capacity was installed by the end of 2017 and actually forecast this to drop to 72 MW by the end of 2018. Other estimates put the total at over 100 MW, consisting of 31 MW of solar power on commercial and industrial buildings and 62 MW of other renewable power generators such as biomass gasifiers using ricehusk and other agricultural residues (Kvammen, 2018).

Solar

Currently, the largest solar power system in Cambodia is a 10 MW solar park at Bavet near the border with Vietnam. This was developed by a Singaporean company that won a tender by the Cambodian Government in 2016, financed with a US$ 9.2million loan from financiers including the ADB. The system is connected to the national grid and EDC has entered a 20-year contract to buy all the electricity generated at a reported rate of US$ 0.096 per kWh (Pradeep, 2018).

This project is relatively small by world standards today, however it is a very significant project for Cambodia's energy sector for a number of reasons. Firstly, it is the first commercial solar project to be procured by the Government with a competitive tender, and the first solar power system supplying EDC on a commercial basis. Secondly, the contracted rate is cheaper than new coal and large hydro plants in Cambodia, signalling an important tipping-point in financial viability of renewable energy (NHI, 2018). And thirdly, the project took less than 18 months from tender to final commissioning. This is fast compared to the coal and large hydro plants that can take well over five years to develop.

Following the success of the Bavet project, the Government is now planning a 100 MW solar park using the same development model. Feasibility studies were underway in early 2018 and a public tender for the first phase of 60 MW is expected in late 2018 (VDB Loi, 2018a).

The first private commercial solar power system in Cambodia is claimed to be a 114 kW system installed in 2014 in Sihanoukville. This was installed by local firm Kamworks on the roof of Don Bosco Technical School, shown in Figure 2, after securing approval from EDC, and surplus electricity is fed back into the local grid (EEP, 2018).

2. The definition of large hydro varies, but the term is generally used for plants with an installed capacity of over 30 MW (US DOE, 2018). The sustainability of large hydro projects also varies greatly, and its classification as a renewable source of energy has been highly controversial (Galbraith, 2011).

↘ Figure 4

Solar power system installed on the roof of Don Bosco Technical School in Sihanoukville

Source : EEP, 2018

MME estimates that there was 28 MW of solar power capacity installed in Cambodia by the end of 2017, including systems installed on private houses and businesses (Chea, 2017). Table 2 below lists some of the larger solar power systems that have been installed on private facilities recently, mainly in Phnom Penh, with a combined capacity of just over 19 MW.

↘ Table 2

List of significant private solar power systems installed recently in Cambodia

Facility Owner	Installed Solar Capacity[3)]	Data Source
Kampot Cement	7 MW	(McIntosh, 2018)
Capital Concord Enterprise Ltd.	3.1 MW	(Bittner, 2018)
Cambodia Beverage Company (Coca-Cola bottling plant)	2.6 MW	(Master Media, 2017)
Sabrina Cambodia Garment	1.4 MW	(Bittner, 2018)
International School of Phnom Penh	1 MW	(Carbon Markets Express, 2017)
Aeon 2 Shopping Mall	1 MW	(Aeon, 2018)
ISI Steel	1 MW	(Bittner, 2018)
Sheico Phnom Penh	858 kW	(Bittner, 2018)
Aeon 1 Shopping Mall	226 kW	(Sharp, 2014)
US Embassy	226 kW	(USAID, 2017)
Phnom Penh Special Economic Zone	126 kW	(Bittner, 2018)

3. The units for installed solar capacity used here are peak watts which refers to the maximum rated instantaneous electrical power output of the system.

The project at Kampot Cement is a floating system situated on a storage dam, designed with the dual purpose of producing electricity and reducing evaporation in order to conserve water needed for the factory process. There are unconfirmed reports of a 10 MW floating solar system being planned at another cement factory in Kampot.

These private investments in solar power projects indicate a significant trend for the energy sector that is well-advanced in many other countries. There are three main reasons that solar power can be an attractive investment for large electricity customers:

a) for some consumers, it can provide electricity cheaper than grid power bought from the local utility due to the falling cost of solar technology and the avoidance of grid infrastructure costs;

b) it helps manage the risk of rising operating costs by effectively fixing the cost of electricity, or at least of the proportion that is supplied by the solar power system, typically for a 10 or 15 year period; and

c) it can reduce a major source of greenhouse emissions in order to comply with a firm's own goals, or those of a customer.

Growing investments in these types of private solar projects have been accelerated in many countries, including Cambodia, by solar project developers that offer attractive business models that are a form of operating lease. Under this type of arrangement, the customer does not pay for the initial investment of the system, which can be significant, but instead they commit to the purchase of the electricity generated over a fixed period, which is usually at least 10 or 15 years. During the contract period, the solar power system is owned, operated and maintained by a developer who effectively leases the roof space from the customer. After the contract period, the ownership of the system usually reverts to the customer.

The commercial viability of private solar power systems is limited by the new solar regulation that restricts grid connection to large customers, and prevents the export to the grid of excess electricity generation except by special agreement with EDC. Consequently, viability of a solar power system project at any site usually requires hourly power demand to be closely matched to the solar power generation profile at the site. This favours sites with a high daytime load, ideally for 7 days per week.

The viability of large private solar power systems will be improved if the costs of battery storage systems continue to fall, as forecast. Or if EDC agrees to offer a feed-in tariff to purchase the exported excess power at a rate similar to what it pays for large-scale coal or hydro projects. This would allow consumers to maximise the proportion of their energy demands that can be met by solar and also support more distributed electricity generation across the grid, reducing losses and supporting grid reliability and quality.

Biomass

EAC's annual report for 2017 states that four biomass power plants supplied a total of 42 GWh of power to the grid for the year (EAC, 2018). These vary in size from 1.5 MW to 5 MW and are fuelled by wood, rice husk and bagasse (Phnom Penh Sugar, 2013). A 700 kW wood-fired

gasifier was commissioned in March 2018 in Preah Vihear, with plans to expand to 1 MW by the end of 2018. While not particularly large, the project is interesting because it supplies to a rural mini-grid to reduce the cost of power to local residents that currently rely on diesel fuel. The gasifier project is reportedly fuelled by waste wood from local forestry operations (IED, 2018).

It has been estimated that around 150 biomass gasifiers have been installed in rice mills, ice factories and rural electricity suppliers across Cambodia over the last 15 years. These are believed to be relatively small systems, between 100 kW and 300 kW electrical rating, and mainly fuelled by rice husk or fuelwood (Energypedia, 2018). Gasifier technologies from India were first introduced by a local organisation, SME Renewables, as a viable replacement for diesel generator sets (Thust, 2013). An EU funded program to accelerate the uptake of the technology was introduced from 2012 to 2015 (Switch-Asia, 2016). However, a series of market changes in this period reduced the viability of the systems and reduced customer demand. The issues included the decreasing costs of diesel fuel and expansion of the national grid so that an increasing number of rural factories had access to cheaper and more reliable power. Businesses were also reluctant to have trained staff to operate and maintain the gasifier systems that were notoriously unreliable, particularly the locally made versions that were cheaper than the original units imported from India (EMC, 2016).

Wind

Wind energy has not offered much potential in Cambodia despite a number of efforts to assess its potential over the past 15 years. A single 250 kW wind turbine was installed near the port of Sihanoukville in 2009 with support from the Government of Belgium (WES, 2010).

A Singaporean renewable energy developer, The Blue Circle, is developing Cambodia's first commercial wind farm. Located on private land in Kampot, the 13 MW first phase is expected to be commissioned in 2019. The company has already built the first phase of a 90 MW wind farm in Dam Nai in southern Vietnam. They have been conducting wind energy assessments in Cambodia since 2014 and believe there is potential for at least 500 MW of wind power capacity here (SEA Globe, 2018).

Power Prices

Cambodia has some of the most expensive electricity tariffs in the region (Derbyshire, 2015). Prices are regulated by EAC and are uniform across the country, except for 47 licensee areas that are not connected to the grid, i.e. they generate their own power (EAC, 2018).

One of the Government's key objectives in its development plans and strategies is to reduce the cost of electricity. This is seen as an important pre-requisite for sustained economic growth, although Cambodia's high energy prices have not prevented it from being one of the best economic performers over the past 20 years (McKinsey, 2018).

EAC reports that power prices have fallen across all consumption categories. The reductions range from around 7% for small EDC customers in Phnom Penh up to around 50% for some customers of rural licensees (EAC, 2018). EAC does not provide details on how these reductions were

achieved, however in early 2018 the Minister of Mines and Energy announced that EDC had subsidised electricity tariffs to a total value of US$ 51 million during 2017 (Sok, 2018). While politically popular, providing energy subsidies is an unsustainable and expensive business, particularly in a country with such a strong growth rate in its demand for electricity.

Regional Context

Cambodia's neighbours and fellow ASEAN member countries provide valuable perspectives on the development of their energy sectors. It is no surprise that Vietnam and Thailand have close to full rates of electrification and that their citizens consume, on average, 5 to 10 times what a Cambodian citizen consumes (World Bank, 2017b). The advanced state of each country's renewable energy industry is less obvious but provides some excellent case studies for Cambodia's development.

Vietnam had over 3,400 MW of renewable energy installed as of June 2018, representing 7.8% of the country's total generation. This consisted mainly of small hydro, followed by biomass and wind with a small but growing proportion of solar. The country's renewable energy targets policy calls for 6 GW of new generation by 2020 and 27 GW by 2030. There is currently 6.1 GW of utility-scale renewable energy projects in the development pipeline, of which wind and solar account for over 2 GW each.

Thailand had over 7,600 MW of renewable energy generation as of June 2018, representing 17% of the country's total. This consists of over 40% each of solar and biomass, just over 11% of wind power and the remainder of small hydro. Most of the new capacity added in the last year was from wind power projects. There are over 3.8 GW of renewable energy projects in the pipeline, with about 2 GW consisting of biomass projects and the remainder split almost evenly between wind and solar power projects (BNEF, 2018a).

The ASEAN member nations have agreed on a joint target of obtaining 23% of the group's primary energy mix from renewable energy sources by 2025. However, the policies that are currently in place, or being developed, are forecast to achieve only 17% renewable energy in the power mix by 2025 (ASEAN Post, 2018). An important conclusion then is that if Cambodia aims to graduate to middle-income status and become a more powerful force in the region, then its neighbours will also expect Cambodia to step-up to commitments such as the renewable energy target. Fortunately, there is no shortage of examples to follow in the region in terms of clean energy policy and project development.

3. Current Progress on SDG 7

The SDGs are defined in very brief and simple language. This helps to engage a global audience of stakeholders, with a wide range of expertise. However, it prevents the accurate measurement and verification of progress towards the goals. This is mainly because terms are not clearly defined, data sources are not specified and methodologies are not provided in order to track each indicator. The problem is exacerbated in countries like Cambodia by the lack of reliable and consistent data and a verified baseline for some of the indicators. Issues such as these are to

be expected with an undertaking as ambitious as global SDGs, and should not be an excuse for inaction. Each of the indicators has been assigned a custodian institution, such as the World Bank, the International Energy Agency (IEA), or the International Renewable Energy Agency (IRENA), to be responsible for ensuring appropriate data and methodologies are available. This is a work in progress as there is still a lack of clarity around some of the indicators (ODM, 2018). In Cambodia the Ministry of Planning is leading a process to develop more appropriate customised indicators if necessary, in consultation with the other line ministries.

A good example of the lack of clarity is the SDG definition of access to electricity. Traditionally this is based on a binary indicator – is a household connected to the grid or not? However, this is not satisfactory because a grid connection does not guarantee a minimum level of energy services. In fact, a stand-alone solar power system may provide superior energy services than connection to the available local grid in many areas.

The World Bank's ESMAP program developed a new survey methodology, called the Multi-Tier Framework (MTF), to address this issue for access to both electricity and clean cooking fuels. Rather than a simple binary indicator, the MTF assesses seven attributes for electricity and six attributes for modern energy cooking solutions. Based on the assessment of these attributes, each house is placed on a spectrum that ranges from Tier 0 (minimal access) to Tier 5 (most access).

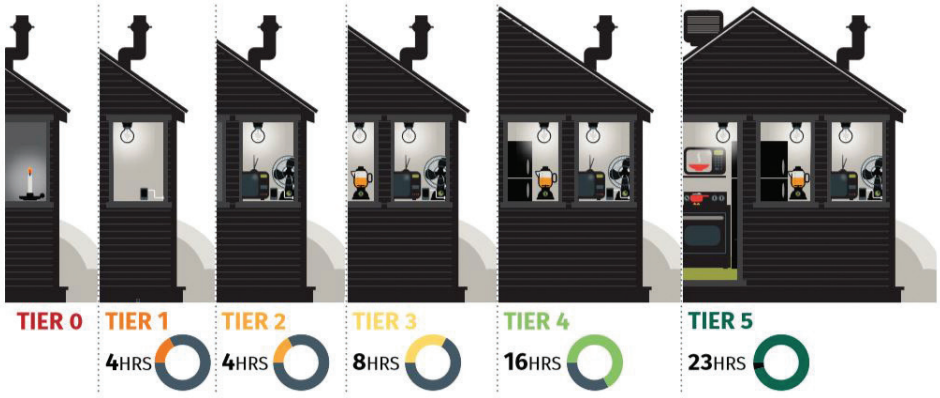
Cambodia was one of the first three countries chosen to participate in an energy access survey using the MTF in 2017. The report, released in July 2018, provides valuable data for the assessment of Cambodia's progress on SDG 7 in terms of access to electricity and clean cooking fuels.

Access to Electricity

The MTF methodology uses the following attributes of electricity access: capacity, availability, reliability, quality, affordability, formality, and health and safety. The definitions of tiers with respect to electricity access are illustrated in Figure 3 below. Each tier is defined by the duration of access, and also the capacity of the supply. This is depicted below by the increasing number and size of the loads in the house for each tier, up to tier 5 that has multiple large appliances including an air conditioner (the full definitions of each tier are provided in the source report).

↘ Figure 5

MTF tiers of access to electricity

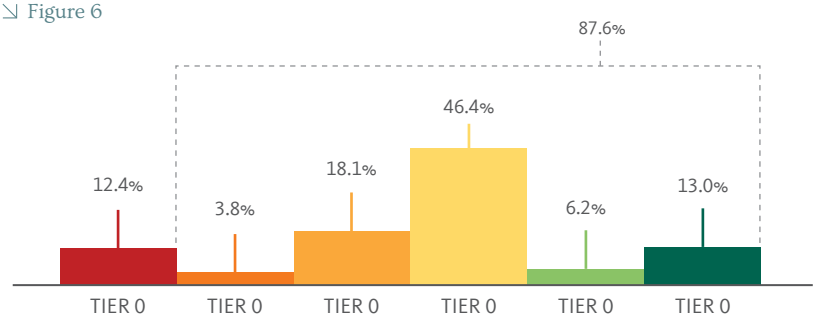


Source : World Bank, 2018a

The results from the Cambodian MTF survey are illustrated in Figure 6.

↘ Figure 6

Results of MTF Survey of electricity access in Cambodia



Source : World Bank, 2018a

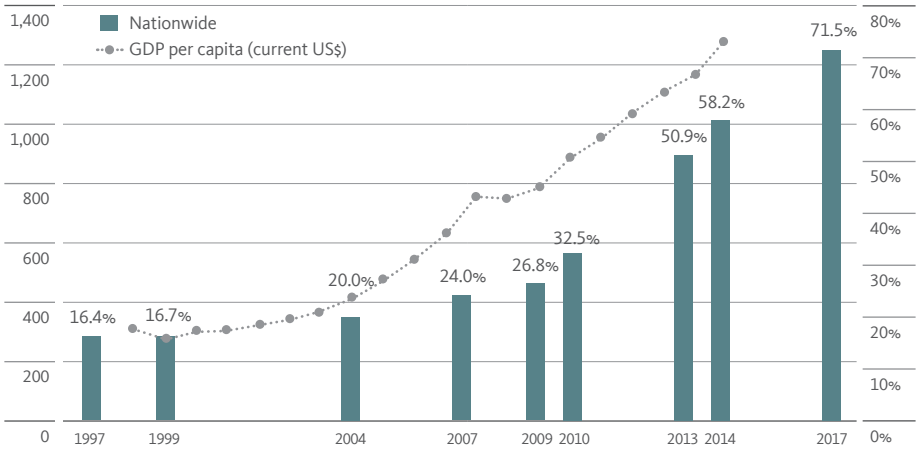
This suggests that only 13% of households have access to a high level of electricity consumption for at least 23 hours per day. This paints a far different picture to the simple electrification rate that is based on whether a household has a grid connection or not. The report concludes that while most households are placed at Tier 3 for electricity access, it's mainly their experience of poor grid reliability that prevents them from reaching a higher tier (World Bank, 2018c).

The MTF survey report provides rich data on the situation found during the survey period, but it does not directly help with measuring trends in progress towards SDG 7 because there is no baseline data for 2015 with which to compare. Unfortunately, the official data source for Cambodia which is specified by the data custodians for SDG 7 is problematic. It is only available for 2014 and 2016, and actually reports a decrease in the proportion of population with access to electricity over that period from 56% to 50% (World Bank, 2018c). This is assumed to be a data anomaly as there is no reported reason for the electrification rate to have dropped.

The EAC reports that the number of households connected to a commercial regulated power grid grew from 42.7% in 2014 to 68.6% in 2017 (EAC, 2018). While this is not an independent data source, these figures are actually more conservative than the World Bank's socioeconomic survey data, as indicated in Figure 7. This data does not provide any indication of the quality of connections provided, but it does give a clear indication of progress towards the first SDG7 target (World Bank, 2018a).

↘ Figure 7

Grid electrification rates and GDP in Cambodia since 1997



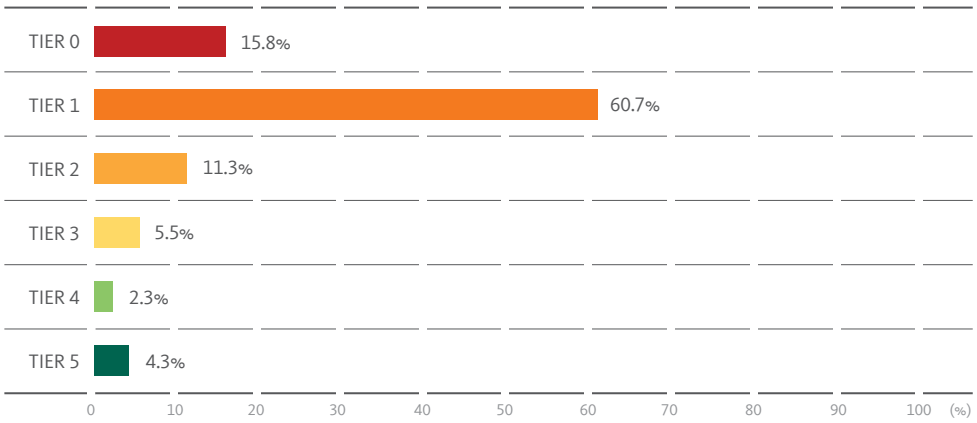
Source : World Bank, 2018a

Clean Cooking Fuels

The attributes of cooking fuels considered in the MTF survey are affordability of the technology, exposure to pollutants while cooking, availability of fuel, and the convenience, safety and efficiency of the technology. The methodology and definition of each tier are found in the study report, and Figure 8 below depicts the results from the Cambodian survey (World Bank, 2018a).

↘ Figure 8

Results of MTF survey of access to cooking fuel in Cambodia



Source : World Bank, 2018a

This distribution indicates that 78.5% of households are classified in tiers 1 or 0, with a very low access to modern cooking solutions. Due to the MTF method's broad assessment, it's possible that some households in these low categories actually use a clean LPG stove, but they receive a low score because they also use a fuelwood stove. This "fuel stacking" or "stove stacking", where households use more than one fuel or technology, is common in Cambodia and could be expected to distort surveys based on binary indicators (World Bank, 2018a).

Once again, this rich MTF data is valuable, but without a 2015 baseline, it does not allow an analysis of progress towards the SDG 7 target. The reference data for this indicator suggests that the proportion of Cambodia's population with access to clean cooking fuels has increased from 15% in 2014 to 18% in 2017. The 2017 figure appears to agree with the MTF data, if the proportions of households with tiers 3, 4 and 5 are combined with half of tier 2. In any case, the data does not show significant progress in this area and suggests this SDG 7 target may be the most difficult for Cambodia to achieve (World Bank, 2018c).

Proportion of Renewable Energy

The IEA is the source of official data for tracking progress of the SDG7 renewable energy target. Unfortunately, this data is only available for 2014 and 2015, and the calculations behind the data are not clear. It reports a figure of 65% for the proportion of the country's energy consumption that comes from renewable sources. This figure may be based on an incorrect assumption that a high proportion of the household biomass energy use is renewable, such as from waste sources rather than forests. The IEA does classify large hydro as renewable, but this should not have a significant impact since electricity is a relatively small proportion of the total energy consumption. In any case, it does not agree with any other data discussed

in this paper. EAC reports that the amount of electricity generated from renewable energy, not including large hydro, has nearly tripled from 2014 to 2017, albeit from a small base. However, as a proportion of total generation, it has only increased from 0.55% in 2014 to 0.75% in 2017, due to the large growth in other generation. Based on these results, it is reasonable to conclude that progress needs to improve substantially in order to reach this SDG target by 2030 (EAC, 2015) (EAC, 2018).

Energy Efficiency

The indicator for the SDG 7 target on energy efficiency is the energy intensity of the economy. This is measured in units of energy consumed (in mega-joules) for each unit of economic output (in US dollars). Data on the total energy consumed by the economy is difficult for a country like Cambodia where the majority is in the form of unregulated and informal biomass consumption. The official IEA data set for Cambodia's energy balance is only available for 2014 and 2015, and in fact reports that Cambodia's energy intensity increased slightly over this period, although it is similar to other countries in the region, as indicated in Table 3 (World Bank, 2018c). Once again, it is clear that progress will need to improve significantly in this area in order for Cambodia to meet its SDG 7 target for energy efficiency.

↘ Table 3

Energy intensity of Cambodia and its neighbours

Country	Energy Intensity (MJ / US$ PPP 2011)		
	2014	2015	2030 Target
Cambodia	5.6	5.8	2.9
Vietnam	5.7	5.9	2.95
Thailand	5.6	5.4	2.7
Lao PDR	3.9	5.2	2.6

Source : World Bank, 2017b

Policy Performance

This paper opened with a summary of the policy framework that has been developed in Cambodia's energy sector over the past 15 years. There has been no shortage of plans, strategies and reports on the energy sector. However, it's unclear to what extent the current policy framework has been effective in helping Cambodia progress toward its targets under SDG 7.

The World Bank's Regulatory Indicators for Sustainable Energy (RISE) program was initiated in 2014 with the aim of providing a consistent and relevant framework to assess and benchmark the extent to which a country's policies were suitable to encourage the uptake of sustainable energy. This assessment is based on three main "pillars" that align with the targets of SDG 7: energy access, energy efficiency and renewable energy. Table 4 shows that Cambodia is ranked sixth out of the eight ASEAN countries that were included in the RISE analysis for 2016 (World Bank, 2017a).

↘ Table 4

RISE indicators for selected ASEAN countries

Country	Energy Access	Energy Efficiency	Renewable Energy	Overall Score
Vietnam	100	71	64	78
Thailand	100	63	60	74
Malaysia	100	52	68	73
Philippines	82	42	67	64
Indonesia	61	34	55	50
Cambodia	70	21	34	42
Myanmar	59	13	43	38
Lao PDR	47	8	46	34

Source : World Bank, 2017a

Some analysis in this field has questioned the usefulness of the RISE methodology, as the data currently does not suggest a causal relationship between a good RISE score and achievement of effective progress towards sustainable energy targets (Moss & Portelance, 2017). In Cambodia's case, however, the ranking does seem to agree with the other sources and analysis presented here, which indicate that Cambodia is lagging in the region in each of the three targets.

4. Challenges to Cambodia's Progress on SDG 7

The SDGs are intended to be ambitious and challenging for all 193 signatory countries. However, some SDGs will be harder for some countries, due to their specific circumstances. Cambodia faces a number of challenges in achieving SDG 7, some of which are unique to its situation and others that are common to many countries.

Business as Usual Implications

Perhaps the greatest challenge to increasing the proportion of renewable energy is the inertia required to change the mindset and development path of Cambodia's electricity industry. This inertia is manifested in existing policy, committed project pipelines, commercial arrangements and vested interests, to name a few. These challenges apply to the electricity industry as well as the market for cooking fuel.

The target of increasing the proportion of renewable energy in the electricity generation mix will trigger many of the same challenges that are faced in other developing countries. Conventional power planning is based on large baseload power stations and transmission networks that require long lead times for planning, financing and construction. Consequently, Governments are often bound by contractual obligations for projects already in the pipeline, even if cheaper and more attractive options emerge.

The first step to address this challenge will be to ensure that the imminent

revision of the Power Development Plan incorporates world's best practices and accurate cost forecasts for all available technologies and fuels. This should be used as an opportunity to adjust Cambodia's electricity sector onto a more sustainable and competitive development path.

Stranded Assets and the "Death Spiral"

Governments often have a financial interest in maintaining the status quo of the power supply. Even if they don't have a direct investment in existing power stations, they will probably have a contractual obligation to pay for any electricity generated by them, even if that power is no longer needed in the network. The same goes for the use of transmission infrastructure, some of which is privately owned in Cambodia. This can provide a strong disincentive for the Government or private owners to encourage embedded generation, energy efficiency or new renewable energy generation.

The alarming term "death spiral" has been used in developed countries to describe the worst case scenario that could be caused when increasing proportions of customer-owned solar power systems are installed "behind the meter". As more customers generate their own power, the Government or utility finds it harder to recover a return on their investments in power stations and transmission. They compensate by raising the tariffs for the remaining customers. However, this motivates more customers to invest in their own solar power, which further exacerbates the problem. Eventually, it is assumed there would be a cascade of plunging load and diminishing revenue. At that point, the generating and transmission infrastructure would become "stranded assets" for which the original investment can't be recovered.

There is also a social equity implication of the "death spiral". It has been observed already in developed countries that it is usually poorer households that are left relying on the grid because they can't afford to invest in solar power or storage. Therefore, they suffer from the impacts of the higher tariffs as utilities attempt to recover investments (Latimer, 2018).

The availability of affordable battery storage systems, coupled with behind-the-meter solar power, will further reduce the demand for grid power. This is because by investing in additional panels, users can generate enough power during the day to cover both daytime and night-time demand, and thus minimise their demand from the grid. This could be expected to further damage the viability of grid operation.

However, a number of grid operators in developed countries are trialling a different business model that treats private battery storage as a "virtual power plant". This is based on the concept that with appropriate incentives and controls a fleet of private batteries distributed throughout the grid network can be harnessed to balance supply and demand. This may even prove to be faster and more economical than the utility building and operating its own generating infrastructure (Shibata, 2018).

Fuelwood is Too Cheap

The issue of cooking fuels in Cambodia has not attracted nearly the amount of attention or funding that the development of the electricity market has in Cambodia over the past 15 years, yet there have still been significant efforts to improve the situation as already described here. There are multiple challenges in this market, but the main ones are related to fuel cost and culture. While Cambodia has had strong economic growth and has managed to halve poverty rates, it still had over 14% of the population below the poverty line, mostly in rural areas, according to the last survey in 2014 (World Bank, 2018b). This in itself is a significant challenge because the cleaner and more sustainable cooking fuel options are more expensive. This highlights the importance of "transition technologies" such as improved cookstoves for Cambodia in order to provide a viable solution for low-income households.

Charcoal and wood fuel remain the cheapest option for cooking fuel in Cambodia, even in urban areas. So clean fuel options such as LPG, electricity or biogas are difficult to sell and limited to peri-urban areas. In addition, Cambodians traditionally prefer meat to be cooked over a fire, rather than on an electric or gas cooktop. Consequently, it is common for even wealthy households to use a wood cookstove in addition to a gas or electric stove (World Bank, 2018a). Improved cookstoves have achieved considerable success over 20 years in terms of high market penetration and development impacts. However, this is the result of around 20 years of hard and consistent program activities by GERES and others in Cambodia.

Prioritising energy efficiency

Across the world, programs to improve energy efficiency face two similar challenges: human nature and the "split incentive" phenomenon. Human nature seems to determine that many of us have a strong aversion to spending money in order to save money. Energy efficiency projects are often very good investments that directly reduce operating costs and improve profits, but they often struggle to attract capital in an organisation.

The term "split incentive" refers to the common situation in which the owner of an appliance, facility or home does not directly benefit from potential efficiency improvements. An example is where the landlord of a leased factory has no incentive to improve the efficiency of lighting or air conditioning because they don't pay the electricity costs.

These issues are relevant in Cambodia where manufacturing facilities are often leased. The problems are exacerbated because many businesses operate on short planning horizons due to the uncertain nature of many aspects of business, including the regulatory framework and market dynamics. If a business operator is uncertain about the viability of the business in the coming 6 or 12 months, then they will be unlikely to make energy efficiency investments, even if they expect a payback within that period.

5. Opportunities for Cambodia to Achieve SDG 7

Achieving the SDGs is obviously a huge challenge for Cambodia, but the outlook is not all negative. There are some opportunities to accelerate progress, and also some secondary benefits that should provide some of the motivation that will be required to make the significant changes necessary.

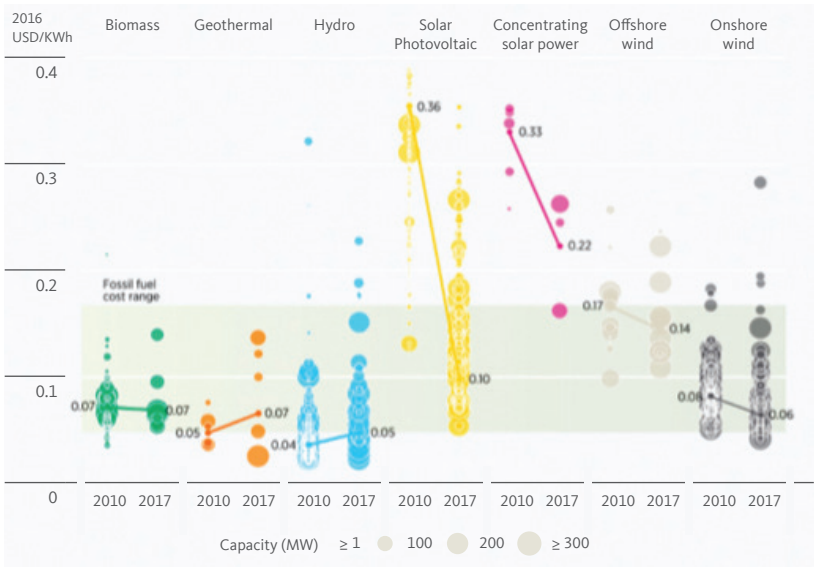
Renewable Energy is the Cheapest Option

The most compelling reason for Cambodia's electricity industry to shift to renewable energy is that it is now the cheapest option for new generation. This tipping point has been discussed and forecast for years, but it has arrived sooner than most commentators expected. The remarkable cost reductions have been reported in two separate reports, both released recently.

The first was by the International Renewable Energy Agency (IRENA), an inter-governmental body that represents 153 countries. IRENA has collated a database with detailed data on over 15,000 utility-scale renewable energy projects around the world and releases an annual report with an analysis of the price and performance trends. Each circle in Figure 9 represents a project from the database with its diameter indicating the project capacity in MW and its centre representing project cost against the y-axis. The thick lines are the global weighted average levelised cost of electricity for each technology. This analysis used a weighted average cost of capital of 7.5% for OECD countries and China, and 10% for the rest of the world. The shaded band indicates the cost range for fossil fuel powered generation (IRENA, 2018).

↘ Figure 9

Global levelised cost of electricity from utility-scale renewable power generation technologies, 2010-2017

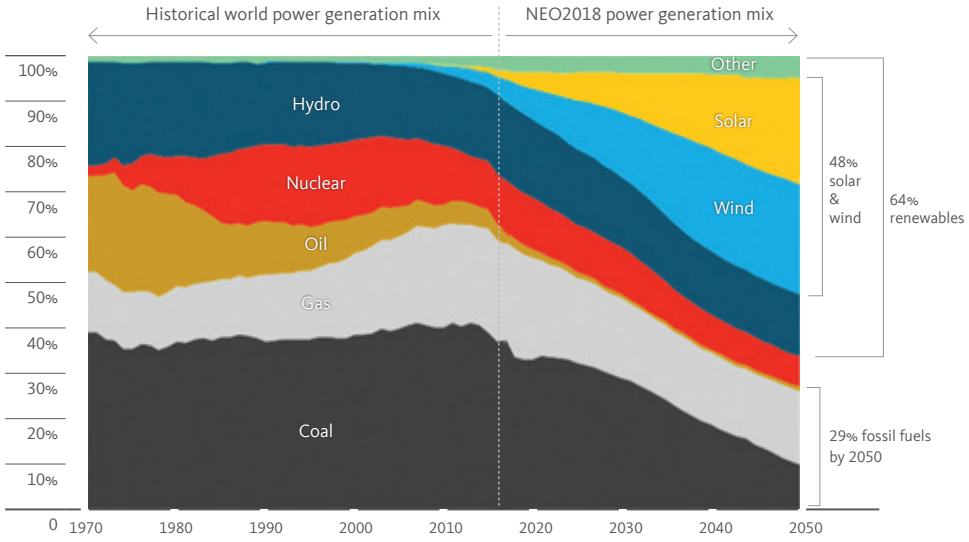


The huge cost reductions illustrated in Figure 7 are attributed to improvements in the technology, competitive procurement on an increasing scale, and the growing base of internationally active project developers (IRENA, 2018).

The second report is the New Energy Outlook 2018 produced by Bloomberg New Energy Finance each year. This private organisation sells its services to large investors that require accurate and evidence-based analysis and forecasts. The report is the outcome of a detailed process of modelling the least-cost mix of technologies to meet expected energy demand profiles in every major economy in the world. The conclusions in this report are stark: solar and wind are already cheaper than coal, and by 2050 over half of the world's power will be generated from renewable energy as illustrated in Figure 10 (BNEF, 2018b).

↘ Figure 10

Global energy mix forecast to 2050



Source : BNEF, 2018b

Energy Efficiency is Win-win

Despite the challenges of improving energy efficiency, as discussed in the previous section, the benefits go far beyond cost savings or environmental outcomes. Manufacturing represents a significant proportion of Cambodia's economy, with the garment industry alone making up over 40% of GDP in 2017. Just as important as the income it generates, the sector also employs over 800,000 workers and therefore it plays an important role in society. Cambodia's garment sector is largely competitive due to low wages and preferential trade agreements with the EU and the US. However, these relative advantages cannot be expected to last forever. In fact, wage levels in Cambodia are already increasing (Spiess, 2018). Since Cambodia is expected to graduate from least-developed-country status, its preferential trade access to the EU and US is expected to be lost by 2030 (Jayant, 2018).

Energy represents a significant proportion of production costs for most factories. A survey of garment factories in 2009 found that energy made up 17% of production costs, on average, but reached up to 60% at one site. An effective energy efficiency program should achieve savings of at least 30% in a poor-performing facility with ageing equipment. This should be achievable in Cambodia's garment factories that have been documented as having poor equipment maintenance and energy efficiency (IFC, 2009).

Improving energy efficiency directly delivers cost savings and improved profits, but just as important are two other benefits. Firstly, the business is insulated from future energy price volatility because energy costs become a smaller proportion of operating costs, so any increases have less of an effect on profits. Secondly, if the program is implemented well, the business will have a greater level of control over energy productivity. This means that the relationship between energy inputs and product outputs will be better understood, more consistent, and more controllable. It is not unreasonable to expect a plant engineer to be able to accurately forecast the facility's energy bill in advance each month, based on the significant drivers of energy consumption (e.g. production mix, volume and climate conditions).

This level of understanding of the plant's performance means that production efficiency can be continually optimised, and the potential effects of external shocks (e.g. energy prices, climate, production etc.) can be accurately modelled and managed.

Fast and Flexible Projects

The only certain thing about the future of the energy sector in any country is that there will be significant change. Some of the likely changes have already been discussed here, including shifts in grid demand and generation costs. The rate of change often surprises the observers forecasting these trends. These changes present a significant risk for the Government of Cambodia if it continues to rely on its conventional power development strategy of large, slow and expensive power stations. Increasing the penetration of renewable energy in the generation mix can help the Government manage the risk of change. This is because technologies such as solar and wind power are highly modular – they can be built in stages, relatively quickly, to match growing demand.

Switching away from Biomass

The unsustainable consumption of biomass is arguably Cambodia's greatest energy challenge. It has been particularly difficult in the past because there have not been easy alternative energy sources for the main end uses of biomass: household cookstoves, industrial steam boilers and brick kilns. Switching to LPG or biogas is not viable for most households and factories due to cost or lack of biogas feedstock.

However, as discussed earlier there is a global trend toward the use of electrical appliances for thermal applications in manufacturing industries. This is partly driven by the trend towards what has been termed "Industry 4.0" that offers much improved efficiencies, productivity and control through the greater use of automation, communications, metering and control technologies. This type of shift has seen traditional gas or biomass steam boilers being replaced by technologies such as industrial electric heat pumps (A2EP, 2018).

Similarly, electrical cooking appliances are available to substitute for most fuelwood stove uses, with the exception of charring meat. Electric rice cookers, microwaves and induction or resistive grills are not new and prices have reduced significantly. It can be expected that as the size of Cambodia's aspirational middle class grows, so will the demand for modern and convenient electrical cooking appliances (UNDP, 2007).

This presents an opportunity for Cambodia to "leap-frog" to the new technology and manufacturing methods. The potential benefits would be to regain Cambodia's manufacturing competitiveness, improve household health and convenience, and significantly reduce the volume of biomass being harvested unsustainably. Of course, the viability of such a shift would be determined by the costs of upgrading to the new appliances and the cost and capacity of the available power source.

Another option for thermal energy demands in manufacturing is solar thermal collectors. Modern systems can be designed for a wide range of required temperatures, pressures and flow rates of steam or

hot water. An interesting example of what this technology is capable of can be found at the Sundrop tomato farm that was commissioned in South Australia in late 2016. This farm produces 15,000 tonnes of tomatoes each year which are sold under a 10-year contract to one of Australia's largest supermarket chains. The interesting part is that the farm is located in a remote arid region of South Australia with no access to fresh water, and is completely self-sufficient. The facility has a world-first solar thermal system consisting of 23,000 heliostat mirrors, across 50,000 square metres, which focus sunlight onto a receiver tower standing 127 metres tall. This system heats salt water, pumped in from the ocean, and stored in tanks. This is converted to steam to drive a turbine to generate all the site's power and the condensate is then used to irrigate the plants (Aalborg, 2015).

The Critical Elements are Ready

The impressive achievements of Cambodia's politicians, planners, policy makers and project developers over the past 15 years could help accelerate a shift to a more sustainable energy mix. In fact, it could be argued that Cambodia is well positioned for such a shift.

The Government bodies, plans and strategies are already in place to develop the required changes. As has been discussed earlier, most of the strategies and plans already describe a "green growth path", energy independence, affordable energy and greenhouse gas mitigation. So it is arguably an easier task to adjust the plans to specifically describe a shift to renewable energy, rather than start from scratch. In addition, Cambodia's ASEAN neighbours can offer a wide range of experience in terms of Government policy drivers that are effective (and some that are not) to stimulate growth in renewable energy generation.

The transmission and distribution network was designed for transporting power from a few large power stations to the capital, and out to each of the provinces. Consequently, medium and high voltage transmission lines are relatively accessible in many areas of the country where large renewable energy generation projects could be located. A recent ADB study concluded that the existing transmission network is aligned well with Cambodia's solar resources (Pradeep, 2018).

Another crucial element in Cambodia's favour is an existing pool of project developers, financiers and suppliers that are ready and willing to invest in renewable energy projects in Cambodia if the demand is clear. Similarly, there is no shortage of diverse projects both in Cambodia and in neighbouring countries that demonstrate how renewable energy projects can be successfully developed. As discussed earlier in this report, there is 11 GW of renewable energy generating capacity already installed in Thailand and Vietnam, consisting mainly of solar, wind and biogas. These projects are directly relevant to Cambodia's situation.

Financing for sustainable energy projects should be plentiful as a growing number of investment funds around the world choose to divest from fossil fuel projects and target more sustainable projects (McKinsey, 2018).

The Demand for Sustainability

The global fashion industry is one of the largest costumers for Cambodia's goods and services, with the garment sector representing around 40% of GDP (Spiess, 2018). However, as discussed previously, Cambodia faces

intense competition in this sector from a number of other developing countries. This competition has traditionally been based on the cost of finished goods landed in the end market, largely determined by a country's production costs and trade agreements. However, increasingly the procurement criteria of large garment brands also include sustainability factors. These consider social sustainability factors, such as workers' welfare, safe work environments and equitable pay rates. They also consider environmental sustainability including local pollution and greenhouse gas emissions. The use of clean energy and energy efficient practices is becoming an important criterion for approval by the brands (IFC, 2009).

This presents a good opportunity for Cambodia to improve its international competitiveness by increasing the proportion of renewable energy in its generation mix. This could be done by contracting more commercial grid-connected generation such as the Bavet solar park, as well as encouraging large users to invest in their own solar power by relaxing connection rules and offering a reasonable feed-in tariff. The benefits of such a move could be an effective boost to the competitiveness of other export-oriented sectors too, such as rice manufacturers and tourism.

6. Conclusion

Cambodia has made clear progress over the last 20 years in rebuilding a destroyed economy. This is particularly evident in its electricity sector. There has also been significant work on developing various Government strategies, policies and plans for green growth and general sustainability. Unfortunately, these documents seem to have largely been left on the shelves as economic growth has been prioritised above all else.

This paper has suggested Cambodia is coming to a point where sustainable development no longer competes with economic growth, but is a necessary pre-condition, even in the short term. In this regard, the commitment to achieve SDG 7 by 2030 is well timed as it provides an effective framework for Cambodia to make a fundamental shift towards a more sustainable future.

Substantial progress has already been made towards the first of the SDG 7 targets and Cambodia is on-track to achieving full access to electricity by 2030. Progress has been very limited on the targets regarding renewable energy and energy efficiency, but rapid gains are possible as has been demonstrated in Vietnam and Thailand. Fortunately, the cost of clean technologies has dropped to the point where Cambodia's economic interests are aligned with sustainability targets.

Current progress and future prospects are not so positive for the target of increasing the access to clean and affordable cooking fuels. Despite impressive efforts of some organisations over the past 20 years, there are few viable solutions to significantly reduce the unsustainable use of forest wood for household cooking. Increasing household wealth may be the best solution because people will naturally move to more modern cooking fuels and technologies as they can afford them. The more that low income and rural households can enjoy the benefits of the country's economic growth, the faster this transition will happen.

References

A2EP. (2018). Replacing steam with electricity technologies to boost energy productivity - A Guide for Business. In J. Jutsen, A. Pears, D. A. Mojiri, & L. Hutton (Eds.). https://a2ep.org.au : Australian Alliance for Energy and Productivity (A2EP).

Aalborg. (2015). 36.6MWth Integrated Energy System based on CSP, Australia. In. https://www.aalborgcsp.com : Aalborg CSP.

ADB. (2015). Renewable Energy Developments and Potential in the Greater Mekong Sub-Region. In. www.adb.org/publications : Asian Development Bank (ADB).

ADB. (2018). TA-9600 REG: Southeast Asia Energy Sector Development, Investment Planning and Capacity Building Facility - PDP Power Development Plan (52096-001). In. https://selfservice.adb.org : ADB.

AECOM. (2009). Cambodia Rural Electrification Strategy and Implementation Plan - Final Report. In. http://documents.worldbank.org : The World Bank and AusAID.

Aeon. (2018). A new entertainment shopping mall to be opened in north Phnom Penh. In. https://www.aeon.info: Aeon Co. Ltd.

ASEAN Post. (2018). Renewable energy challenges for ASEAN. In. https://theaseanpost.com : The ASEAN Post.

ASEAN Secretariat. (2016). Masterplan on ASEAN Connectivity 2025. In. https://asean.org : ASEAN Secretariat.

ATEC. (2018). ATEC Biodigesters. In . https://www.atecbio.com/ : ATEC International.

Bittner, S. (2018). The PV Market in Cambodia (presentation to Intersolar, 21 June 2018). In. https://www.german-energy-solutions.de : GIZ.

BNEF. (2018a). 2018 Southeast Asia Renewable Energy Outlook - Presentation. In C. Chua (Ed.). https://about.bnef.com/new-energy-outlook/ : Bloomberg New Energy Finance.

BNEF. (2018b). New Energy Outlook 2018 (Presentation by Colleen Regan to EuroCham Briefing August 2018, Phnom Penh). In. https://about.bnef.com/new-energy-outlook/ : Bloomberg New Energy Finance.

Brickell, K., Parsons, L., Natarajan, N., & Chann, S. (2018). Blood Bricks: Untold Stories of Modern Slavery and Climate Change from Cambodia. In. London: Royal Holloway University of London.

Buysman, E. (2018). Feasibility study of a credit-line program for energy efficiency projects in Cambodia. In. Phnom Penh, Cambodia: GERES Cambodia.

Carbon Markets Express. (2017). Cambodia: Introduction of solar panel Power Generation at an International School [Asian Gateway Corporation]. In. https://www.carbon-markets.go.jp.

Castanedaa, M., Jimeneza, M., Zapataa, S., Francoa, C., & Dynera, I. (2017). Myths and Facts of the Utility Death Spiral. In. www.researchgate.net : Elseveir.

Chea, V. (2017). New solar and wind power project unveiled. Khmer Times (26/12/2017).

Chea, V. (2018). Cambodia on course to have all villages electrified by 2020. Khmer Times (9/3/2018).

Coren, M. (2003). Rural power suppliers fear state pulling plug. Phnom Penh Post (14/3/2003).

de Ferranti, R., Fullbrook, D., McGinley, J., & Higgins, S. (2016). Switching On: Cambodia's Path to Sustainable Energy Security In. www.mekongstrategic.com : Mekong Strategic Partners.

deJong, R. (2017). Sustainable Energy through Sustainable Consumption Practices in Cambodia. In. http://www.oneplanetnetwork.org : World Scientific Publishing Company.

Derbyshire, W. (2015). Cambodia – In Depth Study on Electricity Cost and Supplies. In S. Hong (Ed.). http://www.seac-cambodia.org: Government Private Sector Forum and Cambodia Chamber of Commerce.

DOE, U. (2018). Types of Hydropower Plants. In. https://www.energy.gov/eere/water: US Department of Energy.

E4C. (2017). Tackling Indoor Air Pollution in Northern Cambodia with Improved Cookstove Technology. In. https://www.engineeringforchange.org: Engineering for Change (E4C).

EAC. (2015). Report on Power Sector of the Kingdom of Cambodia 2015 (based on 2014 data). https://www.eac.gov.kh: Electricity Authority of Cambodia

EAC. (2018). Salient Features of Power Development in Kingdom of Cambodia (EAC's Consolidated Report for Year 2017). https://www.eac.gov.kh: Electricity Authority of Cambodia

EDC. (2016). Electricite du Cambodge Annual Report 2016. In. https://www.edc.org/annual-report: Electricite du Cambodge.

EEP. (2018). Application of solar energy in Don Bosco Technical School, Cambodia. In . http://www.eepmekong.org:Energy and Environment Partnership Programme with the Mekong Region (EEP Mekong).

EMC. (2016). Challenges with Rice Husk Gasifiers in Cambodia. In . http://www.emergingmarkets.asia: Emerging Markets Consulting.

Energypedia. (2018). Cambodia Energy Situation. In . https://energypedia.info: Energypedia.

GERES. (2013). 2 million improved cookstoves distributed across Cambodia. In . http://www.geres.eu: GERES.

GERES. (2018). Kjuongo sustainable charcoal good for you, good for Cambodia forests. In . www.kjuongo.com: GERES.

Hor, K. (2018). Brick prices climb to towering highs on demand from Sihanoukville. Phnom Penh Post (6/3/2018).

IEA. (2016). IEA Energy Balance - Sankey Diagrams. In . https://www.iea.org: International Energy Agency.

IED. (2018). Energy, source of development. In. https://www.ied-sa.fr: Innovation Energie Develloppment (IED).

IFC. (2009). Energy Performance in the Cambodian Garment Sector - A Benchmarking Survey. In D. A. Sandra, S. Oum, D. Isabelle, V. Richard, G. Steve, & P. Huon (Eds.). https://betterwork.org: International Finance Corporation (IFC) and the International Labour Organisation (ILO).

IRENA. (2016). Policies and Provisions for Private Sector Renewable Energy Mini-grids. In V. Salvatore, N. Divyam, P. Bishal, P. Nico, R. Michael, & G. Chris (Eds.). https://www.irena.org: International Renewable Energy Agency (IRENA).

IRENA. (2017). Biogas for Domestic Cooking - Technology Brief. In. https://www.irena.org: International Renewable Energy Agency.

IRENA. (2018). Renewable Power Generation Costs in 2017. In. https://www.irena.org: International Renewable Energy Agency.

Jayant, M. (2018). Planning Cambodia's Future. Khmer Times (4/10/2017).

JICA. (2006). The Master Plan Study on Rural Electrification by Renewable Energy in the Kingdom of Cambodia. In. http://open_jicareport.jica.go.jp: Japan International Cooperation Agency (JICA).

Kvammen, M. (2018). Cambodia's Energy Sector - A Snapshot. In. Presentation to EuroCham Breakfast Briefing, Phnom Penh on 30 August 2018.

Latimer, C. (2018). Buy now, pay later app aims to be Afterpay for rooftop solar. The Sydney Morning Herald (7/10/2018).

Master Media. (2017). Cambodia's Biggest Rooftop Solar System Installed At Coca-Cola Factory. In. https://www.b2b-cambodia.com: Master Media (Cambodia).

McIntosh, B. (2018). Energy Lab Newsletter September 2018. EnergyLab Asia

McKinsey. (2014). Southeast Asia at the crossroads: Three paths to prosperity. In. https://www.mckinsey.com: McKinsey & Company.

McKinsey. (2018). Outperformers: High-Growth emerging economies and the companies that propel them. In. https://www.mckinsey.com: McKinsey & Company.

Moss, T., & Portelance, G. (2017). Does the World Bank RISE to the Challenge of Measuring Energy Access? In. https://www.cgdev.org: Centre for Global Development.

Nam, N. H., Minh, H. D., & Van De Steene, L. (2015). A critical look at rice husk gasification in Cambodia: technology and sustainability. In: International Forum on Green Technology and Management (IFGTM) July 2015, Hue, Vietnam.

NHI. (2018). Sustainable Hydropower Development Alternatives for the Mekong: Maintaining the Flows that Nourish Life (Summary Presentation). In Briefing for 3i Working Group. https://n-h-i.org: National Heritage Institute (NHI).

Niseiy, S. P. (2018). Energy-hungry Cambodia shows no sign of backing down on coal (13/9/2018). In. https://www.eco-business.com . Eco Business

ODM. (2018a). SDG 7 Affordable and clean energy. In. https://opendevelopmentmekong.net: Open Development Mekong (ODM).

PH.D, P. H. (2018). Toward a Low Carbon Energy Transition in Cambodia. In. http://www.enrichinstitute.org: Enrich Institute.

Phnom Penh Sugar. (2013). Phnom Penh Sugar Company Ltd - Electricity Distribution. In . http://phnompenhsugar.com: Phnom Penh Sugar Ltd.

Poch, K. (2013). Renewable Energy Development in Cambodia: Status, Prospects and Policies. In K. S, P. H, & J. B (Eds.), Energy Market Integration in East Asia: Renewable Energy and its Deployment into the Power System, ERIA Research Project Report 2012-26 (pp. 227-226). Jakarta: ERIA.

Pradeep, T. (2018). Cambodia's First Solar Park (Presentation to Asia Solar Energy Forum 5 June 2018). In. https://d2oc0ihd6a5bt.cloudfront.net: ADB.

RGC. (2013). Cambodia Climate Change Strategic Plan 2014 - 2023. http://www.camclimate.org.kh: National Climate Change Committee, Royal Government of Cambodia (RGC)

RGC. (2014). National Strategic Development Plan 2014 - 2018. http://www.mop.gov.kh: Royal Government of Cambodia

RGC. (2016). National Biodiversity Strategy and Action Plan. https://www.cbd.int: National Council for Sustainable Development, Royal Government of Cambodia

RGC. (2018a). Draft Environmental and Natural Resources Code of Cambodia - Tenth Draft. https://data.opendevelopmentmekong.net: Interministerial Working Group, Royal Government of Cambodia

RGC. (2018b). General Conditions For Connecting Solar Generation Sources To The Electricity Supply System Of National Grid Or To Electrical System Of A Consumer Connected To The Electricity Supply System Of National Grid. https://www.eac.gov.kh/site/regulation: Electricity Authority of Cambodia, Royal Government of Cambodia

RGC. (2018c). PM Reminds All Eligible Voters of Forthcoming National Election. In . http://pressocm.gov.kh: Office of the Council of Ministers, Royal Government of Cambodia.

Romain, J. (2015). Biomass Energy Consumption Patterns in Cambodia: Challenges and Opportunities (Summary Presentation). In. http://www.eurocham-cambodia.org: GERES Cambodia.

SEA Globe. (2018). The Blue Circle: unlocking the region's renewable energy potential. South East Asia Globe (5/10/2018).

SEVEA. (2013). SGFE Biomass Energy and Renewable Charcoal Briquettes - Case Study. In. https://www.seveaconsulting.com: Sevea Consulting.

Sharp. (2014). Sharp Receives Order to Supply Solar Power Generation Systems for Aeon Mall Phnom Penh in Cambodia. In. http://www.sharp-world.com: Sharp Corporation.

Shibata, N. (2018). Home and car batteries to help power Japan's grid. Nikkei Asian Review (11/10/2018).

Sivhuoch, O., & Sreang, C. (2015). Ou, S., & Chheat, S. (2015). Analysis of Cambodia's Preparedness for the Implementation of Sustainable Development Goals: Challenges, Opportunities and Financing. In. http://www.ccc-cambodia.org: Cooperation Committee for Cambodia.

SNV. (2018). The Stove Auction. In. http://www.thestoveauction.org: SNV and C-Quest Capital.

Sok, C. (2018). Poor households given $51m in energy subsidies. Khmer Times (25/1/2018).

Spiess, R. (2018). A sector too big to fail? Phnom Penh Post (5/4/2018).

Switch-Asia, E. (2016). Sustainable biomass technology enhances Cambodia's rice milling sector - Case Study. In. https://www.switch-asia.eu: EU Switch-Asia.

Thust, S. (2013). SME: energy sector needs to be organised. Phnom Penh Post (22/3/2013).

Tilleke & Gibbons. (2018). A Break in the Clouds: Regulating Cambodian Solar Energy. In. https://www.lexology.com: Tilleke & Gibbons International Ltd.

UN. (2015). Cambodia submits its climate action plan ahead of 2015 Paris agreement. In . https://unfccc.int: United Nations Framework Convention on Climate Change.

UNDP. (2007). Energy and Poverty in Cambodia: Challenges and the Way Forward. In. http://www.undp.org: United Nations Development Program (UNDP).

USAID. (2013). Cambodia Market Assessment for Improved Cookstoves - Sector Mapping Presentation. In. https://cleancookstoves.org: Domrei Research and Consulting, USAID.

USAID. (2017). Remarks by Sean Callahan, acting Mission Director of USAID Cambodia at the Cambodia Solar Workshop. In . https://www.usaid.gov: USAID.

US DOE. (2018). Types of Hydropower Plants. In. https://www.energy.gov/eere/water: US Department of Energy.

VDB Loi. (2018a). Cambodia Legal Update: New Solar Park Project Receives Approval from the Council of Ministers. In. http://www.vdb-loi.com: VDB Loi.

VDB Loi. (2018b). Cambodia power sector update. In. http://www.vdb-loi.com: VDB Loi.

WES. (2010). Sihanoukville Cambodia Hybrid Project. In. https://windenergysolutions.nl: Wind Energy Solutions (WES).

World Bank. (2015). The State of the Global Clean and Improved Cooking Sector. In V. Putti, M. Tsan, S. Mehta, & S. Kammila (Eds.). https://openknowledge.worldbank.org: The World Bank.

World Bank. (2017a). Regulatory Indicators for Sustainable Energy 2016 - A global scorecard for policy makers. In S. G. Banerjee, A. Moreno, J. Sinton, T. Primiani, & J. Seong (Eds.), A Global Scorecard for Policy Makers. http://documents.worldbank.org: The World Bank.

World Bank. (2017b). World Development Indicators. In . http://databank.worldbank.org: The World Bank.

World Bank. (2018a). Cambodia Beyond Connections: Energy Access Diagnostic Report Based on the Multi Tier Framework. In R. Dave, S. Keller, K. Bonsuk, G. Fleurantin, E. Portale, & D. Rysankova (Eds.). http://documents.worldbank.org: The World Bank.

World Bank. (2018b). The World Bank in Cambodia - Overview. In. https://www.worldbank.org: The World Bank.

World Bank. (2018c). Tracking SDG7: The Energy Progress Report In. https://www.irena.org: The World Bank, IRENA, IEA, UN, WHO.

WWF. (2016). Power Sector Vision Towards 100% Renewable Electricity by 2050 - Greater Mekong Region - Cambodia Report. In. http://greatermekong.panda.org: World Wildlife Fund for Nature (WWF).

IV

Sustainable Cities and Communities

7.
Building Urban Resilience to Disasters : A Discourse of Phnom Penh city, Cambodia

8.
Cambodia's Green Urban Development Program

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Sothun Nop[1) 2)]

Building Urban Resilience to Disasters: A Discourse of Phnom Penh city, Cambodia

With the experience of increasing urban shocks and stresses, building urban resilience has become a common agenda for many countries. Similar to other developing nations, Cambodia has attempted to realize its goal of urban resilience through enhancing critical institutional and priority-sector reforms. This study aims to examine the capital Phnom Penh's performance regarding the process of building urban resilience to disasters. In this regard, key prospects and challenges for promoting resilience of urban areas of the city are critically reflected through the lens of the Rockefeller Foundation's 100 Resilient Cities measurement framework. This qualitative study is based on a review of existing literature and primary information collected during fieldwork between April 2016 and July 2018. NVivo (Pro 11) was used for coding and analyzing the qualitative data, and the Framework Analysis Approach was employed for structuring and synthesizing the obtained data. It is concluded that, despite the presence of a roadmap and strategies for building urban resilience to disasters, Cambodia will need to be on a long journey to realise this goal. This is due to ineffective policy implementation, lack of clear mechanisms to balance the priority sectors, and the absence of holistic and clear urban land-use plans to ensure sustainable and inclusive urban development.

1. Introduction

The 2030 Agenda for Sustainable Development (SD), emphasizing the two-way relationship between poverty reduction and environmental sustainability, has focused on achieving climate stability and enhancing resilience (Casado-Asensio et al., 2016). Its Goal 11 has specifically focused on transforming cities to be more inclusive, safe, resilient and sustainable (UN Habitat, 2016; United Nations (UN), 2017). Resilience is a multi-disciplinary concept which has been increasingly considered and applied in various fields such as psychology, economic geography, disaster studies and environmental planning (Davoudi et al., 2012, p. 301). Davoudi and Madanipour (2015) further suggest that, when resilience was applied in the social context, the principle of self-organization has been translated as self-reliance, which Swanstrom (2008, p. 10) calls the ability of people and place to “pull themselves up by their bootstraps and reinvent themselves in the face of external challenges”. In the process of building resilience in the UK, for instance, improving self-reliance has been a cornerstone of resilience that is a crucial contributing factor for planning theories and

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practice (Davoudi et al., 2012). In this regard, they view resilience as a contested concept, resilience as a fundamental agenda and resilience as a structure or framework for policy and implementation. Resilience can be increased through good systems of self-organization, adaptive capacity and redundancy because these help increase the ability to adjust, adapt to change and persist against adversity (Carpenter & Brock, 2008; Liao, 2012).

While some view resilience in the context of responding to sudden impacts such as natural disasters (Alberti et al., 2003; Pickett et al., 2004), it is, however, not a concept that is limited to dealing with a single adversity, but a multidisciplinary concept that incorporates recovery, persistence, and the transformative and adaptive abilities of social-ecological systems (Biggs et al., 2012; McPhearson et al., 2015; Walker et al., 2004). In relation to this, resilience has been an important concept in the planning, design and management of urban social-ecological systems, with the aim of promoting urban resilience (McPhearson et al., 2015). Schewenius et al. (2014) claim that a social-ecological approach is critical for safeguarding resilience in the city and promoting the well-being of urban humans through supplying ecosystem services in the long term. McPhearson et al. (2015), moreover, emphasize that there is a need for recognizing and integrating the multiple ecosystem services in governance and planning in order to protect the urban ecosystem. Once urban planning and governance for social-ecological resilience are enhanced, along with the management and preservation of improved diversity, quantity and quality of urban ecosystem, resilience can be upgraded at multiple levels.

Evolution of Urban Resilience Thinking

The concept of 'urban resilience' is perceived differently among scholars and development practitioners. Vale and Campanella (2005) define urban resilience as "the capacity of the city to rebound from destruction", with the focus on whether the city has recovered in quantitative terms, its economy, population or built form (Davoudi et al., 2012). Leichenko (2011) confirms that urban resilience refers to the ability of the city or urban system to resist a wide range of stresses and shocks - climate change, for instance, is considered as one of the major stresses facing cities. 100 Resilience Cities (2018) views urban resilience as "the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience". Jha et al. (2013), moreover, demonstrate that urban resilience is translated into a new paradigm for the process of urbanization. It goes beyond risk mitigation and focuses on increasing preparedness and the capacity to respond swiftly to a disaster and recover from it faster. It must also be part of everyday urban development, medium - and long-term investment and planning, urban governance and hazard management. In relation to this, Mehmood (2016, p. 413) defines urban resilience as "a proactive rather than reactive view to planning, policy making, and strategic steering in which communities play a vital role for resilience place shaping through their capacity for active learning, robustness, ability to innovate and adaptability to change". He further emphasizes

that resilience of an area or a place not only refers to the possibility of formulating the immediate response to disaster events such as floods, earthquakes or storms, but also considers long-term adaptation and mitigation strategies in confronting social, environmental and economic challenges. Bruneau et al. (2003) define seismic resilience as the ability of a system to reduce the chances of a shock, to absorb such a shock if it occurs and to recover quickly after a shock. They argue that a resilient system is one that shows reduced failure probabilities, reduced consequences from failures, in terms of lives lost, damage, and negative economic and social consequences, and reduced time to recovery (restoration of a specific system or set of systems to their "normal" level of functional performance).

Why Resilience is Crucial in Contemporary Urban Development

As many cities have actually or potentially faced a range of adversities, resilience thinking has been considered as the tool to respond to those problems. Eraydin and Tasan-Kok (2012) argue that integrating resilience thinking into development policies and planning is required in the face of rising economic, social and spatial vulnerabilities, rapid exhaustion of natural resources and ineffective resource management. Since cities in the 21st century are confronting a range of adversities and challenges such as rapid rural-urban migration, insufficient infrastructure, pandemics and climate-related disasters, resilience is what helps cities cope with and prepare for both expected and unexpected disturbances (100 Resilience Cities, 2018). The same author further indicates that through a resilience lens, the policies and projects can be better designed, leading to addressing simultaneously multiple challenges, improving service deliveries and ensuring resources efficiencies. McPhearson et al. (2015) highlight that, in climate-change impacts in the absence of resilience in ecological, economic and social factors, disturbances can move the trajectories of urban systems away from sustainability. In this regard, integrating resilience thinking into urban planning, local development planning and local strategies for climate-change adaptation is extremely important for formulating urban resilience and promoting sustainability (Davoudi et al., 2013).

2. Urban Development Trends in the Cambodian Context

Cambodia, over the past 15 years, has experienced sustained economic growth, the result of the flourishing of national and international investment and innovative economic development initiatives (Diepart et al., 2016; Nam, 2017). The diversification of key sectors including agriculture, garment exports, tourism and, more recently, construction and real estate has brought about huge economic growth and offered new directions for development (Diepart et al., 2016; World Bank, 2018). Institutional arrangements and procedures, particularly the process of decentralization and de-concentration, have brought more political and administrative responsibilities. This has increased the functions and roles of sub-national governments in managing resources and in promoting infrastructure and other development activities, which is beneficial for the entire population (Diepart et al., 2016).

Along with the positive trend in economic growth, rapid urbanization has occurred noticeably, leading to an increase in the density of people in the

centre and surrounding areas of Phnom Penh City, Shihanouk Ville and Tole Sap Great Lake (Pen, 2016). He further indicates that about 90% of Cambodian people live in these areas, which covers a total land area of less than 40% of the total land area in Cambodia. The huge growth rate of urban populations has been associated with natural causes and with the rural-to-urban migration (Biswas & Tortajada, 2010) of people seeking job opportunities in various sectors, including the garment industry, and the construction, tourism and the entertainment sectors (Abraham et al., 2015; Yavuz, 2010). However, while the motivation of many rural-to-urban migrants is to seek employment, job opportunities and incomes are poor, leading to high rates of urban poverty, with approximately 55% of urban families living in slums in Cambodia in 2014 (UN Data, 2015).

Phnom Penh : A Fast Growing City

Urbanization in Phnom Penh has substantially increased in the last decade. Noticeably, the city's area has almost doubled because many communes from nearby provinces were integrated into the city in 2010. Currently, Phnom Penh covers a total area of 678 km², administratively divided into 12 Khans (districts), 96 Sangkats (communes) and 909 villages (Trac, 2015). This expansion has fed demand for national and international investment. The rapid growth of the construction sector, especially real-estate investment, has helped achieve the goal of economic growth in response to the needs of the rising city population, an increase from 1.13 million to 1.50 million between 1998 and 2008, and rising to 1.85 million in 2012 (Phnom Penh Capital Hall, 2017; Trac, 2015). According to JICA (2014) cited in World Bank (2018), the urban population of Phnom Penh city is projected to increase to about 2.86 million by 2035.

Critiques, however, have argued that Phnom Penh's speedy growth has been mostly unplanned, leading to urban sprawl and increased urban stress such as traffic and congestion (World Bank, 2018). The literature suggests that, as a consequence of unplanned urban development, the city has been confronted with many other issues. These include land conflict and forced evictions, leading to insecure shelters(Bugalski & Pred, 2009; Flower & Fortnam, 2015; McFarlane, 2012; Mgbako et al., 2010; NGO Forum on Cambodia, 2014); declining urban ecosystems, leading to a limited urban capacity to cope with natural hazards (Bugalski & Pred, 2009; Flower & Fortnam, 2015; Yen et al., 2016; Yen et al., 2017); limited public services, causing low living standards and incomes (Biswas & Tortajada, 2010; Flower & Fortnam, 2015; Khemro & Payne, 2004); and pollution, causing health problems (Denney, 2016; Flower et al., 2017; Kum et al., 2005). As well, the city has encountered a number of stresses including floods, heatwaves and landslides, which required immediate solutions to the problem of building urban resilience (Flower & Fortnam, 2015).

Furthermore, there are concerns regarding the sustainable urban development of Phnom Penh. Nam (2011) demonstrates that, while modern, often controversial, construction makes Phnom Penh one of the most lucrative real estate markets in the region, an official master plan for city development remains absent. The development of the city

has often followed a mixed approach, based on the perception of investors and government bodies. While Phnom Penh city is on the way towards modern development (Irvine et al., 2015), VannMolyvann(2003) has raised the concern that the development process has not followed the best path. In this regard, the development activities which have brought about the decline in urban ecosystems and wetlands tend to move in the opposite direction to eco-city planning. The current trend in urban development has compromised the capacity of urban ecosystems, had negative impacts on emerging climate-related hazards such as floods and heat waves and exacerbated urban vulnerabilities, especially the poor communities in lowland and slum areas (Flower & Fortnam, 2015).

In confronting current disturbances and responding to future concerns, the Cambodian government has ratified global policies and declarations as a commitment to achieving universal goals, particularly the goal of building inclusive, resilient and sustainable cities. In this frame, the government has attempted to increase city resilience through establishing and amending urban development policies, promoting instructional reform and strengthening stakeholder collaboration. While Cambodia is determined to build resilience, there is limited study on how well this effort has been implemented and accomplished over time. This study, therefore, aims to reflect on the city's performance in the process of building urban resilience to disasters. In this regard, the main prospects and barriers in constructing resilience in the urban areas of Phnom Penh will be critically analyzed.

Since the efforts in urban resilience building are continuing, it is crucial to conduct this study. Weichselgartner and Kelman (2014) argue that by addressing and detailing challenges, urban resilience can be effectively enhanced. Through critical reflection on stakeholder performance on urban resilience building tasks, key prospects and potential barriers can be identified, which can possibly lead key actors to perform their tasks better by looking at their past experiences. The study results can be used as supporting documents for policy makers and urban development practitioners in establishing holistic and just urban development policies and guidelines for addressing contemporary urban challenges. The empirical study can also be a useful database, contributing to scholarly discussions as well as benefiting further study on similar topics and context.

3. Methods

This study has selected Phnom Penh city of Cambodia for analysis because it is a city in a developing country where a resilience building attempt has been promoted in a rapid urbanization process. Within the complex system of urban areas, the analysis of this case focuses on crucial empirical evidence showing the real challenges and opportunities in promoting urban resilience in the Cambodian context.

Many frameworks have been developed for the measurement of urban areas, including the UN Habitat disaster measurement system, the Rockefeller Foundation's 100 Resilient Cities measurement framework, a New Zealand based method, the system produced by the Strategy Alliance and the method developed by the Global X Network (Ilmola, 2016). This author further indicates that there is no good or bad in these approaches; they were established for specific purposes, different objectives, principles,

methods and data. In this regard, this study employs the Rockefeller Foundation's 100 Resilient Cities framework for the analysis of Phnom Penh city's performance in building urban resilience because the available information best fits this framework; Phnom Penh was included in 100 Resilient Cities project.

This resilience framework was established in 2014 (updated in late 2015) by the Rockefeller Foundation in partnership with the global design firm Arup (Rockefeller Foundation, 2015). This framework is an outcome of the 100 Resilient Cities project aimed at assisting individual cities to be more resilient and, at the same time, to facilitate the construction of a global practice of resilience among individuals, governments, private sectors and NGOs (Ilmola, 2016; Rockefeller Foundation, 2015). The Rockefeller framework combines four key dimensions of urban resilience: leadership and strategies; health and wellbeing; economy and society; and infrastructure and environment. Each of these key components is split into three more-detailed elements: Leadership and Strategy focuses on the promotion of leadership and effective management, the empowerment of a broad range of stakeholders and the promotion of long-term and integrated planning. Health and Wellbeing looks at the urban capacity to meet basic needs, support livelihoods and employment, and to ensure the availability of public health services. Economy and Society analyzesthe promotion of cohesive and engaged communities, the insurance of social stability, security and justice, and the fostering of economic prosperity. Infrastructure and Environment observes the provision and enhancement of protective natural and man-made assets, the insurance of continuity of critical services, and the provision of reliable communications and mobility (Figure 1).

↘ Figure 1

City resilience framework

Source : Rockefeller Foundation (2015).

This qualitative study relies on both secondary and primary information. The secondary data were gathered through reviewing existing peer-reviewed articles and reports from government agencies and development partners such as NGOs and donor agencies. The primary data were collected at a national workshop on 'The Development of Phnom Penh City: Challenges and Solutions', conducted in late April 2016 in Phnom Penh city, Cambodia. This workshop was a platform for relevant stakeholders including government officials/ representatives (from MLMUPC, MOE, MPWT and Municipality), private-sector representatives, NGO donors, academics and urban-planning experts to discuss their concerns regarding the contemporary development of Phnom Penh city. The information collected from this workshop was used for critical reflection on the performance of the city in the process of transforming urban areas to become more resilient places.

Eight Focus Group Discussions (FGDs), with the involvement of approximately 40 participants, including villagers, community representatives and village leaders were conducted. These FGDs were organized to help understand the overall development of outlying urban communities and to discuss the communities' capacity in preparing and responding to the potential shocks and stresses. FGDs were also platforms for discussing the extent that communities and stakeholders are involved in the local development planning process. In addition, Twelve Key Informant Interviews (KIIs) were conducted with community leaders, commune chiefs, local NGO staff, private-sector representatives and academics/ researchers. The aim of the KII was to gather information related to the overall progress and challenges of the current development of Phnom Penh, the establishment and implementation of the main policies and guidelines for the development of the urban areas, the involvement of stakeholders in the urban development planning and the possible way forward for building Phnom Penh city to become a resilient place. The process of primary data collection was conducted between January 2016 to May 2018. It took approximately one and half hours for each FGD and about 45 minutes for each key KII. The qualitative data from the national workshop, FGDs and KIIs were recorded as audio files and transcribed. Non-participant observations were also conducted to observe the real situation in the field and to capture relevant pictures. The process of data quality verification was conducted by the researcher before moving on to the process of data coding and analysis. NVivo (Pro 11) was used for coding and analyzing the qualitative data, and the Framework Analysis Approach was employed for structuring and synthesizing the obtained information.

4. Results and Discussion

In the process of building urban resilience, many extensive works of government agencies and relevant stakeholders have been progressively put into operation. The overall city performance in accomplishing this long-term goal is reflected through key dimensions and drivers clustered in the Rockefeller Foundation's resilience framework as follows.

Leadership and Strategy

Leadership and strategies concern with the processes of promoting effective leadership, inclusive decision-making, empowered stakeholders,

and integrated planning. In this dimension, the key drivers are included and analysed.

Promote Leadership and Effective Management

By recognizing the emerging shocks and stresses in urban influenced by rapid urban expansion and climate change pressure, the Cambodian government has formulated its strategic inventions to respond to the issues. Study found that several decrees and sub-decrees have been developed to enhance leadership and effective urban management amongst public and private institutions. For example, the Ministry of Land Management, Urban Planning and Construction (MLMUPC) and the City Hall have taken leadership roles in establishing overall city master plans in collaboration with Ministry of Environment (MoE), Ministry of Public Works and Transport (MPWT) and donor agencies. The overall city master plans including Spatial Planning, Land Use Planning, Transportation Master Plan, Waste Water and Solid Waste Master Plan are the important roadmaps leading to long-term growth of urban areas. The MLMUPC, moreover, has been preparing the amendment of Land Law that was established in 2001 and the 1994 Law on Land Management and Constructions to improve the effectiveness of urban management of land ownership (Pen, 2016).

Land-use policy reform has also been conducted to enhance institutional arrangements and the roles of working groups in performing their tasks effectively. As suggested by Diepart et al. (2016), the royal decree NS/RKT/0512/463 was issued to form the National Committee on Land Management and Urban Planning (NCLMUP). This committee involves multiple ministries and acts as the main institution to lead the spatial-planning process in Cambodia. Based on this decree, the MLMUPC was assigned as the secretariat of the NCLMUP. Decree No. 77, moreover, was issued in 2012 to promote the decentralisation process. The subnational authorities at provincial, municipal, district and Khan levels have been empowered to facilitate and formulate sub-national spatial planning. Later on, the sub-decree 'No. 42 ANKR. BK', which focused on urbanisation of capital, municipalities, and urban areas, was issued and disseminated in April 2015. This sub-decree specified the scope, contents and procedures in establishing three distinct urban physical plans, the Urban Detail Plan, the Land Use Plan and the Master Plan/Land Use Master Plan.

As part of building urban resilience, the policy legislations for promoting green growth city have been considered and improved. A high representative of the General Secretariat of National Council for Sustainable Development (GSSD-NCSD), MoE, reveals that in the face of climate change pressure, the Royal Government of Cambodia (RGC) has increased more attentions to preserve environment and natural resource in urban areas. The government has focused on and promoted sustainable green growth in the city and included these into the rectangular strategies phase 3. The national polices of the RGC focuses on balancing 4 main pillars including economic, environment, social and cultural domains in the face of CC. To achieve these, the RGC has established national polices such as National Policy on Green Growth, National Strategic Plan for Green Growth 2013-2030, and National Strategic Plan for CC Adaptation 2014-2023.

In this regard, Mohammed et al. (2013) positively view that the National Green Growth Roadmap for Cambodia (NGGR) has anticipated prospects for balancing key sectors such as culture, society, environment and economy, which are often controversial and traded off against each other in contemporary development processes. The green growth model, formed through multi-stakeholder consultation, is expected to result in sustainable livelihoods, inclusive economic development, poverty reduction and societal well-being. Apart from economic expansion, the green growth approach supports the creation of institutions and strengthening their capacity to implement the existing initiatives and activities, and formulating opportunities for stakeholders to participate and shape decisions for long-term development. For Mohammed et al. (2013), the political stability, constant economic growth, acceptable government capacity, fairly low carbon lifestyle, available natural resources, and the progress of IT and innovation are the main drivers assisting Cambodia to achieve its green growth goal.

While urban policy legislations have been established and continuously updated, the clear leadership to carry the implementation remain unclear. The results from KIIs reveal that cross departments and inter-ministerial collaborations seem to be well-accepted in the early stage but become less active later on as the consequence of losing group momentum and unclear working mechanism. More workload in individual department/institution has resulted in more pressures for focal persons assigned to join working group. The recent study of the World Bank (2018) similarly reveals that lack of clear leadership has brought about ineffective urban management, thereby creating a barrier for promoting sustainable urban development of Phnom Penh city.

Ineffective execution of urban development policies and activities is also connected to the lack of resources. FGD and KII participants demonstrate that insufficient human and financial resources remainkey barriers preventing the city government from effectively implementing its urban policies. This is consistent with the existing literature arguing that although urban-development policies have been viewed as potential contributors to the improvement of public services (Chan, 2009), to security of tenure and livelihoods (Khemro & Payne, 2004), to the economic situation and to poverty alleviation (Diepart et al., 2016), implementation of these policies remains restricted. This is because Cambodia has also encountered a number of difficulties including poor awareness, low capacity in managing the economy, inadequate inter-sectoral collaboration, extensive inequality and injustice, inadequate investment in education and low investment in the renewable energy sector (Casado-Asensio et al., 2016; Dany et al., 2016; Mohammed et al., 2013).

Empower a Broad Range of Stakeholders

Empowering a range of stakeholders has been one of the government's aims in the process of building urban resilience to disasters. KIIs reveal that many urban development plans and projects have often been publicly announced through television channels, newspapers, meetings or social media. This information sharing process intends to mobilise public opinions and inputs for the sake of effective policies or projects design and implementation. For instance, an inter-ministerial body called 'Nation

Council for Sustainable Development (NCSD)' has been established to be in charge of establishing and promoting sustainable development polices focusing on green growth economies, responding to CC, science and technologies and environmental and biodiversity protection, and bio-safety. Also, to support the implementation of green growth national policies, MoE has modernised the institutional structure of the ministry and established three departments to be responsible for knowledge sharing and information, environmental support and natural resource conservation.

Public sharing and consultation has been practiced in the process of establishing urban community development plans. Based on the interview with KII participants, local development plans of both Khmuonh and Kourk Roka have been conducted through the consultation with local people. In this process, communities' needs and concerns such as roads, security and other issues have been gathered and included in the plans. After the local development plan is completed at Sangkat levels, the plans are usually submitted to Khan levels for finalising and sending to the next levels. In this regard, it is observed that local governments (Sangkats) have very limited capacity to address communities' needs as they can only address small scale needs such as basic civil registration and small conflict resolutions. The response to big scale issues or projects such as road construction, land title registrations or social insecurity often require approval and supports from upper levels including Khan, municipality and development partners.

Although there is more room for local community involvement in local development plan, this is limited for other civil society organizations. Results from KIIs reveal that many NGOs whose works related to urban areas have not been widely informed about and involved in local development plan formulation even though those plans are very important in guiding urban upgrading. The constraints for promoting meaningful public participation in local development planning are also raised by Dany et al. (2016) arguing that the engagement of stakeholders, including communities, civil society, researchers and the private sector, in national development planning has also been restricted. For Patel et al. (2016), the main reason for such limitation is that power remains centralised at the higher levels of government despite the fact that decentralisation and participatory governance have been institutionalised since 2001. Based on the core discussion of Blunt and Turner (2005, p. 86), the decentralisation process in Cambodia has performed ineffectively because the three key elements identified by Manor (2002) and by Blunt and Turner (2005), which include adequate power at lower government levels, sufficient resources (especially financial resources) and reliable mechanisms to promote downward accountability, have not been sufficiently developed.

The lack of a mechanism to ensure fair and inclusive growth remains a constraint for implementing urban development policies. FGD and KII participants raise that while the urban areas of Phnom Penh has rapidly expanded, the equity in benefit sharing remains questionable because some outskirt and slum communities are facing many livelihood constraints. In this sense, Connell (2015) claims that good resettlement policies have been particularly difficult to implement fairly when the

implementing state agencies are not fully committed to wider-based social protection and equality in a broad context. Inequitable and weak legal and institutional frameworks for urban development have resulted in two major urban risks: development-induced flooding and tenure insecurity (Flower et al., 2017). This unequal treatment may be associated with the process of local elite capture, as suggested by Alicias (2011) with regard to the limited opportunities and rights of the poor during their conflicts with rich and large businesses. Furthermore, Phonphakdee et al. (2009) argue that while the current government is committed to reducing urban poverty, the poor have been excluded from key development activities. Also, the poor are usually pushed from the central part of the city so that those areas can be redeveloped as highly commercial economic zones. This reflects the failure in promoting inclusive development because the poor have often been perceived as externalities to modern development, as was discussed by McMichael (2012).

Foster Long-Term and Integrated Planning

Developing a city is the process of building its aesthetic, functional, and liveable aspects in response to the needs of residents. In terms of the approach in developing a city master plan, both top-down and bottom-up approaches have been applied. The KII participants reveal that top-down has often been used to follow both national and international policies and guidelines in order to ensure that urban development strategies are consistent with the overall national development plans, particularly the Rectangular Strategies and the National Strategic Development Plan (NSDP) as well as other global policies. In this regard, many strategic interventions have been imposed and integrated into the content of urban development policies and plans from the top levels.

The use of integrated approaches in planning processes aimed at promoting effective design and implementation of land-use policies has also been discussed in literature. Diepart et al. (2016), for example, prove that planning working groups have been formed, with the involvement of specialised institutions and technical groups to lead the spatial planning process. In the preparation or inception phase, a comprehensive situation analysis and vision for territory development has been conducted, based on the involvement of relevant stakeholders. The main actors included in the planning processes are the local population and their community-based organisations, the private sector, development partners and government institutions. Apart from this formal process, informal consultations have been conducted to broaden understanding, minimise conflict, ensure consistency and promote ownership of stakeholders.

Despite such, the municipality is generally a dominant actor playing key roles to initiate ideas more than other stakeholders with regard to Phnom Penh city planning. KII participants indicate that by reflecting on the real practice in master plan establishment, top-down process has covered around 70%. While there are involvements from stakeholders such as state departments and some urban NGOs, those institutions can only partly support with the areas that have been identified and agreed by the municipality.

Fragmentation of urban development plans remains an issue for promoting urban resilience in contemporary urban development of Phnom Penh city. KII participants note that the government ministries andspecialised departments seem to pay more attention to developing and implementing their internal plans and less to integrating their plans with other specialised institutions. While most of the time those plans need to be consistent with and contribute to address the specific parts of national plans (NSDP or Rectangular strategies), the result remains falling behind expectations. This finding is similar with recent World Bank (2018) report suggesting that while many national and sub-national urban development policies, guidelines and frameworks have been established, issues of institutional fragmentation and weak policy and law enforcement prevented an effective implementation. Moreover, while city master plan 2035 provides a broad direction, there is no detail land use plan in place for fostering the implementation. The absence of implementation strategies can also be found in the various sectoral plans which has been support by the donor agencies (World Bank, 2018).

The privatisation of planning seems to be another challenge in promoting urban resilience to disasters as this can possibly be leading to limited local government authority to perform their roles effectively. This is consistent with the idea of Paling (2012) arguing that, despite the rapid development of many urban areas in Phnom Penh, city leaders and the government have not been able to provide a clear reference and vision for Phnom Penh. This author further indicates that the privatization of planning in Phnom Penh is part of a common pattern in the region in which privately developed urban spaces have been established by elites, isolated from current conditions in the city. Paling (2012) argues that, while there are more international development aid and foreign direct investments in the current development process in Phnom Penh, state agencies have very limited capacity to direct, restrict and combine these processes with a reference to a long-term vision for urban development. This reflects the limited institutional capacities and mechanisms to plan, guide and monitor stakeholders' activities for inclusive and sustainable urban growth. As suggested by Shatkin (2011), moreover, the development of the urban areas of Phnom Penh seems to follow a privatized model of urban planning which has been designed essentially to reach the state's goals of global economic integration.

Besides, lack of clear mechanisms for building and monitoring urban resilienceis also found in this study. While the government has the goal to transform Phnom Penh into a smart and resilient city, there is a lack of valid strategies to engage relevant stakeholders such as researchers, civil society and the private sector in the processes of decision making, planning and monitoring achievements. In this regard, Dany et al. (2016) indicates that neither the Climate Change Committee nor the Climate Change Strategic Plan (CCSP) working group has been involved in the process of planning for urban development at the national level. Also, inputs from stakeholders have not been adequately included in the planning and monitoring stages, and the resilience thinking seems not well considered.

Health and Wellbeing

The component of health and wellbeing focuses on ensuring that everybody living and working in the city has access to what they need to survive and thrive. In this aspect, three main drivers clustered under this division are:

Meet Basic Needs

Urban poverty reduction projects aimed at improving access to basic needs have been implemented in urban areas. Results from FGD and KII reveal that the connection of electricity and clean water system has been enlarged to almost every part of urban areas under the collaboration between government agencies, private investors and development partners. As indicated by Biswas and Tortajada (2010), for instance, the Phnom Penh Water Supply Authority has expanded the access to clean water for urban communities and around 90% of the urban population have access to clean water (Chan, 2009). Despite such, ensuring everyone access to sufficient basic need remains a challenge in the face of huge scale of rural-to-urban migration. Study found that many people have moved from the rural areas to the city seeking for employment opportunities and better lives. With this high volume of people movement, more and more pressures will happen due to the deficiency of public services to accommodate the entire dwellers. This is consistent with literature arguing that outskirt or peri urban areas with a high density of people have meagre access to sufficient basic needs (Khemro & Payne, 2004) and face many issues such as insecure livelihood strategies, poor quality of houses and water, sanitation and hygiene (WASH) (Flower & Fortnam, 2015).

In responding to urban community's basic needs, moreover, land sharing which is a part of urban upgrading projects has been undertaken. As indicated by KII participants, for instance, the current official land sharing in Sen Sok community (Figure 2) has resulted in more security on land ownership and enabled community members to build stronger shelters. Literatures also raised the similar land sharing mechanism that took place since the early 2000s. This includes the process of upgrading of four settlement areas located in the heart of Phnom Penh and in prime economic zones, encompassing Borey Keila, Dey Krahom, Santipheap/Railway A and Roteh Phloeung/Railway B (Paul, 2005). This author further indicated that this process of land sharing was considered as a "win-win-win" scenario among all parties, since communities could live and work in the city with full ownership and rights on the land/settlement, private investors could have the right to invest in the core commercial areas and the government could promote economic growth in the city. Yet, in spite of this promise, this land sharing has not turned out as planned. Two years after the declaration of the upgrading campaign, the land-sharing agreement of only one of the four has proceeded, with two other settlements in deadlock. In the fourth settlement, the land-sharing mechanism was abandoned as some residents instead chose voluntary relocation and others faced the issue of forced eviction (Olds et al., 2003; Paul, 2005).

Besides, the mechanism for providing basic needsin the face of crisis remains unclear. Interviews reveal that in times of crisis such as flooding or fire, local governments have often called on support from the Cambodian

Red Cross, NGOs or donor agencies for the provision of food items, temporary shelters or medication. Due to the limited amount of available fund and sometimes politically driven, however, those supports can only partly address survivors' needs. Consequently, many affected communities need to rely on individual strategies for survival.

↘ Figure 2

Land distribution for dwellers of informal urban community

Source : Author (2017). This photo was taken during the author's fieldwork in Sangkat Khmuonh in Khan Sen Sok in July 2017.

Support Livelihoods and Employment

One of the goals of urban upgrading projects is to directly support the economic activities of urban poor communities through an integrated program of human resource development, employment establishment and micro-finance services. Study found that private investments, especially those in manufacturing or garment factories and construction companies, have generated thousands of jobs for urban residents. Critiques, however, raised that while urban dwellers have access to those employments, their working conditions remain difficult. This includes imbalance of their wages and families' expenses, distance travelling, job insecurity and the lack of employers' responsibility on their employee well-being. Consequently, even after working for a number of years, many workers fail to gain new skills and are left with very little savings which make it very difficult for them to effectively response to the cases of emergencies.

Also, many urban dwellers are involved in livelihood improvement projects of NGOs or development partners under collaboration with the local government. As suggested by Phonphakdee et al. (2009), over 350 saving groups with around 20,000 poor community members have been established in Cambodia. Also, these groups saved approximately USD 300,000 by April 2008, which can be used for the improvement of the group members' livelihoods. Apart from these, many other international agencies such as the European Union, Dan Church Aid/ Christian Aid, Action Aid, Oxfam, ACR/Caritas Australia, Save the Children and People in Need have worked in partnership with and supported local NGOs to run their urban development projects to improve urban community capacity and livelihoods (Flower & Fortnam, 2015). However, these authors also demonstrate that some NGOs have not produced a big impact because those NGOs could only run short programs, which often rely primarily on external funding sources.

Ensure Public Health Services

Improving access to health care services has also been the focus of urban improvement programs. Interview results prove that with the increases of urban population, many health centres have been built close to the communities. Those centres have played important roles in providing basic health care services including giving birth, general health issue consultation and treatment, medicine provision and basic health care knowledge delivery. In line with poverty reduction strategies, urban poorest often have the privilege to get health care services with low fee or free of charge.

Despite the availability of those health care services, the sufficient amount of the facilities and quality of the services remain questionable. Interviews show that generally local health centres can only provide very basic services for non-serious illnesses. Apart from giving advice and consultation, they can only provide medicines for minor conditions like headache or fever treatment. In the case of persistent health problems, patients are often recommended to go to the referral hospitals or private clinics in the city centre. In the face of such situation, urban dwellers often spend lots of money for transportation and treatment in case of emergencies. For treating a condition that the patient's family has no reserved fund, they often borrow from local lenders or micro finance institutions to cover the cost. This makes their livelihoods properties especially land or shelter more likely to be sold or confiscated for the return of the debt.

↘ Figure 3

Waste duping and sewage condition in slum communities

Source: Author (2017). The picture was captured during fieldwork in Andong village in Sangkat Kork Rokar, Khan Prek Phnov

In order to contribute to healthy lives, NGOs have worked towards improving the city's environmental conditions. Denney (2016), for example, contends that the activities of NGOs have made the overall environment of the urban areas cleaner. NGOs have played a key role in mobilising community members to manage their household waste as well as negotiating with rubbish collection companies to improve their services. Through their program activities, NGOs are also able to educate communities to preserve the environment and to participate in rubbish clean-up campaigns in many urban areas. This can significantly contribute to reduce health issues, especially in slum communities. However,

irresponsible littering of some people causes the urban clean-up campaigns less effective. As indicated in literature, tonnes of rubbish are littered in public spaces leading to blockage of sewage systems (Figure 3), and burning trash causes air pollution (World Bank, 2018). These misbehaviours are caused in part by poor enforcement of waste management policies and regulations.

Economy and Society

This component observes whether the social and financial systems enable urban populations to live peacefully, and act collectively. The three main drivers which have been included in this dimension are:

Promote Cohesive and Engaged Communities

The attempt to promote participatory approach can be reflected as a process of fostering cohesive and engaged communities. KII participants note that in the process of building peace and solidarity among urban areas, government agencies attempt to create spaces for stakeholder consultation where relevant actors can express their concerns regarding local development issues. This has also been publicly announced by the Prime Minister Hun Sen as one of the tools for effective institutional reform. For example, the rights of official ethnic groups in the city are protected by giving them space to practice their cultures and involving them in local development activities as part of building harmony and peace in the communities. As mentioned by Diepart et al. (2016), in addition, city governments are committed to promoting information sharing, consultation, and active participation of stakeholders as an instrument to create social harmony.

The result from FGDs also reveals that active participation is also encouraged in NGOs' or development partners' projects based on the belief that effective stakeholder collaboration can bring about peace and strengthen communities. Their involvement in the planning stage can also reduce potential controversies between stakeholders which can lead to undermining the result of planning. The involvement of both service providers and receivers in the planning process reflects that spatial planning is a democratic tool for long-term development. Literature also suggests that NGOs have played mediative roles to build stronger connections between community members and government agencies. Phonphakdee et al. (2009) claim that, through the activities of NGOs, the relationship between poor communities and local government has become closer because both parties have often been invited to participate in meetings in which they can discuss and exchange ideas in setting up, planning and collaborating in making positive changes in the communities.

While there are attempts to build solidarity and collaboration, the actual outcomes remain far below expectations. Study found that in the course of modern development, many urban residents tend to care more about their personal interests and care less about the common good. Because of this, enhancing mutual understanding and trust among them seems to face a lot of challenges. This is consistent with Nop (2018) who suggested that sense of community in the contemporary development

of Phnom Penh encounters many challenges related to individualism, nepotism and business in livelihoods activities. In this regard, Cambodia still has a long way to go in building a strong society where strong sense of community is ensured and mutual understanding and collaboration are enhanced.

Ensure Social Stability, Security, and Justice

Institutional reform and public education have been conducted in the process of enhancing law enforcement and justice for fostering a stable, secure, and just society. This study found that government agencies have taken actions for effective law enforcement through clarifying the roles and responsibilities of officials, increasing public awareness on laws and policies, and applying penalties for offenders. For example, to address the issues of public land invasions, government agencies have educated the general public to respect Land Law, and negotiations between stakeholders have been organized to address the emerging conflicts. The similar approach has also been applied in the case of promoting effective enforcement of traffic law or other policies. The KII and FGD participants, however, have called for the enhancement of 'public disciplines' for effective policy and law enforcement as well as for the process of building stable, secure and just society.

Moreover, efforts were made to enhance village security as part of promoting stable and secure society. Research found that a group of security guards has been formed at the village level. Principally, the group is supposed to work closely with police officers and local government to prevent crimes including human trafficking, drug abuse, violence or any chaotic activities. Where necessary, the group also provides support to ensure general security during cultural or traditional events such as wedding receptions and festivals in the communities.

Apart from government actives, NGOs have implemented their programs in contributing to promoting secure and just society. FGD and KII participants revealthat national campaigns have been established to inform all relevant stakeholders about human-rights issues. For instance, the safe-city campaign organised by Action Aid and its alliances has promoted the rights of women living in cities (Abraham et al., 2015). This is also aimed at reducing any forms of violence again women and girls, who have often been perceived as one of the most vulnerable groups in urban areas. These campaigns, therefore, have played contributing roles in addressing gender issues, and promoting social welfare and inclusive development in cities.

However, while land sharing mechanism based on Land Law is seen as a way to improve the urban situation, archiving the expectation of justice and security remains questionable. Study found that the controversies between some urban communities, investors or government agencies regarding the process of land distribution cannot be fully avoided. This is consistent with Paul (2005) arguing that the process of land sharing can be a complex mechanism and generate little impacts when very limited opportunities were provided for the consultation and negotiation between local communities, private investors and government parties. Khemro and Payne (2004) suggest that controversies around land ownership have often been related to inaccuracies in civil registration, which can possibly connect to nepotism and corruption. This may lead to prolonged conflicts

when residents who claim land ownership are evicted without fair and appropriate compensation and continue to react against private investors and government agencies. The cases of land sharing in Phnom Penh city are identical to the common trend in Asian cities where the procedure of providing secure settlement is complicated and time-consuming (Paul, 2005)

Foster Economic Prosperity

The commitment of fostering economic prosperity can be seen through the government's attempt in building peace, managing institutional reforms and promoting good international collaboration. Interview result verifies that enhancing all above sectors is a key tool to gather more funding sources and potentials local and internal investors for the development of the city and the country as a whole. For example, a Secretary of State of MLMUPC indicates that the construction sector of Cambodia has rapidly grown since 2015. There were 2305 construction projects with the total areas of 7.6 million square meter with an estimated worth of USD 3,338 million. Compared to 2014, there was an increase of about 31.14%. By looking at the statistics of the last quarter of 2016, there were 473 investment projects with the total construction areas of 3.7 million square meters with an investment capital of USD 1,647. This figure has increased by 257.51 % compared to the same period in 2015. Based on the official statistics of MLMUPC, between 50-70% of the above-mentioned construction projects were capital investments in Phnom Penh city. Most of those construction projects are launched to build houses, multi-purpose buildings, and service or industrial buildings, which can potentially create many employment opportunities for city residents.

At the same time, there are many development partners and donor agencies supporting the development of urban areas of Phnom Penh. Literature, for instance, shows that the government of Cambodia received co-financing from the Asian Development Bank (ADB) to support a review of settlement policies and practices (Urban Resource Centre Phnom Penh, 2002) and in 2006 for the Cambodian railway project (Connell, 2015). In addition, in 2014, Phnom Penh was selected as one of the resilient-city projects of the Rockefeller Foundation. This project focuses on the issues of flooding, pollution, solid waste and sewage systems (Denney, 2016).

While the government is taking actions to foster economic prosperity, there are many challenges in promoting inclusive growth. Interviews suggest that while the city economy has grown dramatically, the gain for the poor remains minor because most of the growth benefits go to large business enterprises and powerful elites. In some cases, the lives of the poor in slum areas have even deteriorated, influenced by the negative impacts of private investments.

Infrastructure and Environment

This component concerns with the aspect of both man-made and natural systems that provide critical services, protect, and connect urban assets enabling the flow of goods, services, and knowledge. Three main drivers included for the assessment of infrastructure and environment

component are:

Provide and Enhances Protective Natural and Man-Made Assets

For achieving the goal of green growth or eco city, government bodies, especially the MoE, have focused on collaborating with ministries, civil society organisations and donor agencies to construct physical infrastructure (roads, bridges, traffic facilities, sewage systems, or waste water treatment systems) and preserve existing natural urban ecosystems (lakes, canals, or vegetation). KII participants reveal that many infrastructure development projects have been proposed and implemented in line with national strategic development plans and international declarations. For example, the urban transport system and sewage improvement projects have been implemented with the support from the Japan International Cooperation Agency (JICA) and other development partners.

Despite such, there are critiques and concerns regarding the balance between urban development and natural assets conservations. KII participants highlight that by reflecting the model of city development of other countries such as Vietnam, Singapore, Australia or European countries, cities' lakes and forest areas are usually preserved and additionally created to design a sustainable city. Research participants believe that not all development projects need to remove or refill lakes. However, if the development process cannot avoid removing the lakes, a careful consideration with the participation of stakeholders should be conducted. Also, the critical study on impact assessment needs to be made before taking any actions. For example, when Bueng Kak Lake was refilled, a question of where storm water goes has been raised. This is identical to the case of refilling Bueng Tompun which covers a catchment area of 2000 ha and the clearing of flooded forest as well as catchment areas in the outskirt urban areas shown in Figure 4. Therefore, when all those urban natural resources are completely removed, the questions of 'where does the water go?' and 'where does the wastewater go?' have often been asked by the public. So far, it was observed that after the removal of those lakes and flooded areas, without any treatment system, urban wastewater lines have flown back to nearby lakes, catchment areas or Tonle Sap Great Lake, leading to the damage of urban ecosystem including polluting city's water sources, and disturbing river systems.

↘ Figure 4

Pictures of flooded forest clearing and soil refilling

Source : Author (2018). The pictures were taken during the fieldwork to Phnom Penh's outskirt urban areas. KII participants reveal that these used to be state flooded forest areas, but they are now owned by private investors who are transforming the areas into residential and commercial zones.

Ensure Continuity of Critical Services

Preserving natural and man-made resources to withstand disasters has been taken into account in the process of implementing urban upgrading and green growth projects. Study found that through urban development projects, government agencies and stakeholders have worked together to improve urban ecosystem management. For example, as part of real estate investment projects, private sectors are required to establish liveable environment by following the city guidelines. This includes the construction of appropriate roads, sewage systems, parking spaces or parks for the residents. At the same time, all stakeholders are encouraged to contribute to preserving natural assets such as lakes acting as reservoirs collecting stormwater or wastewater.

However, KII participants highlight that even though the economic boom in 2003 enabled dramatic urban development and led to rapid urban sprawl, there is insufficient infrastructure such as road structures and systems, drainage or sewage systems and other emergency facilities in place. What has happened was that road structures follow the residents. This implies that the physical infrastructure has usually been developed and extended after the establishment of the residential areas. Critiques further raise that cost of constructing urban physical infrastructure is usually high due to unsystematic constructions of roads and culvert systems. This means that many culvert systems were built or renovated after completion of road construction activities. This urban development trend concerns most people because the city cannot be well organised and resilient with the absence of clear urban infrastructure planning.

At the grassroots level, it is found that in responding to the issue of flooding, urban communities have applied different strategies to deal with the problems. Aa suggested by Flower and Fortnam (2015), some poor community members have built temporary floating walkways connected to the roads, whereas other communities have had to temporarily relocate their houses to the higher available land areas. Some communities have built flood defences and increased the height of local roads to turn them into safer areas where communities can evacuate to during flood events.

Despite such, many urban communities, especially the poor, have not been sufficiently supported by a clear mechanism from the state agencies in coping with the shocks and stresses; they need to depend on their own capacities and strategies to address these issues and to improve the resilience of their areas. Apart from the burden of addressing the complex issues of land ownership, insufficient instruments to deal with issues of flooding and solid waste remain a problem for Phnom Penh. Irvine et al. (2015) stress that while the volumes and duration of flooding could be reduced through increasing pumping activities, some urban areas remain flooded as a consequence of drainage system constraints. Moreover, lack of competent professional staff and inadequate functional authorities have led to many problems in developing, negotiating, managing, monitoring and enforcing a sound contract mechanism for solid-waste collection in the city (Kum et al., 2005). Consequently, the objective of building a less polluted city seems tobe hardly achieved, and urban residents remain exposed to pollution, leading to several health issues.

Provide Reliable Communication and Mobility

Effective information sharing among stakeholders has been considered for enhancing good urban governance and promoting active public participation. This study found that government agencies are committed to applying participatory approach and providing all key actors with broad information about urban development process. For example, information sharing should be conducted through the media, meetings or public forums where stakeholders can express their concerns and comment on the plan. According to FGD and KII participants, bottom-up approach has been used in the process of collecting data from relevant stakeholders such as communities, educational institutions, NGOs or CSOs and a few private sectors during the early stage of urban development planning. This process is conducted based on interviews and focus group discussions with the above stakeholders. Once all the required data are collected, it is then synthesized and verified before integrating as inputs for policy formation. On the other hand, many KII and FGD participants proved that while public opinion at the grassroots level has been somehow collected and reported to the upper levels, they are not clear about the extent to which those ideas are integrated in plans or policies. They have been often involved in the process of raising issues or expressing their needs, but they have not been involved in the process of finalizing urban development plan or urban master plans.

Besides, efforts were made to improve multimodal transport systems and ensure the extensive movement of urban residents. The current renovation and update of public transport means including buses, trains and ferries have made it easier and more convenient for people to get around. The upgrades are made based on the view that these new facilities can respond to the transportation needs and reduce the density and burden of traffic on the roads. Despite such, the use of public transport by the public remains limited. This study found that although public city bus networks have been expanded, there are constrains regarding improving comfort and punctuality of those public transport means due to narrow road systems. While the number of vehicles in the city has rapidly increased, most of road sizes remain unchanged. The illegal driving and parking of some drivers worsen congestion, making people waste their time and money, especially at rush hour.

5. Conclusion and Way Forward

In conclusion, while Cambodia has a clear intention to build its urban areas to become more resilient to shocks and stresses, the current progressess how it isfar from meeting its expectations. It can be observed that although Cambodia's appropriate roadmaps and strategies toward this long journey have been documented, the implementation of those strategic guidelines remains ineffective due to complicated governance system, lack of resources, and low institutional capacity. The current city development model which seems to outweigh the economic benefit can potentially put more strains on the process of building a resilient society capable of coping with disasters because without appropriate management systems, the city environment or ecosystem can be damaged leading to poor urban system dynamic. This can be reflected as a flaw of promoting 'green capitalist' approach to ecological preservation in modern development explained by Ewing (2017). Moreover, without strong commitments and clear mechanism to form social justice and unity, society can easily become fragile and separated, leading to deepen inequality, instability and discrimination. To avoid these potential issues and to accelerate its aim of building sustainable and resilient urban areas, the Cambodian government agencies should consider the following key components:

- Land use planning which clearly categorises the core zones (business zones, residential areas, parks, schools, hospitals, or recreation areas) is urgently needed. This should be developed based on participatory approach where all relevant state departments, private sectors, and civil society organisations are actively involved in all planning and implementation processes. Also, the monitoring and evaluation process aimed at reflecting what have been done should be regularly conducted with active involvement of all relevant actors. Besides, the restriction on the elimination of urban ecosystem should be firmly monitored to avoid the shrinking of urban ecosystem capacity. With the design of this compact city model, the local residents can have better access to required public services and improve their incomes, reduce travelling distance for work, shopping and recreation, and make the city more environmentally friendly.
- Information about local development plans and activities need to be widely disseminated to the general public as this can help gather more extensive inputs from relevant key actors for urban resilience building process. Establishing a community centre in each urban community can be a key tool for sharing information among urban dwellers, enhancing their social networking and mobilising their ideas/ inputs for improving their communities. As part of this activity, the significance of active community participation in the process of urban development should be constantly highlighted.
- Establishing a clear mechanism for responding to urban disasters is a priority. Although urban areas of Phnom Penh have not experienced a serious devastation like some of Japanese cities or others, a robust preparation for potential disaster risks is crucial. In this sense, the clear structure and roles of urban disaster management committee need to be specified. Also, evacuation places or centres should be established

to ensure people's safe movement in times of crisis. More importantly, emergency responses should be made through a clear and fair system to avoid jealousy or conflict amongst community members, and it is important to provide appropriate support to those in real need.

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References

100 Resilience Cities. (2018). Resources. Retrieved from http://www.100resilientcities.org/resources/#section-2

Abraham, C., Jayasinghe, D., Noble, R., & Staszewska, K. (2015). Safe Cities programming and campaigning in the ActionAid Federation. Gender & Development, 23(1), 31-44.

Alberti, M., Marzluff, J. M., Shulenberger, E., Bradley, G., Ryan, C., & Zumbrunnen, C. (2003). Integrating humans into ecology: opportunities and challenges for studying urban ecosystems. BioScience, 53(12), 1169-1179.

Alicias, M. D. (2011). Decentralization and local participatory development: experiences from Cambodia and the Philippines.

Biggs, R., Schlüter, M., Biggs, D., Bohensky, E. L., BurnSilver, S., Cundill, G., Dakos, V., Daw, T. M., Evans, L. S., & Kotschy, K. (2012). Toward principles for enhancing the resilience of ecosystem services. Annual review of environment and resources, 37, 421-448.

Biswas, A. K., & Tortajada, C. (2010). Water supply of Phnom Penh: an example of good governance. Water Resources Development, 26(2), 157-172.

Blunt, P., & Turner, M. (2005). Decentralisation, democracy and development in a post-conflict society: commune councils in Cambodia. Public Administration and Development, 25(1), 75-87.

Bruneau, M., Chang, S. E., Eguchi, R. T., Lee, G. C., O'Rourke, T. D., Reinhorn, A. M., Shinozuka, M., Tierney, K., Wallace, W. A., & von Winterfeldt, D. (2003). A framework to quantitatively assess and enhance the seismic resilience of communities. Earthquake spectra, 19(4), 733-752.

Bugalski, N., & Pred, D. (2009). Land titling in Cambodia: Formalizing inequality. Bridges Across Borders Cambodia: A Year in Review, 2009, 1-7.

Carpenter, S. R., & Brock, W. A. (2008). Adaptive capacity and traps. Ecology and society, 13(2), 40.

Casado-Asensio, J., Drutschinin, A., Corfee-Morlot, J., & Campillo, G. (2016). Mainstreaming Adaptation in National Development Planning (2222-0518). Retrieved from Paris: http://dx.doi.org/10.1787/5jlsv0689qs6-en

Chan, E. S. (2009). Bringing safe water to Phnom Penh's city. Water Resources Development, 25(4), 597-609.

Connell, J. (2015). Is "good" resettlement policy unimplementable? Learning from advocacy in Cambodia. Development in Practice, 25(5), 655-672.

Dany, V., Taplin, R., Bajracharya, B., Regan, M., & Lebel, L. (2016). Entry points for climate-informed planning for the water resources and agriculture sectors in Cambodia. Environment, Development and Sustainability, 1-22.

Davoudi, S., Brooks, E., & Mehmood, A. (2013). Evolutionary resilience and strategies for climate adaptation. Planning Practice & Research, 28(3), 307-322.

Davoudi, S., & Madanipour, A. (2015). Reconsidering Localism: Routledge.

Davoudi, S., Shaw, K., Haider, L. J., Quinlan, A. E., Peterson, G. D., Wilkinson, C., Fünfgeld, H., McEvoy, D., Porter, L., & Davoudi, S. (2012). Resilience: A Bridging Concept or a Dead End?"Reframing" Resilience: Challenges for Planning Theory and Practice Interacting Traps: Resilience Assessment of a Pasture Management System in Northern Afghanistan Urban Resilience: What Does it Mean in Planning Practice? Resilience as a Useful Concept for Climate Change Adaptation? The Politics of Resilience for Planning: A Cautionary Note: Edited by Simin Davoudi and Libby Porter. Planning Theory & Practice, 13(2), 299-333.

Denney, L. (2016). Reforming solid waste management in Phnom Penh

Diepart, J.-C., Koditek, W., Hänert, T., Rock, F., Pen, S., & Meng, B. (2016). Introduction to the Cambodian Spatial Planning System. Retrieved from https://www.google.com.au/search?q=Introduction+to+the+Cambodian+Spatial+Planning+System&ie=utf-8&oe=utf-8&client=firefox-b&gfe_rd=cr&ei=M2hTWPXiGIfx8AeEg63YAQ

Eraydin, A., & Tasan-Kok, T. (2012). Resilience Thinking in Urban Planning Retrieved from http://unsw.eblib.com/patron/FullRecord.aspx?p=1083570

Ewing, J. A. (2017). Hollow Ecology: Ecological Modernization Theory and the Death of Nature. Journal of Would Systems Research, 23(1).

Flower, B., & Fortnam, M. (2015). Urbanising disaster risk: Vulnerability of the urban poor in Cambodia to flooding and other hazards. Retrieved from http://www.preventionweb.net/publications/view/47109

Flower, B., Fortnam, M., Kol, L., Sasin, P., & Wood, R. G. (2017). Using participatory methods to uncover interacting urban risks: a case study of three informal settlements in Phnom Penh, Cambodia. Environment and Urbanization, 0956247817735481.

Ilmola, L. (2016). Approaches to Measurement of Urban Resilience. In Yamagata Y. & Maruyama H. (Eds.), Urban Resilience. Advanced Sciences and Technologies for Security Applications: Springer, Cham.

Irvine, K., Sovann, C., Suthipong, S., Kok, S., & Chea, E. (2015). Application of PCSWMM to assess wastewater treatment and urban flooding scenarios in Phnom Penh, Cambodia: A tool to support eco-city planning. Journal of Water Management Modeling, 1-13.

Jha, A. K., Miner, T. W., & Stanton-Geddes, Z. (2013). Building urban resilience: Principles, tools, and practice: World Bank Publications.

Khemro, B. H. S., & Payne, G. (2004). Improving tenure security for the urban poor in Phnom Penh, Cambodia: an analytical case study. Habitat International, 28(2), 181-201.

Kum, V., Sharp, A., & Harnpornchai, N. (2005). Improving the solid waste management in Phnom Penh city: a strategic approach. Waste management, 25(1), 101-109.

Leichenko, R. (2011). Climate change and urban resilience. Current opinion in environmental sustainability, 3(3), 164-168.

Liao, K.-H. (2012). A theory on urban resilience to floods-A basis for alternative planning practices. Ecology and society, 17(4), 48.

McFarlane, C. (2012). The entrepreneurial slum: Civil society, mobility and the co-production of urban development. Urban studies, 49(13), 2795-2816.

McMichael, P. (2012). Development and Social Change: A Global Perspective: Sage.

McPhearson, T., Andersson, E., Elmqvist, T., & Frantzeskaki, N. (2015). Resilience of and through urban ecosystem services. Ecosystem Services, 12, 152-156.

Mehmood, A. (2016). Of resilient places: planning for urban resilience. European Planning Studies, 24(2), 407-419.

Mgbako, C., Gao, R. E., Joynes, E., Cave, A., & Mikhailevich, J. (2010). Forced eviction and resettlement in Cambodia: case studies from Phnom Penh. Washington University Global Studies Law Review, 9, 39.

Mohammed, E. Y., Wang, S., & Kawaguchi, G. (2013). Making growth green and inclusive: The case of Cambodia (2226-0935). Retrieved from http://www.oecd-ilibrary.org/environment/making-growth-green-and-inclusive-the-case-of-cambodia_5k420651szzr-en

Nam, S. (2011). Phnom Penh: From the politics of ruin to the possibilities of return. Traditional Dwellings and Settlements Review, 55-68.

Nam, S. (2017). Urban speculation, economic openness, and market experiments in Phnom Penh. positions: asia critique, 25(4), 645-667. doi:10.1215/10679847-4188350

NGO Forum on Cambodia. (2014). Statistical Analysis ofLand Disputes in Cambodia, 2013. Retrieved from Phnom Penh:

Nop, S. (2018). Sense of community in modern development: A discourse on urban areas in Cambodia. Japan: Centre for Southeast Asian Studies (CSEAS), Kyoto University.

Olds, K., Bunnell, T., & Leckie, S. (2003). Forced Evictions in Tropical Cities: An Introduction. Singapore Journal of Tropical Geography Volume 23, Issue 3, 23(3).

Paling, W. (2012). Planning a future for Phnom Penh: Mega projects, aid dependence and disjointed governance. Urban Studies, 49(13), 2889-2912.

Patel, S., Sliuzas, R., & Georgiadou, Y. (2016). Participatory Local Governance in Asian Cities Invited, Closed or Claimed Spaces for Urban Poor? Environment and Urbanization Asia, 7(1), 1-21.

Paul, E. (2005). Land Sharing in Phnom Penh: An Innovative but Insufficient Instrument of Secure Tenure for the Poor. Paper presented at the Expert Group Meeting on Secure Land Tenure: New Legal Frameworks and Tools Bangkok, Thailand.

Pen, S. (2016). Keynote and Opening Remarks. Paper presented at the The Development of Phnom Penh, challenges and solutions.

Phnom Penh Capital Hall. (2017). Phnom Penh City Facts.

Phonphakdee, S., Visal, S., & Sauter, G. (2009). The Urban Poor Development Fund in Cambodia: supporting local and citywide development. Environment and Urbanization, 21(2), 569-586.

Pickett, S. T., Cadenasso, M. L., & Grove, J. M. (2004). Resilient cities: meaning, models, and metaphor for integrating the ecological, socio-economic, and planning realms. Landscape and Urban Planning, 69(4), 369-384.

Rockefeller Foundation. (2015). City Resilience Framework. Retrieved from https://assets.rockefellerfoundation.org/app/uploads/20140410162455/City-Resilience-Framework-2015.pdf

Schewenius, M., McPhearson, T., & Elmqvist, T. (2014). Opportunities for increasing resilience and sustainability of urban social-ecological systems: insights from the URBES and the cities and biodiversity outlook projects. Ambio, 43(4), 434-444.

Shatkin, G. (2011). Planning privatopolis: representation and contestation in the development of urban integrated mega-projects. Worlding cities: Asian experiments and the art of being global, 41, 77.

Swanstrom, T. (2008). Regional resilience: a critical examination of the ecological framework. Paper presented at the Urban Affairs Association Annual Meeting University of California

Trac, T. S. (2015). Smart City Master Plan of Phnom Penh. Paper presented at the Sustainable Urban Transport Workshop, Danag, Vietnam. http://citynet-ap.org/wp-content/uploads/2015/07/Phnom-Penh.pdf

UN Data. (2015). Slum population as percentage of urban, percentage. Retrieved from http://mdgs.un.org/unsd/mdg/seriesdetail.aspx?srid=710

UN Habitat. (2016). Urbanization and Development: Emerging Futures. Retrieved from

United Nations (UN). (2017). Sustainable development goals: 17 goals to tranform our world. Retrieved from http://www.un.org/sustainabledevelopment/cities/

Urban Resource Centre Phnom Penh. (2002). Study of Relocation of Urban Poor Communities in Phnom Penh. Retrieved from

Vale, L. J., & Campanella, T. J. (2005). The resilient city: How modern cities recover from disaster: Oxford University Press.

Vann, M. (2003). Modern Khmer Cities: Reyum.

Walker, B., Holling, C. S., Carpenter, S. R., & Kinzig, A. (2004). Resilience, adaptability and transformability in social--ecological systems. Ecology and society, 9(2), 5.

Weichselgartner, J., & Kelman, I. (2014). Challenges and opportunities for building urban resilience. A/Z ITU , 1. Journal of the Faculty of Architecture, 11(1), 20-35.

World Bank. (2018). Urban development in Phnom Penh. Retrieved from Phnom Penh: http://documents.worldbank.org/curated/en/286991511862455372/pdf/121692-REVISED-Phnom-Penh-Urban-report-V8-V-low.pdf

Yavuz, Y. (2010). Gender, Development, and Neoliberalism: HIV/ AIDS in Cambodia. Review of Radical Political Economics, 42(4), 528-548. doi:10.1177/0486613410375062

Yen, Y., Wang, Z., Shi, Y., & Soeung, B. (2016). An assessment of the knowledge and demand of young residents regarding the ecological services of urban green spaces in Phnom Penh, Cambodia. Sustainability, 8(6), 523.

Yen, Y., Wang, Z., Shi, Y., Xu, F., Soeung, B., Sohail, M. T., Rubakula, G., & Juma, S. A. (2017). The predictors of the behavioral intention to the use of urban green spaces: The perspectives of young residents in Phnom Penh, Cambodia. Habitat International, 64, 98-108. doi:https://doi.org/10.1016/j.habitatint.2017.04.009

8

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Cambodia's Green Urban Development Program

Cambodia's impressive economic growth over the past decade has resulted in significant population growth, particularly in urban areas. Rapid urbanization is taking place in the capital city, Phnom Penh, and many major secondary cities. However, the rapid pace of urbanization in an unstructured way is generating significant social, economic and environmental challenges in Cambodia. The capital city and secondary cities are experiencing the stress of urban growth, including urban sprawl, insufficient provision of basic services and infrastructure such as housing, energy, transport, water supply, waste and wastewater, resulting in urban flooding, air pollution, water pollution, increased congestion, unemployment and inequality.Transport infrastructure development and traffic management measures have been outpaced by the rapid expansion of the ownership and use of private transport in cities, resulting in an exponential increase in traffic volumes, congestion, and road accidents. Cambodia's Urban Development Program was proposed in 2015 by the Global Green Growth Institute (GGGI) and has been implemented in partnership with the Royal Government of Cambodia (RGC) to support sustainable urbanization by defusing green growth concepts and instruments as well as to work together in the development of bankable green city projects that can address theseurban challenges, hence achieving strongereconomic growth, climate change resilience, and improved livelihoods for Cambodia's urban poor.

1. Introduction

The Cambodian economy has seen very high levels of growth over the last two decades, with an average real growth rate of 7.6% between 2000 and 2015. After it graduated from Least Developed Country status in July 2016, Cambodia's economy has remained healthy with a GDP growth rate of 6.9 per cent in 2017. This was driven by the recovering tourism sector, the ongoing construction boom and the gradual emergence of non-textile exports.

Cambodia is currently undergoing a period of rapid demographic change associated with rapid growth and structural change in the economy. This is characterized by falling fertility levels, lower natural population growth rates (in urban and rural areas) and rapid urban population growth driven by high levels of rural-urban migration.

During the 1990s and following the end of decades of destructive civil

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conflict, Cambodia had a very high population growth rates in both urban and rural areas. Since the turn of the century, however, population growth has fallen dramatically, reflecting falling fertility levels and lower natural population growth (NIS & DGH, 2014; NIS, 2008; NIS, 2013). Nevertheless, total population grew by approximately 46% (over 5 million) between 1995 and 2015 (Table 1). This trend is expected to continue as the country moves towards middle-income status (UNDSEA, 2014).

↘ Table 1

Population growth, Cambodia, 1990-2015

Population	1995	2000	2005	2010	2010e
Phnom Penh*	-	1,198,080	1,376,391	1,663,341	2,065,321
Urban	1,864,281	2,271,793	2,560,946	2,845,724	3,248,723
Rural	8,904,917	9,951,078	10,795,478	11,519,207	12,428,336
Total	10,769,198	12,222,871	13,356,424	14,364,931	15,677,059
Growth rate	**1990-1995**	**1995-2000**	**2000-2005**	**2005-2010**	**2010-2015**
Urban	5.61	3.95	2.40	2.11	2.65
Rural	3.04	2.22	1.63	1.30	1.52
Total	3.46	2.53	1.77	1.46	1.75

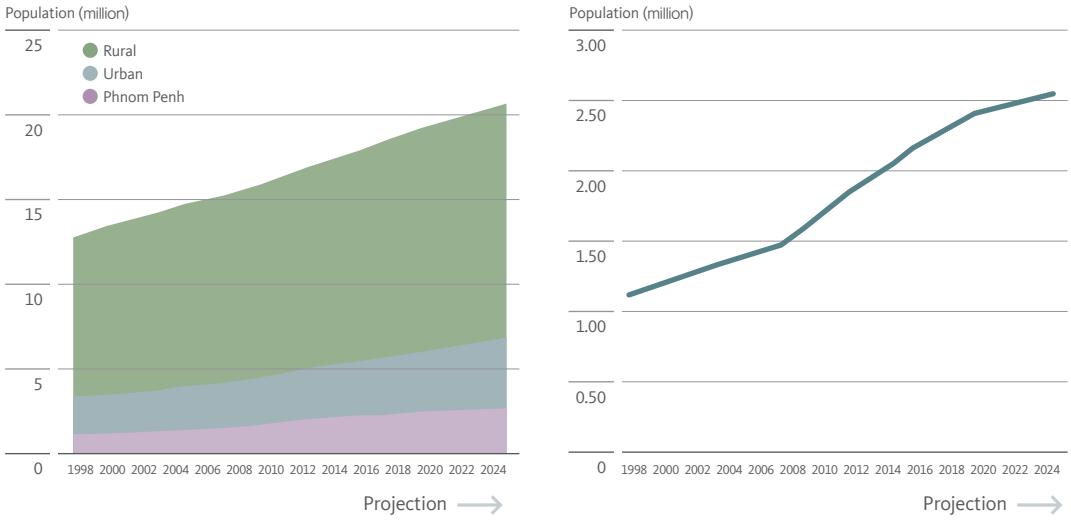
Source : UNDSEA 2014; JICA 2014. (e – estimated;* - figures from JICA 2014 for the new area of Phnom Penh)

Cambodia remains predominantly rural, with official figures suggesting that currently approximately four-fifths of its population reside in rural areas. Long-term population growth projections foresee continued rural population growth until the 2040s.[3] At the same time, Cambodia has been experiencing rapid urban population growth, with much of it concentrated in Phnom Penh and major secondary cities such as Battambang, Siem Reap, Sihanoukville, Kampong Cham, and so on. Cambodia's urban population has increased from 17% in 1995[4] to an estimated 22% in 2015 (NIS, 2009). As urban areas have lower fertility rates than rural areas, the difference in population growth rate is explained by rural-urban migration. While the motivation for migration tends to be complex, the lack of economic opportunity and rural poverty are important push factors. Conversely, the economic opportunities offered by growth in services, construction and manufacturing industries concentrated in and around urban centers are an important pull factor for migrants (MoP, 2012).[5]

3. Ibid.
4. Ibid.
5. Ministry of Planning 2012. The report noted that: "...data can identify five main individual-level motivations for migration: to pursue or transfer a job or pursue a better labor situation, to pursue education, due to marriage, due to calamities such as lost land, lost home, natural disaster or insecurities and for repatriation. There is also an 'other' category, which we suspect includes following a family member."

↘ Figure 1

Population growth (1998–2012) and projections to 2025 in Cambodia (left) and Phnom Penh expanded area (right)



Source: Based upon UNDSEA 2014; Phnom Penh data based upon population figures from JICA 2014 for the expanded area of Phnom Penh.

Cambodia's rapid urbanization is expected to continue for the foreseeable future as urban population growth continues to accelerate and rural population growth decline (Figure 2 and Table 3). This points to accelerating rural-urban migration as fertility rates and overall population growth rates fall, and differentials between urban and rural fertility rates persist (UNDSEA, 2014). Projections for Phnom Penh foresee urban growth continuing to outstrip other urban areas in the country, and an increase in its already high share of Cambodia's urban population (Figure 2 and Table 2). This trend is expected to continue until after 2020, by which time growth in other urban areas is expected to exceed that of Phnom Penh and, as a consequence, its share of the national urban population is expected to fall.

↘ Table 2

Current and projected population growth in Cambodia and Phnom Penh, 2010 - 2025

Population	2010	2015e	2020p	2025p
Phnom Penh (proportion of total urban population)	1,663,341 (59%)	2,065,321 (64%)	2,405,500 (65%)	2,549,736 (60%)
Urban	2,845,724	3,248,723	3,723,400	4,273,673
Rural	11,519,207	12,428,336	13,223,429	3,846,034
Total	14,364,931	15,677,059	16,946,829	18,119,707
Growth rate	**2005 - 2010**	**2010-2015e**	**2015-2020p**	**2020-2025p**
Phnom Penh	3.79	4.33	3.05	1.16
Urban	2.11	2.65	2.73	2.76
Rural	1.30	1.52	1.24	0.92
Total	1.46	1.75	1.56	1.34

Source: UNDSEA 2014; figures for Phnom Penh from JICA 2014.

2. Key Urban Development Challenges

Urban planning

Steady urban growth is a driver for economic development but needs to be more carefully managed in Cambodia.Cambodia is still predominately a rural country with the majority of people living in rural areas, and with most of the cities and towns beingrelatively small. However, urbanization is underway and Cambodia needs to plan for it. To date, the challenge of urbanization has largely been unplanned for and unregulated which is generating significant social, economic and environmental issues. The capital city and many Cambodian cities such as Battambang, Siem Reap, Sihanouk Ville, Kampong Cham, Suong, border town such as Bavet are also undergoing steady urban growthand are facinga severe lack of systematic urban spatial planning, and financial resources for sustainable urban infrastructure and services.

For a well-structured urban development, urban spatial planning is a precondition forthe development of sustainable urban infrastructure. Among Cambodia's secondary cities, only Battambang city finalized its Land Use Master Plan for urban development in 2015. Other cities are still undergoing spatial planning, zoning, mapping, and drafting of their masterplans. The challenge is that the process of developing master plans takes years, while the pace of urbanization is rapid.

This slow process will lead to unstructured settlements, uncontrolled building constructions, unmanageable zoning for businesses and/or residential development, and the possibility of mis-directed urban infrastructure development. For instance, the Kampong Cham city had to resolve all the impacts of their reinstallation of sewerage and drainage system, causing considerable socioeconomic costs. The city had to compensate owners of already built houses, buildings or roads to make way for the sewerage system. It can be observed that the longer the urban planning takes, the slower the urban infrastructure investment develops, hence, slowing down the potential economic growth and infrastructure services. Limited local capacity and lack of national government technical and budget support is one of the main concerns raised by local governments, underpinning the slow urban planning development.

Without urban planning interventions that take the rapid pace of economic development into consideration, Cambodia will continue to experience widening spatial and economic disparities within its cities. Most of the cities and urban areas have already experienced the stress of urban growth and lack of urban infrastructure, and this already has impacts on the economy, society and environment. In consultation with city officials, the common challenges include inefficient solid waste management, lack of wastewater treatment plants andsewerage and drainage networks, lack of public spaces, lack of systematic urban commutation and parking spaces, and so on.

Waste management - solid waste and wastewater

Solid waste is a common issue across Cambodian cities. Due to population growth and increased economic activities especially in tourism, construction and industry, the amount of municipal waste

disposed at landfills nationwide has increased rapidly, from 397,311 tons per year in 2006 to 1.2 million tons/year in 2016 (Dek, 2017). Such a sharp increase in waste disposal coupled with poor waste management (including storage, collection, transport, and dumping at landfill) and lack of community participation present serious challenges for the cities.

At present, waste management in many cities is outsourced to private companies. As the collection fee and process for the services differ from city to city,this leads to different standards of service. Additionally, existing dumpsites are of poor quality technical design and management, leading to environmental and social problems (odour, leachate, vermin, gas and litter).

Waste collection services also do not cover all parts of the cities due to lack of economy of scale, road accessibility and community's willingness to pay. It is estimated that only 58% of the urban population is covered by existing waste collection services (Sethy, Sothun & Wildblood, 2014). Open burning is the most common mode of waste disposal for those who do not use the collection service. Open burning is generally done without prior waste segregation (for example by removing plastics) and at low temperature which causes the release of toxic gases and fine particulates into the atmosphere, leaching of harmful substances into the ground, which in turn can affect waterways.

Public awareness toward proper rubbish storage, disposal and recycling options is still low. Communities lack support to implement behavioral change programs on the responsibility and accountability of individuals in storing and disposing of their own rubbish in a proper manner. Many public awareness campaigns are needed in this area.

The 3Rs (Reduce, Reuse, and Recycle) and waste separation concepts are being introduced but have not yet been implemented fully and effectively and the concepts remain unfamiliar. Except for Battambang city, which has a small composting facility, recycling remains largely unstructured within and outside cities and at dumpsites. Some valuable materials like PETbottles, tin plates, aluminum cans and glass bottles are informally collected and sold to intermediaries. The rest of the collected waste is dumped in the outskirts without any further measures of environmental protection.

In an attempt to decentralize waste management, the government passed a Sub-decree No. 113 in August 2015 to provide a better and clearer mandate on solid waste management. Amongst others, the Sub-Decree has the following objectives:

- Strengthen responsibilities of ministries, institutions, specialized units, sub-national administration and relevant stakeholders who are involved with garbage and solid waste management in urban areas;
- Assign the task of garbage and solid waste management in urban areas to municipalities, towns, and district administrations;
- Identify necessary measures to increase effectiveness and safety in garbage and solid waste management in urban areas;
- Increase public awareness and people's participation in the development and implementation of local garbage and solid waste management.

The implementation of the Sub-Decree has remained limited due to the lack of finance and human resources for monitoring and enforcement. In 2017, the Ministry of Economy and Finance granted 8,000 million riels to 26

cities nationwide to fill the financial gaps in solid waste and waste water management. However, the amount is still not sufficient to keep cities clean. There is a need for a more transparent and sustainable model for waste collection fees across the cities that are subsidized by resources from the municipalities if waste collection is to be provided as a public service.

Budget for Environmental Cleanliness Service 2017

↘ Table 3

City Administration	Amount (million riels)	City Administration	Amount (million riels)
Serei Sophoan	405	Prey Veng	222
Poi Pet	447	Pursat	331
Battambang	561	Banlung	235
Kompong Cham	260	Siem Reap	783
Kompong Chhnang	267	Preah Sihanouk	361
Chbar Mon	285	Stung Treng	236
Stoeung Sen	307	Svay Rieng	278
Kampot	249	Bavit	259
Takhmao	350	Daun Keo	271
Khemarak Phoumin	230	Samraong	320
Kratie	238	Kep	209
Sen Monorom	192	Pailin	252
Preah Vihear	214	Suong	252

Source: Presentation slides from the Department of Solid Waste Management, MoE

Wastewater is another key challenge for cities. Presently there are only three municipal wastewater treatment plants operating in Cambodia: Siem Reap, Sihanoukville and Battambang, which have a treatment capacity of 3,000 m³, 6,900 m³ and 1,000 m³ per day respectively. These facilities cannot sufficiently respond to the cities' growing demand. The system in Sihanoukville dated from the French era and was designed to service a population of just 38,000 people. The facility in Battambang was intended to service 15,000 people over 89 ha but its capacity is currently limited to 450 m³/day because of the degradation of the system. These cities are now developing plans to upgrade their treatment plants in partnership with multilateral development banks.

Other cities simply release untreated wastewater into receiving water sources such as canals, ponds or rivers. This results in pollution, environmental degradation and human health issues. In Kampong Cham, for example, all the city's wastewater is discharged through the old sewerage and drainage system into the Mekong river without treatment. Suong city does not even have a drainage or sewer system and the wastewater is currently discharged to natural ponds and rivers through old canals. Bavet and Kep are also facing similar challenges.

The lack of adequate financial and human resources, and empowerment at the city level is also a key barrier for the development and management of the sewer system. Even though cities are aware of the serious consequences of wastewater problems, they have no choices but to wait for technical and financial support from the provincial/national government and development partners.

The Royal Government of Cambodia recognized the severity and urgency of wastewater issues and has established a clear set of national policies and plans for wastewater treatment and sanitation services in major cities and urban areas through short, middle, and long-term strategies. The Ministry of Public Works and Transport (MPWT) released a sub-decree on sewerage management and wastewater treatment to govern and manage the sector in a more sustainable manner. By 2030, under the MPWT strategy, septic tanks/DEWATS from households will be connected to centralized septic tanks, and by 2050 wastewater management and sanitation services will be provided for all (Vong, 2015).

However, achieving these goals will require strong implementation strategies and stakeholder participation. This includes identifying implementing drivers, namely institutions, policies, regulations, and service providers. It also requires formulating sustainable funding and financing schemes, selecting appropriate technologies based on specific situations, and raising public awareness on the importance and benefits of wastewater treatment, water reclamation and sanitation services.

Transportation

Rapid increase of population moving into urban areasand the growing GDP per capitaposetough challenges of urban transport in Cambodia. The rapid expansion of the ownership and use of private transport in cities have resulted in increasing traffic volumes and increased congestion as infrastructure development and traffic management measures have been outpaced. The net result of this in the city has been slowing traffic and increased levels of congestion, increased road accidents and high levels of air pollution. In Phnom Penh, the proportion of registered vehicle has been increasing at an average rate of about 20% each year, and has reached almost 1,500,000 in 2015. The average driving speed in the city decreased from 22.9 km/h in 2000 to 14.6 km/h in 2012, indicating growing traffic congestion (Figure 29).[6] At peak times traffic speeds can be extremely low in central areas, at around an average of 10 km/hr.[7]

Cambodia has the worst road traffic accident rate in Southeast Asia, with an estimated 2,000 to 2,100 fatalities in 2014 (Phnom Penh Post, 2014). Motorcycle users accounted for 77% of the casualties and 68% of the fatalities, and the majority of motorcycle accidents occurred in Phnom Penh. The two leading causes of fatalities were speeding (51%) and alcohol abuse (18%).[8] [9]

Air pollution in the city is due in large part to the high levels of traffic. This has not increased dramatically between 2008 and 2012. One-hour averages for carbon monoxide (CO) at between approximately 6 and 10 ppm and for nitrogen dioxide (NO_2) at between 0.02 and 0.035 ppm are lower than many cities in OECD countries, and are below the limits set by the World Health Organisation (WHO, 2005). However, no figures were available for

6. Ibid.
7. Ibid.
8. Ibid.
9. Following the introduction of the road traffic law in 2009, motorcycle drivers have been required to wear helmets, and the law is being enforced in Phnom Penh, although it is not clear what impact this has had on reducing injuries.

particulate matter (PM_{10} and $PM_{2.5}$) or O_3 concentrations which may pose more of a threat in Phnom Penh. Figures for SO_x concentrations were also not available. In this regard fuel quality standards in Cambodia give cause for concern. Standards for sulphur content in transportation fuels allow sulphur content of 1,500 ppm for diesel and 1,000 ppm for petroleum, this is much higher than is typically the case in the region, in which 50 ppm is a more typical value (UNEP, 2015).

Vulnerability to Climate Change

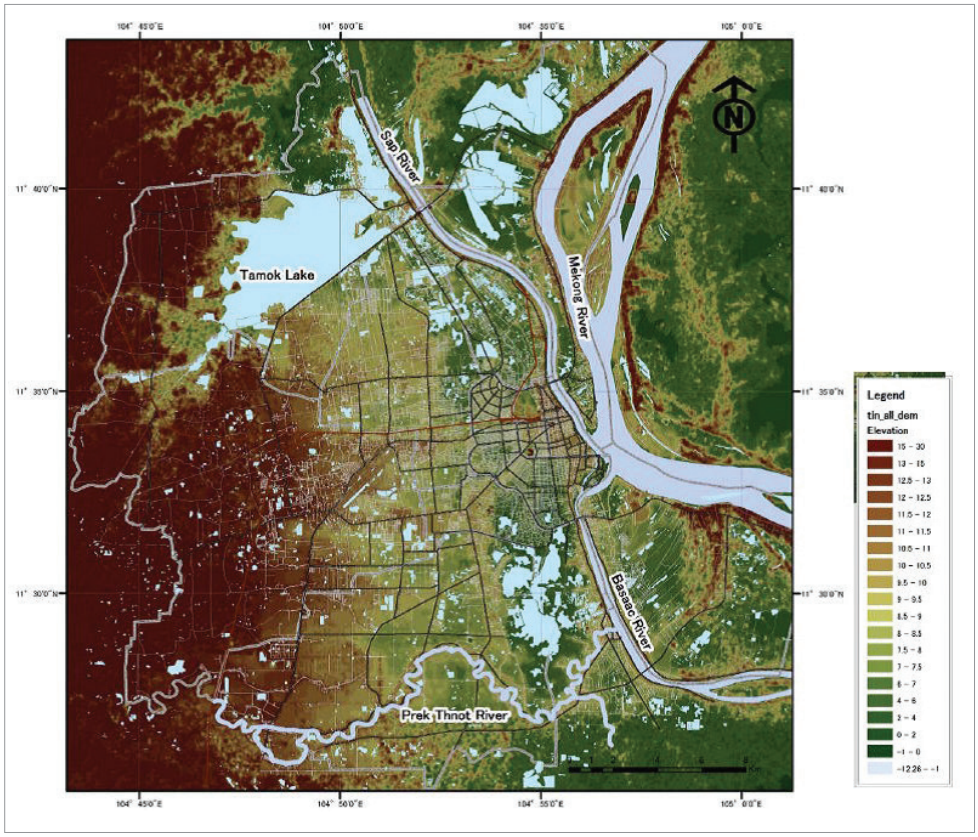
Cambodia has a history of life-threatening and damaging flooding events. Over the last 50 years, destructive flooding has occurred approximately every 5 years (PIN, 2015).Coupled with the lack of green infrastructure development, Cambodia is one of the most vulnerable countries to climate change. The country was already hit by disasters such as floods and droughts. Many urban areas despite their higher resources and adaptability are still the victims of climate change. For example, in Battambang 753 people, 1581 hectare of agriculture land and 59,324 meters of road were affected by the 2013 flood[10]. In Siem Reap, 1921 families were impacted by the 2015 drought and 14,200 meters of road were destroyed in the 2015 flood[11]. In Kep, 107 people were affected by the storm in 2016[12]. In Sihanoukville, tourism is highly vulnerable to climate change due to its dependence on climate sensitive attractions. The potential impacts of climate change include increased beach erosion due to rising sea levels and storm surges, loss of marine resources and reduction in tourist numbers during the rainy season.

Recent flooding and rainfall records suggest that the 5-year flooding interval may be shortening. Particularly, Phnom Penh experienced some of the most extreme flooding in history during 2011 and 2013. The 2013 flood event was caused by a combination of heavier than normal monsoon rains, successive occurring typhoons, and rising water levels in the Mekong River. In the Phnom Penh municipality, over 17,000 families were impacted by the 2011 flood (visualised in Figure 2), and around 3,500 families by the 2013 flood (NCDM & UNDP, 2014). For the 2013 flood on a nationwide perspective, the total costs for damage and loss were about USD 356 m, and a further USD 306 m was required for recovery and reconstruction. The 2011 flood damage and loss costs amounted to USD 625 m.[13]

10. Battambang Social Economic Statistic 2017
11. Siem Reap Social Economic Statistic 2017
12. Kep Social Economic Statistic 2017
13. Ibid.

↘ Figure 2

Image of Phnom Penh at the peak of the 2011 season floods



Source: JICA 2015b.

As a preventative measure, an early storm warning system was introduced in Phnom Penh. MOWRAM receives advanced weather forecasts from climate network linked to international weather stations. Once a storm forecast is received, MOWRAM communicates the information to the National Committee for Disaster Management, which in turn broadcasts emergency warnings to the general public through various media including mobile phone-based systems.

The likelihood of heavy rainfall events appears to be increasing in Phnom Penh. The Fifth Assessment Report by the Intergovernmental Panel on Climate Change contains climate forecasts for the Cambodia region. The forecasts show a trend of increasing rainfall severity, coupled with droughts and rising temperatures (IPCC, 2015).[14] On 3 August 2015, the city experienced a high rainfall of 103 ㎜; the previous recorded high was 80 ㎜. The 103 ㎜ rainfall resulted in destructive local flooding, which some residents blamed on uncontrolled filling of the city's natural lakes (Sothear, 2015).[15]

Flooding is becoming more serious in Phnom Penh. This is largely due to private-sector commercial developments in areas that were originally public green spaces, natural lakes or wetlands, and which historically and collectively served as natural flood control and wastewater management systems. During the period of 2003-2015, it is estimated that the area of Phnom Penh marshes, lakes and wetlands decreased by 50%. This observation is based on comparison of aerial photographs taken over this period (JICA, 2015a).

14. IPCC 2015.
15. Sothear 2015.

The city has only about 70 ha of green public space, mostly located in the inner city core.[16] These public areas have few trees and are largely non-functional with regard to recreational use. The Phnom Penh inner core also has seven natural catchment ponds (Boeungs) to manage storm water. However, the 90-ha BoeungKak, a major catchment pond (Figures 3), was recently filled for development purposes due to its attractive central location (JICA, 2015b).

↘ Figure 3

Google Maps of Boeung Kak before and after development

Source: Floodlist 2016.

To address the aforementioned challenges, comprehensive urban planning, sustainable urban infrastructure and mobilization of investment to deliver basic services e.g. waste water treatment, waste management are urgently required in Cambodia's secondary cities. Designing and strengthening sustainable city interventions will be crucial to support the cities in their planning, financing and implementation of sustainable long-term urbanization initiatives.

3. Green Urban Development Program

The Green Urban Development Program (GUDP) was initiated in 2015to address the needs for the sustainable development of cities in Cambodia. The program, jointly implemented by the National Council for Sustainable Development, the Ministry of Interior and the Global Green Growth Institute, adopts a holistic approach to green city development, looking at adapting to climate change impacts and reducing emissions via proposed interventions that target wider benefits of green growth such as job creation, the environment, and poverty

16. Ibid.

alleviation. The desired outcomes of the Program are that: (1) there is strong support and commitment for green cities development and policy initiatives, as well as for institutional reform from the Royal Government of Cambodia (RGC) and (2) there is increased sustainability of the program through financial feasibility analysis for projects and the long-term ability for government counterparts to prioritize, develop, and mobilize financing for green urban projects in secondary cities.

Under GUDP phase 1 (2015-2016), a Green City Strategic Planning Methodology was developed and endorsed by the Minister of Environment in 2016. The methodology is a step-by-step guide for Cambodia's policy-makers to help transform Cambodia's cities by achieving greater sustainability. Using the methodology, a Sustainable City Strategic Plan for the capital city of Phnom Penh was developed. The Phnom Penh Sustainable City Plan assesses eight key urban sectors, sets development vision and goals, and offers a list of priority actions to achieve the vision. The plan aims to provide guidance for Cambodian policymakers, local administrators and their national and international development partners in order to pursue the implementation of urban green growth in the context of tackling climate change, while simultaneously pursuing economic development, poverty alleviation and social inclusion.

Building on Phase 1, GUDP2 (2017-2018) expanded its scope to develop a joint Sustainable City Strategic Plan for seven other cities in Cambodia, namelySiem Reap, Battambang, Sihanoukville, Kep, Kampong Cham, Bavet and Suong. The Strategic Plan aims to promote the green growth of strategically important secondary and tertiary cities in Cambodia by providing a strategic direction and guidance to city governments to integrate the principles of sustainable city in their respective city's development and investment plans. The green development of these cities will promote a more balanced and sustainable urbanization in Cambodia.

↘ Figure 4

Phnom Penh Sustainable City Plan (left) and Sustainable City Strategic Plan for Secondary Cities (right)

In addition to developing strategic policy documents, GUDPhelpsset up important institutional mechanisms to facilitate effective implementation of green city initiatives. For example, through GUDP, GGGI initiated the set up of the Sub-Technical Working Group (TWG) on Urban Waste Water and Sanitation toreflect the high importance the RGC attaches to development of the sanitation sector and to respond to the needs of the wastewater and sanitation sector in a more strategic manner, by examining and reviewing existing sector policies and institutional frameworks, identifying bottlenecks in the sector and developing sustainable solutions to address them. GGGI also provided technical inputs into the TOR of the National level TWG on Sustainable City, with the objective to accelerate city developments in compliance with the national policy for green development as well as the national strategic plan for green development of the Royal Government in the economic sector.

GUDP also aims to help mobilize resources for the government to implement green city projects. Out of the 48 projects proposed in the Phnom Penh Sustainable City Plan, 13 concept notes were developed, two pre-feasibility studies were conducted, and one funding proposal worth of $5 million was submitted to KOICA for implementation. Similarly, the joint Sustainable City Strategic Plan for seven other cities proposed more than 100 projects ideas, of which 10 ideas were developed in detail concept notes and two ideas are being studied for a potential investment from donors and private sector.

GUDP sees capacity building an integral part in successful green city development and thus has integratedcapacity building activities throughout the project cycle. GUDP's capacity building initiatives include training workshops at the national and sub-national level and seminar series on green city topics such as waste management, sustainable transport, project prioritization, and resource mobilization. The program also promotes South-South Knowledge Exchange by organizingstudy tours to Melaca city in 2016 and Surabaya City in 2018 for Cambodian delegates from relevant government institutions to learn from green city development experiences in the region.

4. Conclusion

With its steady economic growth of 7% annually in the last decade, Cambodia is moving to lower middle-income country. With this economic growth, Cambodia is one of rapid urbanization countries in Asia and this puts pressure on thesustainability of natural resources. Many major cities and towns across the country is facing rapid, unplanned and unsustainable patterns of urban growth and development. This makes the cities, the focal points for many emerging environment and social issues including inefficient land use, insufficient provision of basic services and infrastructure, loss of natural resources, increased congestion, pollution, unemployment and inequality.

These problems can be attributed to poor urban management, little strategic spatial planning, poor connectivity between urban planning and environmental management, and insufficient investment in public services and infrastructure. Current urbanization is overwhelmingly

concentrated in and around Phnom Penh, with some urban clustering in the Northwest around the Tonle Sap Lake and the Plain region. There is less urban development in the coastal zones, which can potentially become growth poles.

There is an over concentration of industries, employment and services in some of these urban centers, particularly Phnom Penh. The availability and quality of public services, such as water supply and solid waste collection, is also unfairly distributed with conditions in Phnom Penh being much better than those in many smaller cities, towns, and rural areas.

Cities are now being recognized as engines of growth and economic development.Unless cities and national urban development are carefully planned and managed, economic growth may remain limited to the few larger urban areas. The need for improved urban planning and development management (and urban governance) is now becoming critical if the growing urban areas are to be compact and "liveable", as well as economically and environmentally sustainable in the medium to long term.

Sustainable city development, if implemented effectively, is an approach that can help achieve that goal. Sustainable cities move towards long-term environmental protection, social inclusion and economic sustainability. More specifically, sustainable cities are the ones that are resource-efficient, climate-resilient, socially inclusive and equitable. Green growth in cities has the potential to offer many benefits including green job creation, improved connectivity between cities and markets, infrastructure development, inclusive services provision, urban adaptation, and low-carbon development. To achieve these goals, GUDP proposed the following recommendations:

1. Develop sustainable urban infrastructure, integrated urban land-use planning and strengthened urban environmental management, to provide high quality public services, preserve natural capital and reduce environmental pollution and climate change impacts
2. Improve the local economy by strengthening the city's comparative advantages and exploring opportunities to promote circular economy, public-private partnerships, and green technology
3. Promote social inclusiveness and access to services and job opportunities for all
4. Improve the city's governance by building strong, accountable institutions, developing local human resources and promoting knowledge and experience sharing among cities.

References

Dek, V. (2017). Solid Waste Management in Cambodia. Presentation, Siem Reap, Cambodia.

IPCC (Intergovernmental Panel on Climate Change). 2015. Climate Change 2013: The Physical Science Basis. URL: http://www.ipcc.ch/report/ar5/wg1/.

JICA (Japanese International Cooperation Agency). 2015a. The Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area. Progress Report II, November 2015.

JICA. 2015b. "Drainage Improvement and Flood Protection in Phnom Penh – Achievements, Constraints and Plans". JICA PowerPoint presentation, July 2015.

Ministry of Planning. 2012. Migration in Cambodia. Report for the Cambodian Rural-Urban

National Committee for Disaster Management and UNDP Cambodia. 2014. Post-Flood Early Recovery Needs Assessment Report – Cambodia 2013. URL:http://www.undp.org/content/dam/cambodia/docs/PovRed/Cambodia%20post-flood%20recovery%20need%20assessment%20report.pdf.

National Institute for Statistics (NIS) and Directorate General for Health (DGH). 2014. Cambodia Demographic and Health Survey 2014. Key Indicators Report.

NIS. 2008. General Population Census of Cambodia – 2008 Provisional Population Totals. URL: http://www.stat.go.jp/english/info/meetings/cambodia/pdf/pre_rep1.pdf.

NIS. 2013. Cambodia inter-censal population survey 2013 – Final Report. URL: http://countryoffice.unfpa.org/cambodia/drive/CIPS_Report_English_Final.pdf.

NIS. 2015. Cambodia Socio-Economic Survey 2014. URL: http://www.nis.gov.kh/nis/CSES/CSES_2014_Report.pdf.

People in Need Cambodia. 2015. Urbanising Disaster Risk, Vulnerability of the Urban Poor in Cambodia to Flooding and Other Hazards.

Phnom Penh Post. 18/11/2014. "Road deaths to rise: minister". URL: http://www.phnompenhpost.com/national/road-deaths-rise-minister.

Royal Government of Cambodia (RGC) 2017a. Battambang Social Economic Statistic 2017

RGC 2017b. Battambang Social Economic Statistic 2017

RGC 2017c. Battambang Social Economic Statistic 2017

Sethy S., Sothun C., Wildblood R. (2014) Municipal Solid Waste Management in Cambodia. In: Pariatamby A., Tanaka M. (eds) Municipal Solid Waste Management in Asia and the Pacific Islands. Environmental Science and Engineering. Springer, Singapore.

Sothear, K. 2015. "Record rainfall prompts debate over drainage". The Cambodian Daily, 03/08/2015. URL: https://www.cambodiadaily.com/news/record-rainfall-prompts-debate-over-drainage-90412/.

United Nations Department for Social and Economic Affairs (UNDSEA). 2014. World Urbanisation Prospects, the 2014 Revision. URL: http://esa.un.org/unpd/wup/.

United Nations Department for Social and Economic Affairs (UNDSEA). 2014. World Urbanisation Prospects, the 2014 Revision. URL: http://esa.un.org/unpd/wup/.

United Nations Environment Programme (UNEP). 2015. Status of Fuel Quality and Vehicle Emission Standards in Asia-Pacific.

Vong, P. (2015). The State of Wastewater Management in Cambodia. Presentation, Bangkok, Thailand.

World Health Organization, & UNAIDS. (2006). Air quality guidelines: global update 2005. World Health Organization.

Annexes

GUDP stakeholders

Government

National Council for Sustainable Development (NCSD)

Ministry of Interior (MoI)

Ministry of Economic and Finance (MoEF)

Ministry of Public Works and Transport (MPWT)

Ministry of Land Management, Urban Planning and Construction (MLMUPC)

Ministry of Environment (MoE)

Ministry of Industry and Handicraft (MIH)

Ministry of Mines and Energy (MME)

Ministry of Water Resources and Meteorology (MoWRM)

Ministry of Tourism, the National Committee for Clean City Assessment

National Committee for Disaster Management

Council for the Development of Cambodia (CDC)

Ministry of Commerce (MoC)

Ministry of Women's Affairs

Phnom Penh Capital Administration (PPCA)

Provincial Hall and relevant Provincial

Private Sector & Financial Institutions

The European Chamber of Commerce's Green Business Committee

The Association of Banks in Cambodia

Cambodia Chamber of Commerce

Federation of Association of SMEs for Cambodia

Solar Association of Cambodia

Development Partners

Agencefrançaise de développement (AfD)

Asian Development Bank (ADB)

Japan International Cooperation Agency (JICA)

Australian Aid (DFAT)

European Union (EU)

KOICA

UNDP

UNIDO

UN-Habitat

UNESCO

Cambodia Climate Change Alliance (CCCA)

World Bank

International Finance Corporation

UN-Capital Development Fund

Climate Technology Initiative - PFAN

Academic, Research Institutes, NGOs/CSOs

Cambodia Institute for Urban Studies (CIUS)

Royal University of Phnom Penh (RUPP)

Urban Voice – Cambodia

People In Need (PIN)

The NGO Forum on Cambodia

Enrich Institute

SNV

GERES

Nexus

WaterAID

ESC-BORDA

ACRA

V

Climate Action

9.
Integration of Climate Change Measures into National Policies, Strategies and Planning in Cambodia

10.
Climate Change and ODA Actions in Cambodia

9

HENG Chanthoeun[1)]

Integration of Climate Change Measures into National Policies, Strategies and Planning in Cambodia

Abstract

Climate change potentially impacts and threatens socio-economic development, people, livelihoods, health risk and ecosystem. To meet the need for integrated approaches to planning climate change interventions in coherence with a relevant sustainable development way towards poverty reduction Cambodia is taking measures to cope with frequent climate hazards and to reduce the country's vulnerability to loss and damage not just in the current short term but in the medium to long term. The key priority actions respond to climate change impacts by integrating climate change measures into national policies, strategies, planning, and the implementation of climate change implications in national strategic development plan update, climate change action plan of Cambodia's climate change strategic plan implementation, sustainable development goals integration, national development sectoral policy, and synergized with Mekong adaptation strategy and action plan. Therefore, the implementation plan for climate change financing framework includes national adaptation plan under changing climate. This paper presents the current climate change activities implemented as an effort to integrate climate adaptation into sectoral policy, strategies, planning and budget planning. These have also prompted a process of responding to climate change issues to support sustainable development by strengthening technical and institutional capacity, and increasing knowledge and raising awareness.

1. Introduction

Cambodia is considered a country highly vulnerable to the effects of climate change such as changing rainfall patterns, increasingly frequent floods, tropical storms and drought as well as sea-level rise. Climate change impact is already taking a toll on the population, livelihoods and food security of those most vulnerable to potential impacts and risks. The Royal Government of Cambodia (RGC) is taking measures to cope with climate challenges and to reduce the country's vulnerability in the medium- to long-term.

Cambodia acceded to the UNFCCC in December 1995 and ratified the convention in December 1996, Kyoto Protocol in July 2002, and ratified the Paris Agreement in February 2017. It established the National Climate

1. Department of Climate Change, NCSD, MoE, Cambodia

Change Committee (NCCC) in 2006. Since 2009, the NCCC has been honorably chaired by the Prime Minister and a new sub-decree on NCCC was issued in 2014. The National Council for Sustainable Development was established in 2015 by Royal Decree to ensure the balance among the economy, environment, society and culture in the Kingdom of Cambodia.

The priority activities are contributing to sustainable socio-economic development in Cambodia, in particular, ensuring the sustainability of agricultural productivity and food security and rural infrastructure improvement. In addition, most priorities respond to climate change as a way of promoting the implementation and updating the National Adaptation Programme of Action to climate change. An effort is underway to integrate climate adaptation into policy and budget planning, and the government has also launched a process to develop and implement its National Adaptation Plan.

The government updated NSDP by settings out a rectangular strategy to achieve economic growth, poverty reduction and the Cambodia Millennium Development Goals and the Sustainable Development Goals. The Cambodia Climate Change Strategic Plan (2014-2023) represents a significant step towards integrating climate change into the National Strategic Development Plan (2014-2018) and into the sector-wide development plans of all the relevant ministries. The financing framework of the NAP include the Intended Nationally Determined Contribution submitted by Cambodia to the UNFCCC in 2015, the sectoral Climate Change Action Plans focused on key climate sensitive areas, and the Cambodian Climate Change Financing Framework undertaken at national and sub-national levels. The objective of Integration of Climate Change into National Policies, Strategies and Planning in Cambodia is to understand the status of Climate Change Implications in NSDP Update; CCCSP implementation; Sustainable Development Goals integration; National Development Sectoral Policy and MASAP; Implementation Plan for NAP Financing; and Monitoring and Evaluation Framework for Climate Change.

2. Policy and Legal Frameworks

United Nations Framework Convention on Climate Change

Currently, there are 197 Parties (196 states and 1 regional economic integration organization) to the United Nations Framework Convention on Climate Change (UNFCCC). In accordance with article 20, it was open for signature at Rio de Janeiro from 4 to 14 June, 1992, and thereafter at the United Nations Headquarters, from 20 June 1992 to 19 June 1993. By then, the Convention had received 166 signatures. The global nature of climate change calls for the cooperation of all countries and their participation in an effective and suitable international response, which can serve as a framework for international cooperation to combat climate change by limiting average global temperature increases, in accordance with their common but differentiated responsibilities and respective capabilities and their social and economic conditions (UNFCCC, 1992). The Earth's surface and atmosphere is warming

and may affect natural ecosystems, resulting from human activities that significantly increase the atmospheric concentrations of greenhouse gases and intensify natural greenhouse effect.

The Royal Government of Cambodia (RGC) after considering the framework convention of the United Nations on Climate Change concluded in New York on May 09, 1992 acceded to the same and undertook to carry out all the stipulations contained therein. Cambodia ratified the UNFCCC on 13 December, 1995. The Convention entered into force in Cambodia on 17 March, 1996, thus making the country eligible under the financial mechanism of the UNFCCC. In August 1998, the RGC and the United Nations Development Programme (UNDP)/Global Environment Facility (GEF) signed a project document, enabling Cambodia to prepare its First National Communication in response to the UNFCCC through Climate Change Enabling Activity Project which started in January 1999 and as the first step taken by the government in the actual implementation of the UNFCCC.

The first National Communication describes how Cambodia, as a Non-Annex 1 Party to the Convention, is meeting its commitments under the UNFCCC. This Communication provides information on the national circumstances and national GHG inventory for 1994. The second National Communication describes how Cambodia, as a Non-Annex 1 Party to the Convention, is meeting its commitments under the UNFCCC and national GHG inventory for 2000. In addition, the Intended Nationally Determined Contribution (INDC) also describes Cambodia's capability to respond to the impacts of climate change and measures taken to mitigate climate change in the country. Also stated are the major sources of greenhouse gas emissions and sinks, vulnerability and adaptation options, together with the necessary mitigation measures that Cambodia has implemented and will continue to implement to adapt to climate change impacts and to further contribute to global efforts to reduce greenhouse gas emissions.

Kyoto Protocol

The Kyoto Protocol legally binds developed country parties to emission reduction targets. Countries launched negotiations to strength the global response to climate change and two years later, adopted the Kyoto Protocol. The Protocol's first commitment period started in 2018 and ended in 2012. The second commitment period began on 1 January, 2013 and will end in 2020. There are 192 Parties to the Kyoto Protocol. The Parties included in Annex I (developed countries) must make sure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases are in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5% below 1990 levels in the commitment period 2008 to 2012 (UNFCCC, 1998). Each Party included in Annex I shall, by 2005, have made demonstrable progress in achieving its commitments under this Protocol.

The Clean Development Mechanism (CDM) assists Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and reduction commitments under Article 3. CDM of the Kyoto Protocol is a practical means for transferring mitigation technology to developing countries. However, in terms of

geographical distribution and equity, CDM has many limitations, in particular for least developed countries.

The RGC after reviewing the Kyoto Protocol to the UNFCCC adopted in Kyoto, Japan on December 11, 1997 by the 3rd Conference of the Parties (CoP3) acceded to the same and undertook to carry out all the stipulations contained therein. Cambodia signed and sealed this Instrument of Accession in 2002.

Paris Agreement

The Paris Agreement is a global effort to combat climate change by seeking to accelerate and intensify the actions and investment needed for a sustainable low carbon future. It was adopted in Paris on 12 December, 2015, marking the latest step in the evolution of UN climate change regime and efforts to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels. To reach these ambitious goals, there were appropriate financial flows, including by before 2025, setting a new goal on the provision of finance from US$ 100 billion for the purpose of enhancing capacity building framework, transparency of action and support for developing countries and the most vulnerable countries, in line with their national objectives. The Conference of the Parties (CoP21) held in Paris, France had successfully endorsed this historical agreement to address climate change, which entered into force at CoP22 held in Marrakech.

The RGC after considering the Paris Agreement to the UNFCCC adopted in Paris, France on 12 December, 2015 ratified the Paris Agreement on 6 February, 2017. The Agreement, once ratified by Cambodia, enabled the country to participate in the new climate regime, which is expected to lead to greater access to climate finance and to innovative technologies for low carbon climate resilient development, increased support for capacity development, research and cooperation in priority areas of adaptation and mitigation. These activities included (MoE, 2015) were aimed at promoting energy efficiency and renewable energy, forest protection, climate proofing of infrastructure including transport, as stated in the INDC. In addition, the Paris Agreement is significant in that it mobilizes the private sector to become more involved in climate change related investments, and ensures wide international recognition of the country's political will, commitment and efforts in addressing climate change.

Institutional Arrangement

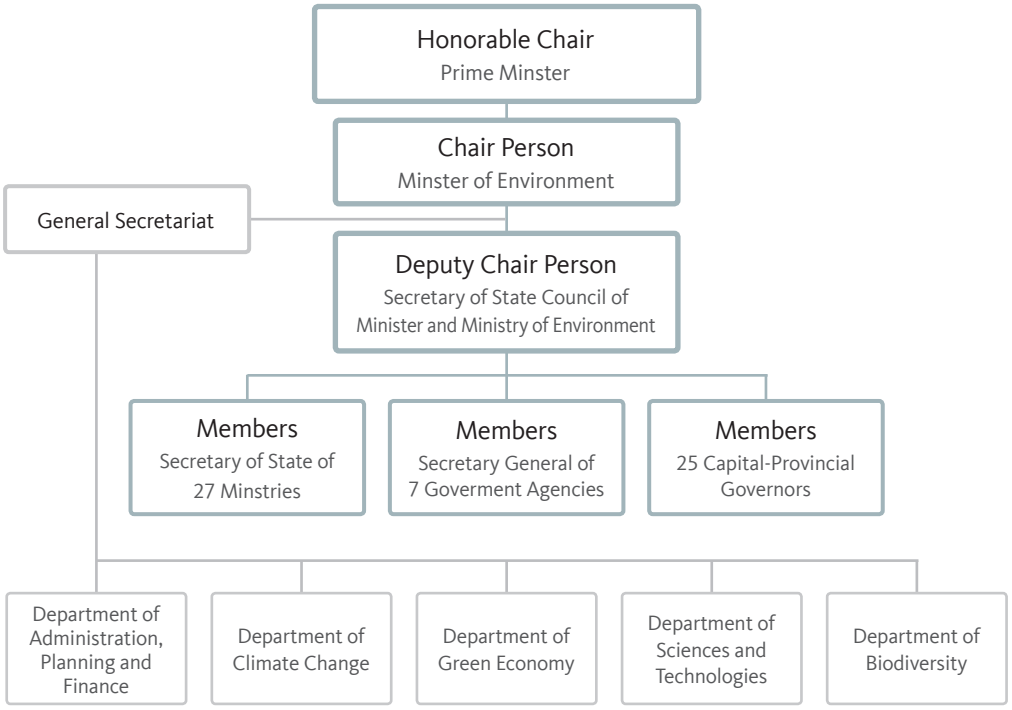
The RGC established the National Climate Change Committee (NCCC) in 2006, a cross-sectoral and multi-disciplinary body with the mandate to prepare, coordinate and monitor the implementation of policies, strategies, legal instruments, plans and programmes related to climate change. The new NCCC (RGC, 2014) consists of 22 members representing different institutions. The Prime Minister (PM) is the honourable Chairman of the NCCC. There are 22 members including PM (Honourable Chair); Ministry of Environment (Chair); Ministry of Agriculture Forestry and Fisheries (Vice Chair); Ministry of Mines and

Energy (Vice Chair); Ministry of Water Resources and Meteorology (Vice Chair); Ministry of Commerce; Council of Ministers; Ministry of Interior; Ministry of Economy and Finance; Ministry of Public Works and Transport; Ministry of Industry and Handicraft; Ministry of Planning; Ministry of Foreign Affairs and International Cooperation; Ministry of Education Youth and Sports; Ministry of Health; Ministry of Land Management Urban Planning and Construction; Ministry of Rural Development; Ministry of Information; Ministry of Women Affairs; National Committee for Disaster Management; Cambodian Development Councils; and Cambodia National Mekong Committee.

In accordance with Article 1 of NCSD, the National Council for Sustainable Development (NCSD) was established to enhance the balance among economy, environment, society and culture in the Kingdom of Cambodia (Royal Palace, 2015). The NCSD consists of 39 members representing different institutions, and the secretary was appointed on 18 May, 2015 (RGC, 2015) to serve as the secretariat and coordinate all the activities in the country undertaken for the implementation of the Cambodian Climate Change Strategic Plan 2014-2023, the Sectoral Climate Change Action Plans and the Climate Change Financing Framework. The organization of NCSD is shown in Figures 1 and 2 below.

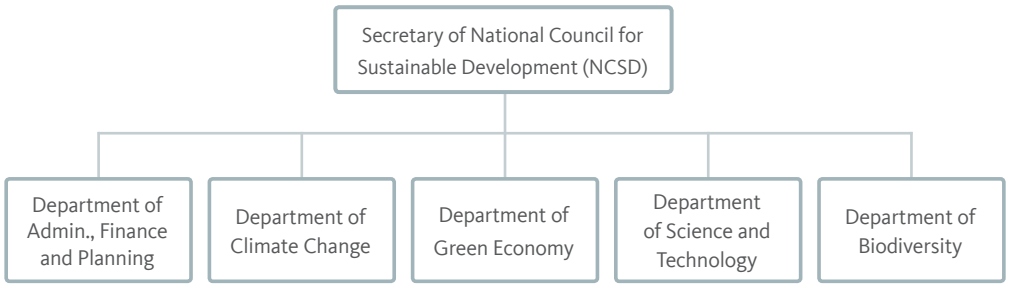
↘ Figure 1

National Council for Sustainable Development Structure



↘ Figure 2

Organization of Secretary of the National Council for Sustainable Development



The Department of Climate Change (DCC) of the Ministry of Environment is the secretariat to the NCCC. In 2010, the DCC was promoted from Climate Change Office, which was established in 2003. The mandate of DCC included undertaking technical activities for implementing the UNFCCC, liaison with other agencies and enhancing cooperation to promote the implementation of climate change policies, advising the government in the field of climate change, as well as other tasks such as raising public awareness, data management, and promoting science research and capacity building.

3. National Development Policy and Strategic Plan

Rectangular Strategy Phase III for Growth, Employment, Equity and Efficiency is expanded in scope, with refined and reprioritized sides, and improved and more effective policies and mechanisms (RGC/MoP, 2014). It continues to strengthen technical and institutional capacity to promote the mainstreaming of climate change responses into the policies, laws and plans at national and sub-national levels, to ensure development sustainability and poverty reduction in response to the aspirations of the people in new national and international contexts. Managing the environment and climate change has become another challenge for the sustainability of Cambodia's socio-economic development and the RGC is working towards reducing the impacts of climate change by strengthening adaptation capacity and resiliency.

The NSDP 2014-2018 was formulated by defining priorities, indicators and timeframe for the implementation and by identifying the mechanism for Monitoring and Evaluation of the Result Framework, especially by setting the responsibility of the line ministries and agencies within each angle in order to gain high benefits from ASEAN Economic Integration in 2015 and to graduate from the Least Developed Countries status and become an Upper-Middle-Income Country by 2030 (RGC/MoP, 2014). The Ministry of Environment (MoE) will continue to take a comprehensive development approach toward environmental management in Cambodia (RGC, 2013), by (i) Managing natural resources in a sustainably manner; (ii) Intensifying efforts to reduce the impact of climate change by strengthening adaptation capacity and resiliency based on the implementation of the "Cambodia Climate Change Strategic Plan 2014-2023", "National Policy on Green Development" and the "National Strategic Plan on Green Development 2013-2030" (RGC/MoP, 2014); (iii) Continuing to strengthen technical and institutional capacity to promote the mainstreaming of climate change responses into policies, laws and plans at national and sub-national levels; and (iv) Continuing to introduce measures to better manage the environment and ecosystems.

The National Sustainable Development Strategy for Cambodia (2008-2030) seeks to ensure environmental sustainability, human wellbeing and social development alongside the development of a prosperous economy. The RGC has developed laws, policies, strategies and plans in order to cope with the protection and management of natural resources for a more sustainable economic and social development (MoE, 2009). However, until now there was no long-term comprehensive strategy

integrating the core dimensions of sustainable development. Environmental sustainability essentially equates to protecting the quality of the environment and natural resources (RGC/MoP, 2014). The National Policy and Strategic Plan for Green Growth (2013-2030) drives the Cambodian economy towards the green economy, focusing on effective use of natural resources, environmental sustainability, green jobs, green technologies, green finance, green credit, and green investment (MoE, 2013).

Policy Related to Climate Change Strategic Plan

Mission, Vision, and Goals

The RGC, under the leadership of Samdach Hun Sen, announced the Cambodia Climate Change Strategic Plan (CCCSP) 2014-2023 at the Third National Forum on Climate Change held in November 2013. The RGC has recognized climate change as a major challenge to sustainable development (RGC, 2013). Given the country's high vulnerability to the impacts of climate variability and change, e.g. severe floods, droughts, storms, increasing temperatures, sea level rise, and a changing rainfall regime, CC can affect and undermine Cambodia's economic growth and poverty reduction efforts, unless adequate measures are timely put in place. The 2009-2013 NSDP prioritized the development of a strategic response to the challenges imposed by changing climate conditions and shown in Figure 3 below.

↘ Figure 3

High Vulnerability to Floods

CCCSP's Mission: Creating a national framework for engaging the public, the private sector, civil society, and development partners in a participatory process for responding to climate change to support sustainable development.

Vision: Developing Cambodia towards a green, low-carbon, climate-resilient, equitable, sustainable and knowledge-based society.

Goals: (i) Reducing people's vulnerability to climate change impacts, in particular the most vulnerable and critical systems; (ii) Shifting towards a green development path by promoting low-carbon development and technologies, and (iii) Promoting public awareness and participating in climate change response actions.

Strategic Frameworks and Objectives

Cambodia is highly vulnerable to climate change and the RGC recognizes the need for mainstreaming climate change into the NSDP and national policies at all levels based on selected key guiding principles. To achieve the vision, mission and goals, eight strategic objectives were identified: (i) Promote climate resilience by improving food, water and energy security; (ii) Reduce sectoral, regional, gender vulnerability and health risks posed by climate change impacts; (iii) Ensure climate resilience of critical ecosystems, biodiversity, protected areas and cultural heritage sites; (iv) Promote low-carbon planning and technologies to support sustainable development; (v) Improve capacities, knowledge and awareness of climate change responses; (vi) Promote adaptive social protection and participatory approaches in reducing loss and damage caused by climate change; (vii) Strengthen institutions and coordination frameworks for national climate change responses; and (viii) Strengthen collaboration and active participation in regional and global climate change processes.

National Development Forecasting

Cambodia's economic growth rate was projected at 7-8% for 2014. The RGC reviewed the Revenue Collection Policy and prepared and carried out the Medium-Term Revenue Mobilization Strategy 2013-2018 and will be able to maintain the economic growth rate of around 7% by 2019. The RGC continues to implement economic diversification policies based on the competitiveness of the Cambodian economy by focusing on the regional production value chain with special attention on increasing rice production and milled rice for export, raising manufacturing and agro-industry products, and further the Tourism Development Plan 2011-2020.

The RGC set the target agricultural growth rate of 5% per annum in order to meet the national economic growth target through enhanced productivity, diversification and commercialization. The agricultural sector contributed 32.1% to GDP in 2011 and the share is estimated to decrease slightly to 26.7% to GDP in 2016 (Global Finance, 2018). With a 5.72% annual growth rate in rice production, Cambodia expects to export 1 million tonnes of milled rice per annum by 2015.

The RGC will frame policies to ensure macroeconomic stability, low inflation and a stable exchange rate exchange, so as to gain high benefits from ASEAN Economic Integration in 2015, and enable Cambodia to graduate from its Least Developed Country status to become a Lower-middle Income Country by 2018, and a Higher-middle Income Country by 2030 (RGC/MoP, 2014). It will strive to reduce poverty by at least 1% per year, and accomplish its Millennium Development Goals and Sustainable Development Goals. The RGC strives to make sure that the standard of living in rural areas is improved to a level close to urban areas by 2025.

The nation is intensifying efforts to reduce the impact of climate change by strengthening the adaptation capacity and resiliency to climate change, particularly by implementing the "Cambodia Climate Change Strategic Plan 2014-2023", "National Strategic Plan on Green

Development 2013-2030". Cambodia has an opportunity to benefit from carbon market mechanisms such as REDD+ with 57.07% of land area and cover. Furthermore, it manages forest and wildlife resources in a sustainable and equitable manner according to the "National Forest Program 2010-2029", and "National Action Plan for Disaster Risk Reduction 2014-2018" through participation from all concerned parties in the government, development partners, private sector, and civil society organizations.

Climate Projections

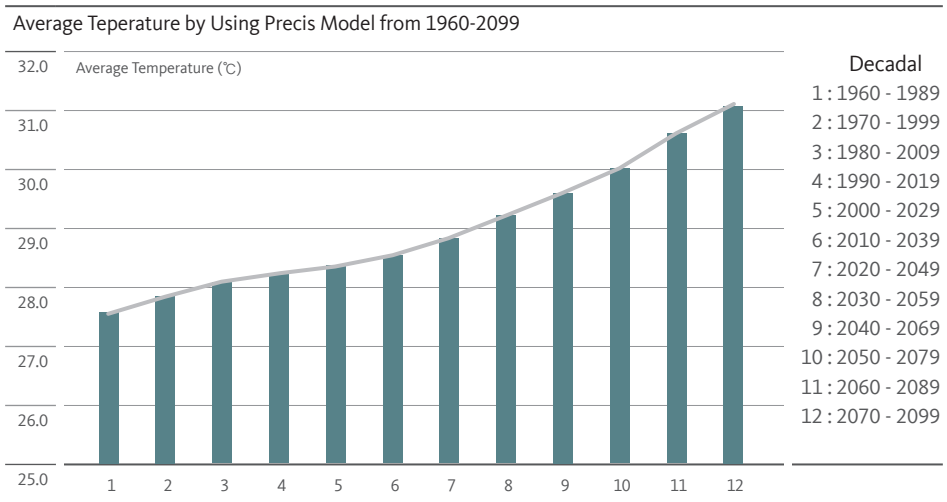
Changes in the average temperatures and rainfall were projected. Taking into account that there is a significant deviation between observed rainfall data and GCM model output used in this analysis (CCSR and CSIRO) of MAGICC-SCENGEN (MoE, 2001), the following projections were made for Cambodia: (i) Mean annual temperatures could increase between 0.3 to 0.6°C by 2025 and 1.6 to 2.0°C by 2100; (ii) Mean annual rainfall could increase between 3% to 35% by the year 2100 with the magnitude of change varying with time and location. Lowland areas would have higher increase in rainfall than highlands.

According to the Fourth Assessment Report of the IPCC, sea levels in the region are projected to rise under various scenarios: by 2090 relative to 1980-1999, the sea level will rise by 0.18-0.43 m under low emission scenarios (SRESB1), 0.21-0.52 m under medium emission scenarios (SRESA1B), and 0.23-0.56 m under high emission scenarios (SRESA2). This corresponds to a 0.56 m rise under the high emissions scenario (A2), which at this rate would cause permanent inundation of about 25,000 ha of coastal Cambodia within 90 years. The selected Representative Concentration Pathways (RCPs) are two of the four greenhouse gas concentration trajectories adopted by the IPCC for its fifth Assessment Report (AR5) (IPCC, 2013). These RCPs scenarios, RCP4.5 and RCP8.5, are possible range of radiative forcing values in the year 2100 by downscaled projection from the 21 models and scenarios. Each of the climate projections includes daily maximum and minimum temperature, and precipitation for the periods from 1950 through 2100 with spatial resolution of 0.25 degrees (25 km x 25 km).

Main findings for projected climate in Cambodia show that the mean annual temperature is projected to increase by 0.7 to 2.7 °C by the 2060s, and 1.4 to 4.3 °C by the 2090s. The range of projections for the 2090s is around 1.0 to 1.5 °C. Based on the result of rescaling temperature data of all grids from PRECIS obtained by using all data downscaled by PRECIS, regional climate model for Mekong River Basin over the land area were averaged 30 years period of record starting from 1960 to 2099 (SEASTART RC, 2009). It was found that the rate of mean monthly temperature increase ranged from 0.013 °C to 0.036 °C per year depending on the location (MoE, 2015a and Heng C.T, 2015a). The rate of temperature increase is high in low altitude areas such as in the central and Northeast Cambodia (0.036 °C per year) and low in the high altitude areas such as the Southwest region (0.013 °C per year) as presented in Figure 4 below.

↘ Figure 4

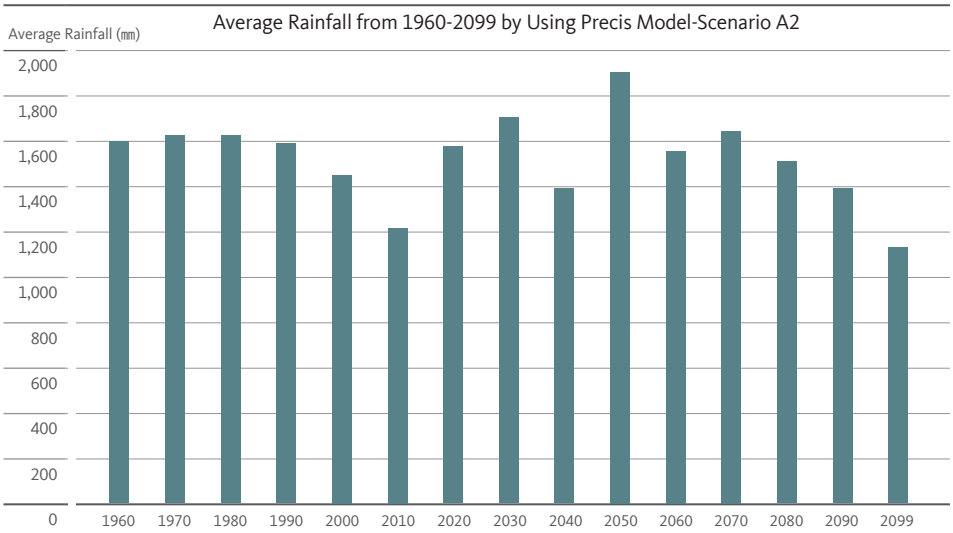
Average Temperature from 1960-2099 Constructed Using Precis Model



Although there is inconclusive evidence of climate impact on rainfall, projections of the mean annual rainfall indicate an increase in rainfall for Cambodia. There is an increasing trend in seasonal rainfall between June and August in the northwest, and a decreasing trend in the northeast of the country. The result of analysis shows a clear upward trend in average rainfall data. By using all data downscaled by PRECIS regional climate model for both scenarios A2 and B2, projections were made for annual precipitation from 2008 to 2099 of PRECIS SRESA2 and it was found that rainfall is expected to increase after 2008 and will be continually increase until 2050 and 2070. The projected annual precipitation from 2008 to 2099 of PRECIS SRESB2 (Heng C.T, 2015a) is as shown in Figure 5 below.

↘ Figure 5

Average Rainfall from 1960-2099 Constructed Using Precis Model



4. National Policy Responses to Climate Change

GHG Mitigation Response Measure to Climate Change

Clean Development Mechanism

The Clean Development Mechanism (CDM) defined under Article 12 of the Kyoto Protocol enables investors (governments or companies) from developed countries to finance greenhouse gas emission reduction or removal projects in developing countries, and receive Certified Emission Reduction Units for doing so, which can be credited towards the commitments of the respective developed countries.

As of 2015, the Ministry of Environment as the Cambodian Designated National Authority (DNA) for CDM approved 11 CDM projects. Of these, 10 projects have been registered at the Executive Board of the UNFCCC. These CDM projects are associated with the use of renewable energy, industrial waste heat, agricultural and livestock wastes to generate electricity and heat, and hydropower. Most of the proponents of the CDM projects are private companies (MoE, 2015a). The Executive Board of UNFCCC adopted the Cambodian DNA's proposal on standardized baseline "Technology switch in the rice mill sector of Cambodia" in November 2013 in Warsaw, Poland. As a whole, this is the 4th approved standardized baseline and the 1st one in rice mill sector, developed jointly by the Ministry of Environment and the Institute for Global Environmental Strategies (IGES) of Japan and submitted to the Executive Board for approval in December 2012. The approved standardized baseline was developed based on a national level survey of nearly 92 rice mills in Cambodia.

Reducing Emissions from Deforestation and Forest Degradation

Reducing Emissions from Deforestation and Forest Degradation (REDD+) is an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. "REDD+" goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.

UN-REDD National Programme is supporting Cambodia prepare for REDD+ Implementation, including development of necessary institutions, policies and capacity. This will contribute to the overall goal of ensuring that by the end of 2012, Cambodia has developed a National REDD+ Strategy and Implementation Framework and is ready to contribute to reducing emissions from deforestation and forest degradation (UN-REDD, 2010). Cambodia developed a national road map for readiness for REDD+ in 2009-2010, established its first REDD+ pilot project in 2008 and submitted a Readiness Plan Proposal to the Forest Carbon Partnership Facility in 2009. It also became a partner country of the UN-REDD Programme in 2009 and signed a REDD National Programme in 2011, and currently three pilot REDD+ projects (Oddor Meanchey, Seima and Kulen Promtep) are being implemented. Cambodia is participating in international efforts to mitigate climate change and reduce emissions from deforestation and forest degradation while also pursuing other national goals for the society and the environment. Deforestation and forest degradation contribute to increasing concentrations of greenhouse gases in the atmosphere which leads to climate change.

Key National Policy responses to Climate Change

The RGC's priority policies in CCCSP are consistent with the NSDP 2014-2018. Institutional capacity development and utilizing science-based solutions to address climate risks are common themes running through these overarching national policy documents. Within the framework, line ministries have prepared Sectoral Climate Change Strategic Plans and Climate Change Action Plans (CCAPs), prepared in 2013-2014 and lasting until 2018. So far, 15 ministries have developed CCAPs and these encompass a total of 171 climate actions of which 7% are mitigation-oriented and 93% are adaptation activities. However, only priority action plans have been allocated with resources and implemented, and remaining 148 actions identified in the CCAPs have not been funded or implemented (MoE/GSSD, 2017).

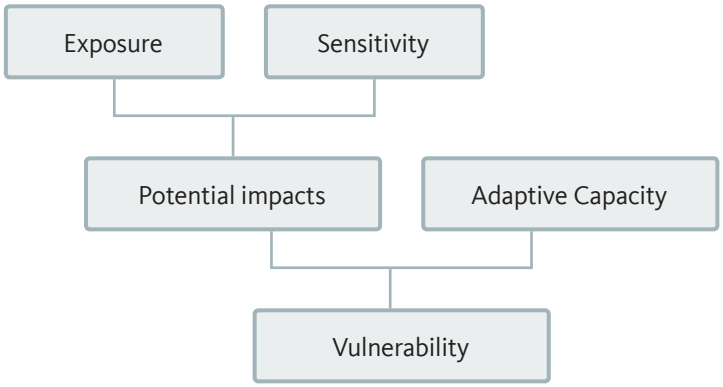
5. NAP Process and Climate Change Financing Framework in Cambodia

Effects of and Vulnerability to Climate change

Climate change consists of three key effects: changing regional rainfall patterns, sea level rise, and increased average temperature. It affects key priority sectors in Cambodia such as agriculture, water resource, forest ecosystem, human health, coastal zone and infrastructure. Cambodia was ranked in the 13th place in the Global Climate Risk Index from 1995–2015 and in the 8th place in World Risk Index 2016. In 2014, Standard & Poor's ranked Cambodia's economy as the most vulnerable to the effects of climate change worldwide. According to the Climate Risk and Adaptation Country Profile prepared by the World Bank Group in 2011, average annual temperature in Cambodia has increased by 0.8 ºC since 1960. The future trend indicates that temperatures across the country are projected to rise by 0.7–2.7 ºC by 2060 and 1.4–4.3 ºC by 2090 (McSweeney et al., 2010). This is likely to vary between different geographical areas, resulting in an overall increase in rainfall during the monsoon season. The impacts of climate change on Cambodians and key economic sectors are likely to become increasingly significant. Climate change and its impacts are assessed through the inter-relationship between the three components of exposure, sensitivity and adaptive capacity as shown in Figure 6 below.

↘ Figure 6

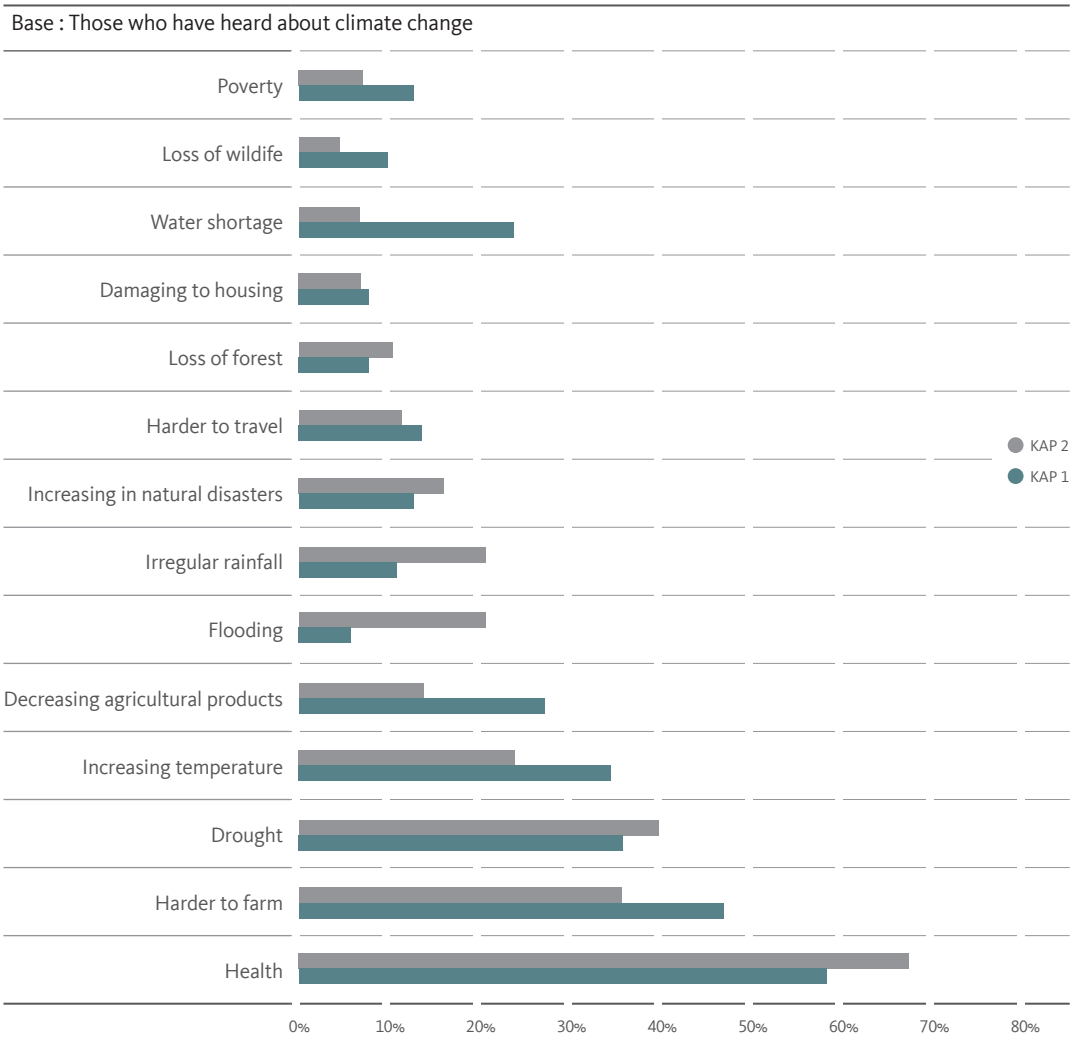
Structure of Vulnerability Assessment



Key findings were derived from a survey in 2016 titled Second Knowledge, Attitudes and Practices (KAP2) (MoE, 2015b), which compared the percentage of Cambodians (93%) who said they have experienced at least one extreme weather event in previous years with the results of a comprehensive survey conducted in 2011 for KAP1 (MoE/BBC World Service Trust, 2011). KAP2 recorded a significant increase in reports of higher temperatures/heat waves (44% in KAP1 to 73% in KAP2) and a more modest increase in rainfall intensity (from 61% in KAP1 to around 68% in KAP2). Other notable experiences included abnormally cool weather, flooding, forest fires, and pest and weed invasions as shown in Figure 7 below.

↘ Figure 7

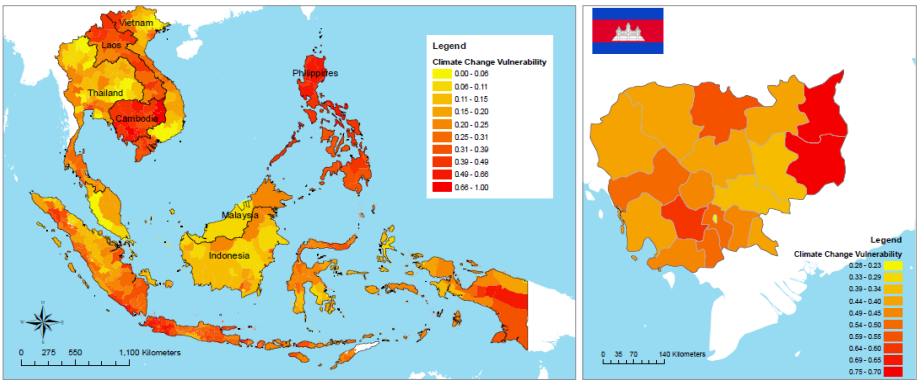
Climate change variability impacts in Cambodia of KAP2, 2015



Cambodia is one of the countries most vulnerable to climate change in the region according to an analysis of Southeast Asian countries. However, analysis is not detail enough to capture the variation of vulnerability among Cambodia's communes (Yusuf and Francisco, 2009). These provinces/districts falling in the fourth quartile were considered the vulnerable areas and further classified as mildly vulnerable, moderately vulnerable, or highly vulnerable. We used two different ways of ranking the areas: first, across

Southeast Asia, and second, within each of the selected countries. This was done simply to rank priority areas for adaptation interventions. Vulnerability mapping of climate change in Southeast Asia and Cambodia show the vulnerable areas by region and country standards, respectively as shown in Figure 8 below.

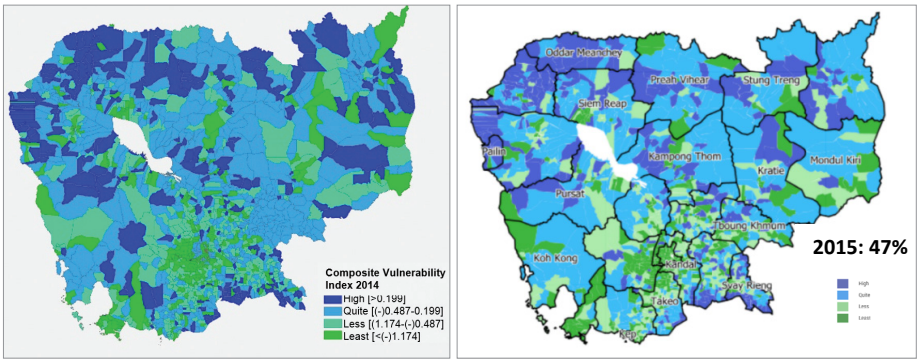
↘ Figure 8



Climate Change Vulnerability Map of Southeast Asia and Cambodia, 2009

The vulnerability mapping assessment, which was carried out for each of the 19 provinces of Cambodia, found that seven provinces belonged to the top 50 most vulnerable regions in Southeast Asia, out of the 590 regions that were assessed. Of these seven, the top three are the provinces of Mondulkiri, Rattanakiri, and Kampong Speu which were classified as vulnerable mainly to the low adaptive capacity of their inhabitants. The five vulnerable provinces lie in the east (Rattanakiri and Mondukiri), north (Preah Vihear), and south part of country (Kampong Speu and Takeo). The dominant feature of their vulnerability to climate change is their low adaptive capacity. However, in 2014 the vulnerability assessment indicated that 279 or 17.2% of Cambodia's communes were highly vulnerable and over 31.5% (512 communes) were quite vulnerable, bringing the total to around 49%. The percentage is expected to decrease to 47% in 2015, and slightly fall to around 34% in 2016. The communes 'quite' vulnerable to multiple climate change hazards are shown in Figure 9 below.

↘ Figure 9



Vulnerability Assessment in Cambodia, 2014 and 2015

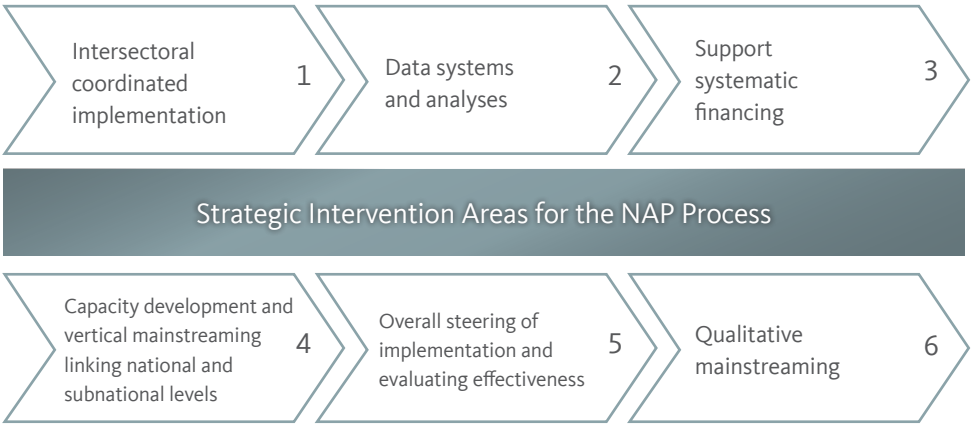
NAP Process in Cambodia

Cambodia's National Adaptation Plan (NAP) process was institutionalised in 2014, and adaptation is progressively taking a more prominent role in the government's policy agenda. The United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) helped identify where to start. A stocktaking report was compiled to that end, in line with the UNFCCC NAP and LEG technical guidelines. Furthermore, specific strategic intervention areas and climate change adaptation processes in Cambodia were analysed using a process landscape tool (UNDP/GIZ/NAP-GSP, 2014).

NAP process is useful for multiple decision-makers and for raising awareness amongst the national and sub-national stakeholders for local communities. NAP process that responds with activities in these strategic intervention areas will generate added value to existing CCA initiatives through these analyses of existing relevant CCA processes. Strategic intervention areas were defined with a focus on (i) Inter-sectoral coordinated implementation for fields of activity based on Sector Climate Change Action Plans (CCAP) which offer synergies through joint collaboration between sectors; (ii) Data systems and analyses for harmonized data processing, modeling, projections, and vulnerability assessments, and use of Geographical Information Systems; (iii) Support financing systematically as MoE might adopt a 'finance brokering' function to match financing needs with sources; (iv) Capacity development and vertical mainstreaming linking national and sub-national levels, advisory services, up-scaling mechanisms, and enhanced ownership at the local level; (v) Overall steering of implementation and evaluating effectiveness (M&E) to ensure learning process for Climate Change Adaptation; and (vi) Qualitative mainstreaming for climate risks and climate proofing larger projects as shown in Figure 10 below.

↘ Figure 10

Strategic Interventions Areas



As implementing the strategic intervention areas require a series of interventions; some of them are iterated throughout the process (UNDP/GIZ/NAP-GSP, 2014). NAP road-map is divided into three work-streams which occur in parallel over the time frame 2014-2019 for Short-Term (2014-2015), Medium-term (2016-2018), and Long-term (2019 and beyond): (i) Workstream 1: Planning, establishing and steering the NAP process. This requires an overall steering of the NAP process. Many activities are from the six strategic intervention areas; (ii) Workstream 2: Implementing the NAP process/the CCCSP and Sector CCAPs. Deal with the implementation of the strategic intervention areas 1 to 5; (iii) Workstream 3: Reviewing and learning. Deal with the implementation of an effective M&E system to implement the strategic intervention area 6.

Policies and Initiatives Supporting the NAP Process, and Priority Actions in Cambodia

The national government policies designed to respond to climate change challenges with a number of climate change flagship initiatives are supported by development partners that implement climate action and build resilience in Cambodia. The NAP process is aimed at strengthening on-going climate adaptation policy responses through cross-sectoral programming, provides an umbrella-framework to build resilience at national level, financing support and implementing the program.

The Cambodia Climate Change Alliance (CCCA) is an approach to address climate change on a national scale. This program was designed to fully align with national institutional framework for climate change, and plays an important role in building capacity through strengthening the national institutional framework for the coordination of the climate change response. The overall objective of the CCCA is to strengthen the capacity of the Department of Climate Change, the National Committee for Sustainable Development (NCSD) and the Ministry of Environment in order to fulfill its mandate of addressing climate change and enabling line ministries and Civil Society Organizations to implement priority climate actions. Phase 1 of CCCA (2010- 2014) and Phase 2 (2014-2019) are funded by the EU, UNDP and Sida (MoE/GSSD, 2017).

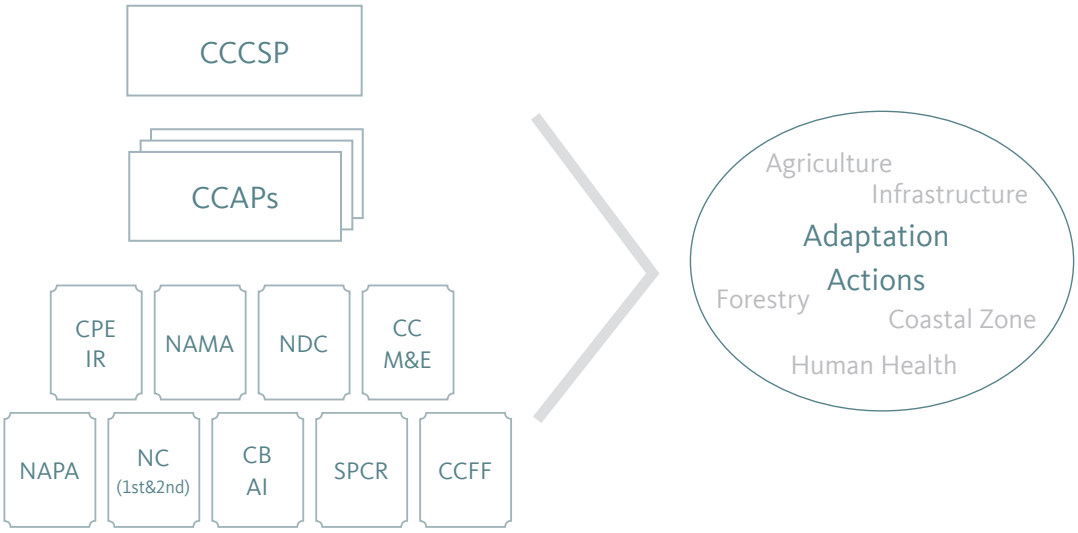
In addition, the Strategic Program for Climate Resilience (SPCR) with a timeframe of 2012-2019 emphasizes two phases for promoting climate resilience: (i) developing knowledge of climate impacts in Cambodia and mainstreaming climate risk management into agriculture, water resources, transport and urban infrastructure sectors and (ii) applying new skills, techniques, technologies, and engineering practices to climate-proof hard investments through the Asian Development Bank (ADB) is funded by the Climate Investment Funds.

Based on knowledge of the priority sectors relevant to the NAP and of the institutional settings in each of the climate-sensitive-institutions through multi-stakeholder consultation, 40 Priority Actions of Climate Change Action Plan were classified into (i) Priority Actions near implementation stage for Adaptation projects at formulation stage that can be launched in the short- term, which account for around 30% of the NAP actions; (ii) Priority Actions in preparation stage for Adaptation

projects that require further formulation of concept notes or ideas and institutional arrangements for implementation, which account for around 60% of the NAP actions; and (iii) Priority actions contributing to the NAP enabling environment for cross-cutting and/or sector-wide initiatives that are necessary for facilitating the implementation of the NAP, which account for around 10% of the priorities adaptation actions as shown in Figure 11 below.

↘ Figure 11

NAP Process and Priority Action



Climate Change Financing Framework

Existing Climate Expenditure Review

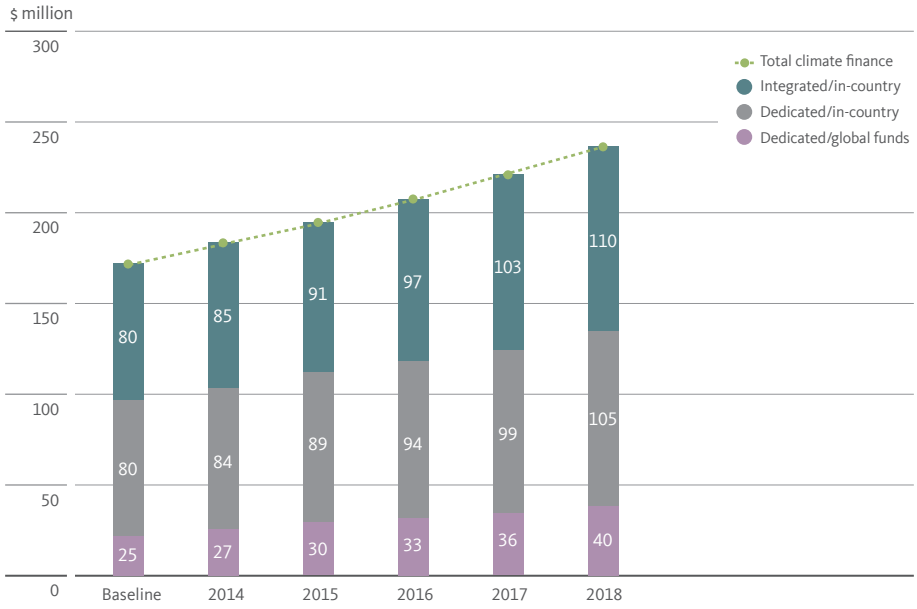
RGC developed Cambodia's Climate Change Financing Framework (CCFF) in 2014 with the following objectives: (i) update the existing climate expenditure analysis across the most affected government agencies; (ii) estimate potential climate funding for Cambodia in the future under low growth and high growth scenarios of 5 to 10 years; (iii) conduct Cost Benefit Analyses for the climate actions prioritized in government plans and an assessment of national benefits of climate finance; and (iv) analyze modalities to manage climate finance. In particular, the CCFF assesses the option of a National Climate Fund and considers the requirements for improved coordination (MoE/GSSD, 2017). In addition, the importance of addressing climate change impacts and better managing climate finance resources was recognized, following the Climate Public Expenditure & Institutional Review (CPEIR) completed in 2012. Adaptation expenditures of the 15 ministries and agencies represent 96% of total climate change expenditure in 2015, and 95% when only external climate finance is included. Therefore, there is significant potential to increase investment in mitigation, while maintaining adaptation as a priority action.

The CCFF play a key role in future climate financing, both from domestic and international sources by promoting a common approach to climate financing demand and assessing the current level of financial resources available for future financing estimated under scenarios of increasing share of public finance from domestic and international sources. Thus, three types of CC finance were defined: (i) New funding that is dedicated to

climate change; (ii) Modification to existing funding in order to respond to climate change; and (iii) Changes in the allocation of resources to reflect the benefits generated by climate change expenditure. Cambodia anticipates an annual flow of climate finance of US$ 255m by 2018. Dedicated and integrated CC projects from in-country sources will remain the prominent features of climate finance source in Cambodia. Both make up 85% of the total and account for almost an equal share (MoE/NCSD, 2014). The flow of climate finance on a linear trend between the baseline in 2013 and 2018 which is focusing on 5-year period (2014-18) shows that the whole flow is expected to provide a total indicative resource of $1,127m to be available for financing climate expenditure, $640m of which is expected to come in the form of dedicated climate finance as shown in Figure 12 below.

↘ Figure 12

Indicative Progression of Climate Finance, 2014-18



NAP Financing Framework

The launch of NAPFF on 12 October, 2017 aims to provide access to information on climate financing and the climate change adaptation priority actions for relevant line ministries and stakeholders (MoE/GSSD, 2017). The development of a NAPFF requires an iterative process to enhance the country's capacity to further plan and implement adaptation measures in the longer-term. A number of aspects need to be expanded to achieve a robust and complete NAPFF Implementation Plan: (i) Further data-gathering focused on climate risks and vulnerability; (ii) Further assessments focused on institutional capacities and further prioritization exercises in updating; (iii) Further coordination efforts to tap into potential synergies; and (iv) Further capacity building focused on climate finance readiness.

6. Mainstreaming of Climate Change into National Policies, Strategies and Planning in Cambodia

Climate Change Implications in the NSDP 2014-2018 and NSDP Update

The NSDP update addresses climate change in national development planning and identifies response measures. The RGC is strengthening water resources management and developing irrigation systems; undertaking repair and maintenance of irrigation infrastructure where required; promoting integration among irrigation, hydropower and transportation systems; and developing legal framework, institutions and human resources.

The RGC works to provide clean water supply to the people for better livelihoods in accordance with the Cambodia Millennium Development Goals (CMDGs) and the Sustainable Development Goals, and to preserve the ecosystem of unpolluted water and clean environment. As part of the vision for the future in water management in the Mekong basin, it continues to take measures to rationalize water use in all water bodies: rivers, lakes and the Great Tonle Sap Lake.

Cambodia's agriculture continues to play an important role in supporting economic growth, ensuring equity, securing food security, and developing the rural economy. The RGC's vision is to modernize the sector with a new approach and with changed scope and pace in order to transform it from one that primarily depends on expanded use of available resources and traditional agricultural inputs into one that primarily depends on the application of techniques, new technologies, mechanization and irrigation to improve the yield rate, and diversify activities into high value crops, livestock, and aquaculture in an environmentally sustainable manner.

Flood implications on infrastructure: (i) the road structure needs strengthening, especially rural roads, so that floods do not affect the movement of people and transportation of goods; and (ii) additional dykes and drainage systems should be constructed in vulnerable areas to control excessive overflow of water from swollen rivers. The RGC fully cooperates with other Mekong Member Countries under the MRC Framework to ensure the sustainability of the Mekong River Basin and implement the Prioritized Policies in the updated MRC Strategic Plan. In addition, the RGC takes a comprehensive development approach toward environmental management in Cambodia by (i) managing natural resources in a sustainable manner; (ii) Intensifying efforts to reduce the impact of climate change by strengthening the adaptation capacity and resiliency to climate change; (iii) Continuing to strengthen technical and institutional capacity to promote the mainstreaming of climate change responses into the policies, laws and plans at national and sub-national levels; and (iv) Continuing to introduce measures to better manage the environment and ecosystems. The priority actions taken through the development of regulatory frameworks and mechanisms for carbon trading will strengthen the capability, preparation and implementation of climate change adaptation measures.

Cambodia Climate Change Strategic Plan 2014-2023

The CCCSP has set out a number of actions structured into three phases of implementation (RGC, 2013): (i) Short term (2013-2014): The

focus of this phase is on putting in place institutional and financial arrangements for the implementation of the CCCSP, development of national monitoring and evaluation (M&E) frameworks and indicators, and development of climate change action plans (2014-2018) by line ministries; (ii) Medium term (2014-2018): This phase will continue to support the implementation of what was planned in Phase 1, while scaling up to cover other activities such as accreditation of the Adaptation Fund and the Green Climate Fund, research and knowledge management, capacity development, and mainstreaming of climate change adaptation so that over time, GHG mitigation activities are implemented across sectors at different levels, and (iii) Long term (2019-2023): The focus of this phase will be on research and learning, but its main objective will be to scale up success cases and to continue mainstreaming climate change into national and sub-national programmes.

Sustainable Development Goals by 2030

Goal 13 of the UN Sustainable Development Goals (SDGs) calls for an urgent action to combat climate change and its impacts (UN-SDG, 2015). This is a technical note for key indicators of Cambodia-SDG13 (MoE/GSSD, 2018) concentrated on (i) Target 13.1: Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters focused on Indicator of Percentage of communes vulnerable to climate change and number of deaths, missing persons, and persons affected by disaster per 100,000 people; (ii) Target 13.2: Integrate climate change measures into national policies, strategies and planning focused on Indicator of Amount of GHGs emissions reduced from the national REDD+ Program implementation; Carbon Intensity of Economy; Prevalence of climate-related diseases and Climate Change Public Expenditure; (iii) Target 13.3: Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning focused on Indicator of Percentage of population with understanding of climate change disaggregated by sex; Level of institutional readiness for climate change response; and Education opportunities in the fields of Climate Change and Disaster Risk Reduction; and (iv) Target 13.a: Implement the commitment undertaken by developed-country parties to the UNFCCC to a goal of mobilizing jointly US$100 billion annually by 2020 focused on Indicator of new and additional climate funds under UNFCCC mobilized through the Green Climate Fund.

National Development Sectoral Policy Related to MASAP

The sectoral policy analysis comprises of the water resource and irrigation system management, flood and drought management, disaster management; agriculture and food security; sustainable management of natural resources; environmental protection, conservation and climate change; land management; infrastructure, energy and cross-cutting issues. The purpose is to ensure alignment with national development goals and policy priorities for Mekong Adaptation Strategy and Action Plan (MASAP) formulation process and flexible strategic adaptation priorities and actions at basin level to enhance adaptive capacity

and resilience to climate change of MRC Member Countries and thus sustainable development of the LMB (MRC, 2016). The implementation timeframe of MASAP's strategic priorities and actions from 2017 to 2022 is to be updated every five years following the MRC strategic planning cycle. In the next strategic planning cycle 2021-2025, the seven strategic priorities for basin-wide adaptation to climate change include: (i) Mainstreaming climate change into regional and national policies, programs and plans; (ii) Regional and international cooperation and partnership on adaptation; (iii) Implementation of transboundary, gender sensitive adaptation options; (iv) Access to adaptation finance; (v) Monitoring, data collection and sharing; (vi) Capacity development for climate change adaptation strategies and plans; and (vii) Outreach of MRC products on climate change and adaptation.

Implementation Plan for NAP Financing Framework

There are 40 Priority Actions derived from the long list of 148 unfunded actions (MoE/GSSD, 2017). They are focused on (i) there is a mixture of actions with potential tangible impact on the ground and actions that seek to address knowledge or capacity gaps at institutional level; (ii) there is a clear need to further incorporate gender-sensitivity to CCAPs' actions; (iii) most of the implementing entities have previous experience in dealing with climate change, but few have in-house expertise in directly managing climate funds; and (iv) some of the actions prioritized would receive international funds and/or are directly or indirectly benefitting from domestic budget allocations. There are three phases: (i) Short-term Implementation Phase: a selection of 13 Priority Actions appear to be at an advanced stage of formulation. These projects are classified as being "Near Implementation Stage"; (ii) Mid-term Implementation Phase (approx. 2-5 years): majority of the Priority Actions identified for the NAP at institutional and technical levels will be effectively implemented. The CCAP planning process covers an estimated 25 Priority Actions; and (iii) Continuous and Long-term Implementation Phase (for the duration of NAP implementation and beyond 5 years): In the long run, the implementation of the NAP Priority Actions will entail a continuous "learning by doing" process for national institutions framework.

Monitoring and Evaluation Framework for Climate Change

Four indicators of the highest strategic level were submitted by DCC to MoP for inclusion in the NSDP 2014-18 (MoE/NCSD, 2014). A national index of vulnerability will be the foundation for assessing impacts of CC financing in adaptation. Preferably, measuring progress in adaptation to CC should be based on changes at the household level, taking into consideration the key elements of vulnerability such as the exposure to potential risk, sensitivity of households to that risk and the adaptive capacity of households to survive the risk. Climate Vulnerability Index (CVI) for provinces which combines four sub-indices (MoE, 2015) estimates: (i) exposure to flood risk; (ii) exposure to drought risk; (iii) forest cover (because of the strong link with floods); and (iv) capacity to cope with risk, which is defined by a range of socio-economic indicators focused on schools, water, sanitation, electricity, housing, mortality and population density.

The national M&E framework for climate change adopts a twin-track approach, measuring on the one hand how well the national institutions are managing climate risks through institutional readiness indicators and on the other hand how successfully climate interventions are reducing vulnerability or lowering carbon emissions by using the impact indicators (Neha Rai et al.,2015). The Institutional readiness indicators are focused on: (i) Status of climate policy and strategies, development of national policies, strategies and action plans for climate change response; (ii) Status of climate integration into development planning, inclusion of climate change in long, medium (NSDP) and short term (PIP) national and sub-national planning; (iii) Status of coordination mechanism for climate change response and implementation of the CCCSP for climate change response; (iv) Status of climate information, production, access and use of climate change information; (v) Status of climate integration into financing, availability and effectiveness of a financial framework for climate change response. The Impact indicators are: (i) Percentage of communes vulnerable to climate change. The indicator can be disaggregated by climate hazards of flood, drought and storm; (ii) Families affected due to floods, storms and droughts in proportion to families affected by these extreme weather events (number of affected families per 1,000 families); and (iii) GHG emissions by sectors and per capita.

7. Conclusion

The impact of climate change has taken a toll on the population, livelihoods and food security of the those most vulnerable to potential risks with limited the adaptive capacity, posing another challenge for the sustainability of economic growth and social development. Cambodia is strengthening technical and institutional capacity to promote the mainstreaming of climate change responses into the policies, laws, strategies and plans at national and sub-national levels, in order to ensure socio-economic development sustainability and poverty reduction in response to the aspirations of the people, and both national and international new context. In order to cope with climate challenges and to reduce the vulnerability that are in urgent need in the medium- to long-term, Cambodia is working towards the integration of climate change measures into strategies, development planning of NSDP update, SDGs, MASAP and national policies at all levels in Cambodia. It is also putting in place institutional and financial arrangements for the implementation of the CCCSP, and implementing Plan for NAP Financing Framework. The aim is to promote climate resilience by improving food, water and energy security, increasing knowledge and awareness, improving adaptive capacity in reducing loss and damage from climate change impacts, and strengthening institutions, coordination and collaboration networks.

References

Heng C.T. (2015). First Draft Policy Analysis on Climate Change and Adaptation in Cambodia. Formulation of the Mekong Adaptation Strategy and Action Plan (MASAP), Mekong River Commission (MRC), Climate Change and Adaptation Initiative (CCAI), and Cambodia National Mekong Committee (CNMC).

Heng C.T. (2015a). Article title: Observed and Projected Changes in Temperature and Rainfall in Cambodia.

Global Finance. (2018). Cambodia GDP and Economic Data, country report 2017.

IPCC. (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [StoCker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley(eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp

McSweeney et al,. (2010). UNDP Climate Change Country Profiles: Cambodia.

MoE. (2001). Vulnerability and Adaptation Assessment to Climate Change in Cambodia.

MoE. (2002). Cambodia's Initial National Communication under the United Nations Framework Convention on Climate Change, Ministry of Environment, Royal Government of Cambodia.

MoE/BBC World Service Trust. (2011). Understanding Public Perceptions of Climate Change in Cambodia, Ministry of Environment (MoE)/ BBC World Service Trust.

MoE. (2009). National Sustainable Development Strategy for Cambodia (2008-2030), Ministry of Environment (MoE), Royal Government of Cambodia (RGC).

MoE. (2013). National Policy and Strategic Plan for Green Growth (2013-2030), Ministry of Environment (MoE), Royal Government of Cambodia (RGC).

MoE. (2015). Cambodia's Intended Nationally Determined Contribution to UNFCCC.

MoE. (2015a). Cambodia's Second National Communication under the United Nations Framework Convention on Climate Change, Ministry of Environment, Royal Government of Cambodia.

MoE. (2015b). A Second Study of Understanding of Public Perception of Climate Change in Cambodia: Knowledge, Attitudes and Practices. Phnom Penh: Ministry of Environment (MoE).

MoE (2016). National Adaptation Plan Process in Cambodia (2016), https://es.slideshare.net/NAP_Global_Network/current-status-of-national-adaptation-plan-process-in-cambodia.

MoE, NCSD (2016). Cambodia's national climate change monitoring and evaluation framework, Department of Climate Change, General Secretariat, NCSD, April 2016.

MoE/NCSD. (2014). Analysis and Recommendation for a Cambodia Climate Change Financing Framework (CCFF), CCCA (2014). General Secretariat of National Council for Sustainable Development/Ministry of Environment, Kingdom of Cambodia, Phnom Penh.

MoE/GSSD. (2017). National Adaptation Plan Financing Framework and Implementation Plan. General Secretariat of National Council for Sustainable Development/Ministry of Environment, Kingdom of Cambodia, Phnom Penh.

MoE/GSSD. (2018). Technical Notes for key indicators of Cambodia-SDG13.

MRC. (2016). Mekong Adaptation Strategy and Action Plan (MASAP), Mekong River Commission (MRC).

Neha Rai et al.,(2015). Developing a National M&E framework for climate change Tracking Adaptation and Measuring Development (TAMD) in Cambodia.

RGC. (2013). Cambodia Climate Change Strategic Plan (CCCSP, 2014-2023).

RGC. (2014). Sub-decree on Adjustment article #2 of sub decree#99 dated on 18 August 2010 the Establishment of the National Climate Change Committee.

RGC/MoP. (2014). National Strategic Development Plan 2014-2018, Royal Government of Cambodia (RGC), Ministry of Planning (MoP).

RGC. (2015). Sub-Decree on Establishment the Secretary of National Council for Sustainable Development (NCSD), Royal Government of Cambodia (RGC), 11 pp.

Royal Palace. (2015). Royal Decree on Establishment the National Council for Sustainable Development (NCSD), 6 pp.

UNDP/GIZ/NAP-GSP. (2014). Cambodia's National Adaptation Plan Process Stocktaking report and recommendations for a road map for advancing Cambodia's NAP process.

UN-REDD. (2010). National Programme Document, Cambodia. UN-REDD programme 5th policy board meeting, USA.

UN-SDG. (2015). Indicators and a Monitoring Framework for the Sustainable Development Goals. Launching a data revolution for the SDGs. A report by the Leadership Council of the Sustainable Development Solutions Network.

UNFCCC. (1998). Kyoto Protocol to the United Nations Framework Convention on Climate Change

UNFCCC. (1992). United Nations Framework Convention on Climate Change (UNFCCC) in 1992.

www.cif.climateinvestmentfunds.org/sites/default/files/meeting documents/ppcr_4_spcr_cambodia_0.pdf

www.germanwatch.org/en/download/16411.pdf

www.weltrisikobericht.de/english/

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Dohyun Park[1)]

Climate Change and ODA Actions in Cambodia

1. Introduction

Cambodia and Climate Change

According to recent studies, Cambodia is often ranked as one of the most climate change-vulnerable countries in the world. It is partly because of its inborn geographic and climate conditions but also because of the country's vulnerable socio-economic structures, which largely depend on climate-sensitive sectors including agriculture, land, water resources, forestry and fisheries. Because the country has relatively limited adaptive capacity and infrastructure, the most vulnerable groups such as rural households and women suffer the most from the negative impact of climate change.

Despite the fact that Cambodia has historically contributed little to the causes of climate change, Cambodians suffer from extreme weather events – both natural disasters and human induced disasters – such as flood, draught, storm, fire, temperature rise and sea level rise. The negative impacts of the events are becoming more critical as time goes by. An Asian Development Bank (ADB) study found that Cambodia lost $1.5 billion – 10 percent of its gross domestic product (GDP) – in 2015 from the negative effect of climate change (ADB, 2016).

The ADB study also warned that the future loss would be even bigger, if appropriate actions are not taken to address this matter. According to the local authority, the main areas affected by climate change are agriculture, water resources and health (Khmer Times, 2016). The Nationally Determined Contribution (NDC)[2)] highlights mitigation side but climate change adaptation issue is particularly important considering the local context.

Climate Actions in ODA

Climate change - SDG 13 - is closely linked to other sustainable development goals in that the negative impact of climate change hinders achieving other development goals as well. Therefore, the international development community regards climate change as a key development challenge we face this century. International efforts for paradigm shift towards low-emission and climate-resilient development pathways have strengthened climate actions in the form of official development assistance (ODA) and other financial support for mitigation and adaptation to climate change.

1. KOICA Climate Change Specialist
2. The NDC is submitted to the United Nations Framework Convention on Climate Change (UNFCCC) with specific national greenhouse gases mitigation targets.

↘ Figure 1

Sustainable Development Goals (SDGs)

↘ Figure 2

SDG 13 Climate Action

Achieving SDGs and the historic Paris Agreement requires development actions and financial and technical support from the developed countries group. This is not only because developed countries are relatively more responsible for climate change but also because both developed and developing countries share the negative impact of climate change. It is not a matter of a single country but a global development challenge that requires united efforts. In other words, a single effort, even if a country has an excellent policy package to respond to climate change, cannot solve the problem if there is no international consensus.

The United Nations Framework Convention on Climate Change (UNFCCC) coordinates international efforts for the Paris Agreement: greenhouse gas mitigation and climate change adaptation. All member countries are required to submit their Nationally Determined Contribution (NDC) plan for mitigation with voluntary mitigation target. Cambodian NDC states that the country targets mitigation of 27% of GHG reduction compared to BAU scenario by 2030.

This paper firstly explores relevant development strategies of Cambodia such as the National Strategic Development Plan, the Climate Change Strategic Plan, and the Nationally Determined Contributions

to understand the current status and future targets. Secondly, Korea's ODA strategy, including climate change strategy, will be introduced so that we can expect what kind of ODA intervention Cambodia is likely to have in the near future. Thirdly, analyses on relative case projects will be conducted to examine climate change ODA in practice. Lastly, some policy recommendations will be drawn from the study.

2. Development Strategy and Climate Change in Cambodia

National Strategic Development Plan

The National Strategic Development Plan (NSDP) 2014-2018 is a central development strategy published in 2014. The NSDP supports the implementation of the Rectangular Strategy III, which is the highest-level national development strategy. Organized in seven chapters, the Plan covers major issues including economic development, poverty reduction, good governance, social and environmental cares, macro-economic and financial environment, and other sectoral issues.

The NSDP covers vast areas. It is notable that the strategy identifies climate change and environmental matters and recognizes it as a major development challenge. It is considered that the plan integrated the SDG 13 targets accordingly considering the national contexts. The plan also recognizes climate change as a crosscutting issue together with disaster risk management and gender issues. The estimation states that expenditure on climate-related policies and actions represented 6.5% of public expenditure in 2012, or 1.31% of national GDP. The NSDP plans to increase the ratio of climate-related expenditure up to 1.5% of GDP in 2018.

Climate Change Strategic Plan

The Cambodia Climate Change Strategic Plan (CCCSP) 2014-2023 is a comprehensive plan to promote national and international efforts to respond to climate change impact. This document is particularly meaningful in that this is the first national policy document responding to climate change issues. The CCCSP is expected to guide national entities and non-governmental participants to take appropriate measure and actions related to GHG mitigation and climate change adaptation. The plan provides national roadmaps for GHG mitigation in key economic sectors and serves as the basis for the country's NDC in the following years. The CCCSP has eight strategic objectives:

- Promote climate resilience through improving food, water, and energy security
- Reduce sectoral, regional, gender vulnerability and health risks to climate change impacts
- Ensure climate resilience of critical ecosystems (Tonle Sap Lake, Mekong River, coastal ecosystems, highlands, etc.), biodiversity, protected areas and cultural heritage sites
- Promote low-carbon planning and technologies to support sustainable development
- Improve capacities, knowledge and awareness for climate change responses

- Promote adaptive social protection and participatory approaches in reducing loss and damage due to climate change
- Strengthen institutions and coordination frameworks for national climate change responses
- Strengthen collaboration and active participation in regional and global climate change processes

The National Climate Change Action Plan supports the strategy to help mobilize resources for climate actions. The National Strategic Plan on Green Growth 2013-2030 also supports climate actions especially in low emission growth in Cambodia. In 2013, it announced the Strategic National Action Plan for Disaster Risk Reduction and approved the Cambodia Climate Change Strategic Plan the following year. In 2016, the Cambodian government established the National Climate Change Committee to be in charge of high-level climate change governance.

Nationally Determined Contribution

Cambodia presented its Intended Nationally Determined Contributions (INDC) to the UNFCCC prior to the COP 21 held in Paris in December 2015. Considering the fact that the country is a low emitter and highly vulnerable to the negative impact of climate change, the INDC emphasizes not only mitigation but also adaptation actions based on local circumstances.

The NDC states that Cambodia will achieve 27% GHG emission reduction by 2030 compared to the baseline, which is an ambitious target. The 16% out of 27% will be met in energy industries, which implicate a large scale of energy transfer to renewable ways. Also, the NDC identifies five most vulnerable sectors: agriculture, infrastructure, forestry, human health, and coastal zones in the adaptation side to urge supports.

Overall, the government of Cambodia did extraordinary works on governance and strategic preparation for climate change for the last few years. It is indeed praiseworthy in international development community because these efforts set the goals and guided development partners supporting directions. The importance of implementation of plans cannot be emphasized enough.

3. Korea's ODA Strategy

Country Partnership Strategy (CPS) for Cambodia

The Country Partnership Strategy (CPS) is the highest-level country strategy of Korean ODA. The second-term CPS[3] identified twenty-four core partner countries with three to four main cooperation areas for each country. The CPS for Cambodia has in-depth analysis of national development plans. It states that the Korean government will support the Cambodia government to realize the Rectangular Strategy Phase III and the National Strategic Development Plan focusing on the following objectives:

- Construction of and consultation on road network, airport and port infrastructure

3. Multi-governmental ODA task force of Korea developed the first-term CPS and it covered period 2011-2015. In 2016, the updated second-term strategies were published targeting the period 2016-2020. One of Korean ODA policies states that Korea will allocate 70 percent of its total ODA budget on the identified areas or sectors in the strategy.

- Capacity building for water resources management and disaster response and extension of universal health service
- Improvement and systematization of education for human resource development
- Rural development for improved living condition, income and public awareness level

According to the strategic objectives, the CPS identifies four primary cooperation areas and supporting plans as below:

↘ Figure 3

CPS Prioty Areas and Supporting Plans

Priority Areas	Supporting Plans
Transport	· Support expansion and rehabilitation of road infrastructures · Support construction of and consultation on airport and port
Water Management and Public Health	· Support capacity building for water resource management and disaster response · Support enhancement of public health services
Education	· Support quality of and access to education · Support education opportunity for girls and women
Rural Development	· Support rural development focusing on living conditions, income increase and public awareness · Support crosscutting sectors in rural areas

Source : CPS to Cambodia, Government of Korea, Adaptation of author

Considering that climate change is a crosscutting issue, it could be applied to all priority areas. Water management, public health and rural development are especially closely linked to climate change. During the CPS period of 2016-2020, Korean ODA is likely to focus on the above areas, and it will significantly affect funding approval process of ODA implementing agencies such as KOICA and the EDCF[4].

KOICA's Climate Change Strategy and Actions

The Korea International Cooperation Agency (KOICA) is the major national grant aid agency[5], under the guidance of the Ministry of Foreign Affairs, which was established in 1991. Since its establishment, development assistances in various forms – such as bilateral and multilateral funding projects, technical support, capacity building program, and volunteering program – were delivered successfully. Annual budget of KOICA's ODA actions is approximately USD 741.9 million in 2018, and it has been steadily increasing over years. Because the government of Korea aims to increase the volume of ODA up to 0.25% of GNI per capita, it is highly likely to double within decades. The current volume represents 0.14% of GNI per capita[6].

KOICA's ODA has traditionally focused on Asia and the Pacific region in every sector. Cambodia is the second largest recipient country of KOICA's ODA, next to Vietnam. KOICA runs development-supporting projects in 46 countries to support partner countries in achieving the SDGs. There is no sectoral budget limit, and activities highly depend on country context and

4. Economic Development Cooperation Fund. The EDCF provides loan type of ODA finance under the guidance of the Ministry of Strategy and Finance of Korea. The annual ODA budget of the EDCF is approximately USD 1.5 billion as of 2018.
5. KOICA provides approximately 50 percent of total grant ODA of Korea as of 2018. Other relevant Ministries and its implementing bodies implement the remaining 50 percent.
6. The United Nations guideline suggests 0.7% of GNI per capita for ODA from developed countries and the OECD DAC average marks 0.31% as of 2017.

local demands. In other words, volume of climate actions highly rely on country demands.

Remarkable program initiative on climate change is the East Asia Climate Partnership (EACP) during 2008-2012. The EACP was Korea's climate ODA package program with a total budget of USD 200 million. The partnership focused on five specific areas: (1) water management; (2) low-carbon energy; (3) low-carbon city; (4) forestation and biomass; and (5) waste management. Specific development targets of each area closely aligned with the MDGs and the concept of low carbon green growth. This program could cover only about 10% of project demands of partner countries due to budget limitation. Practically, the EACP was KOICA's first step to participation in global climate actions.

Between 2005-2015, KOICA further executed USD 380 million to meet requests from partner countries to responding to negative impact of climate change. Mitigation and adaptation activities account for 29% and 53% respectively of the total volume and 18% of crosscutting projects. In general, climate change-related ODA accounts for roughly 10-15% of total ODA volume of KOICA (KOICA, 2018). This figure may vary depending on the definition and scope of climate actions.

KOICA recently introduced its Climate Change Mid-term Strategy 2016-2020. The strategy declares a mission that KOICA will contribute to implementation of the Paris Agreement for partner countries by increasing volume of climate actions and mainstreaming climate consideration into activities. The three strategic objectives are:

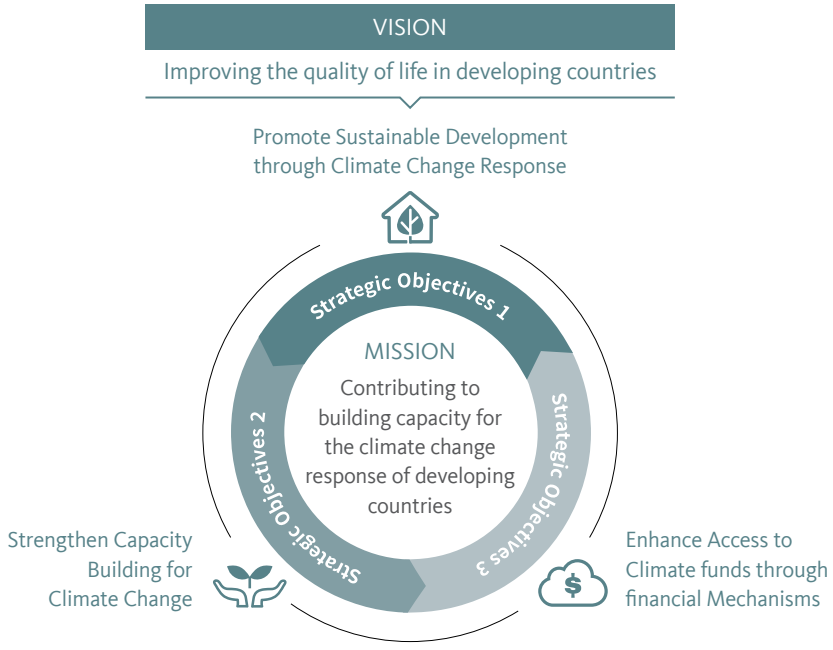
· Promoting sustainable development through climate change response

· Strengthening capacity building for climate change

· Enhancing access to climate funds through financial mechanisms

↘ Figure 4

KOICA Climate Change Response Mid-term Strategy 2016-2020



Understanding the fact that grant aid alone has limitations in delivering significant impact to development paradigm shift, blending finance for ODA and public-private-partnership (PPP) is highly recommended nowadays. It is especially relevant to climate change related ODA, which aims paradigm shift towards low-emission and climate-resilient development pathways. Climate change ODA often comes with larger scale of infrastructure development or replacement; ODA should leverage other financial resources while minimizing the risk of climate projects.

4. Case Analysis

Climate Finance in Cambodia

Global bilateral climate-related development finance increased from USD 18.2 billion in 2010-2011 to USD 30.2 billion in 2016 (OECD, 2016). Most bilateral climate-related development finance targets mitigation or adaptation as significant climate objectives. However, both bilateral – 79 percent – and multilateral climate finance – 97 percent – targeted primarily mitigation actions [7].

Bilateral climate-related development finance

↘ Figure 5

Source : OECD

After the Paris Agreement, climate-related development finance is expected to be steadily increasing. The UNFCCC initially stated that this would be new and additional to current development finance. However, there is no clear distinction between climate finance and development finance so far. Details of implementation for the Paris Agreement are supposed to be contained in the rulebook, which will be announced at the UN climate conference, UNFCCC COP 24, to be held in late 2018.

In the meantime, climate-related development finance in Cambodia significantly increased; USD 0.5 million in 2000 to USD 163.1 million in 2016 according to the OECD Statistics (based on upper bound estimation). The year of 2015 marked as the peak climate-financing year for Cambodia with USD 272 million.

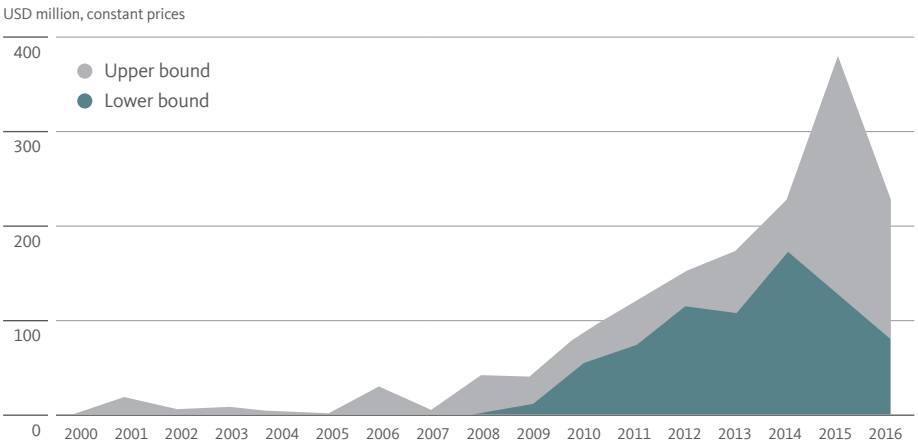
An interesting fact is that Korea is the biggest climate-finance provider while providing almost half of the total climate finance in the country.

7. These numbers include percent of crosscutting actions; targeted both mitigation and adaptation.

This is partly because Cambodia was one of the largest beneficiaries of the East Asia Climate Partnership (EACP) program during 2008-2012 and the Korean Country Partnership Strategy (CPS) contained climate change and environmental objectives. Vice versa, Cambodia is the largest recipient country of Korean climate-related development finance followed by Lao PDR in 2016.

↘ Figure 6

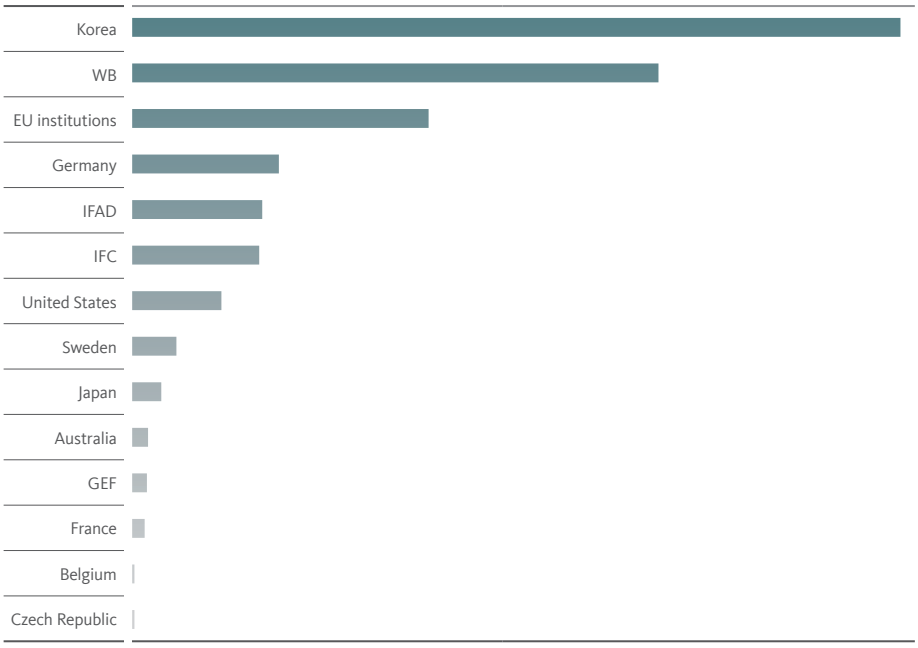
Trends in climate-related development finance in Cambodia



Source : OECD

↘ Figure 7

Top 10 Provider : Climate-related development finance in Cambodia

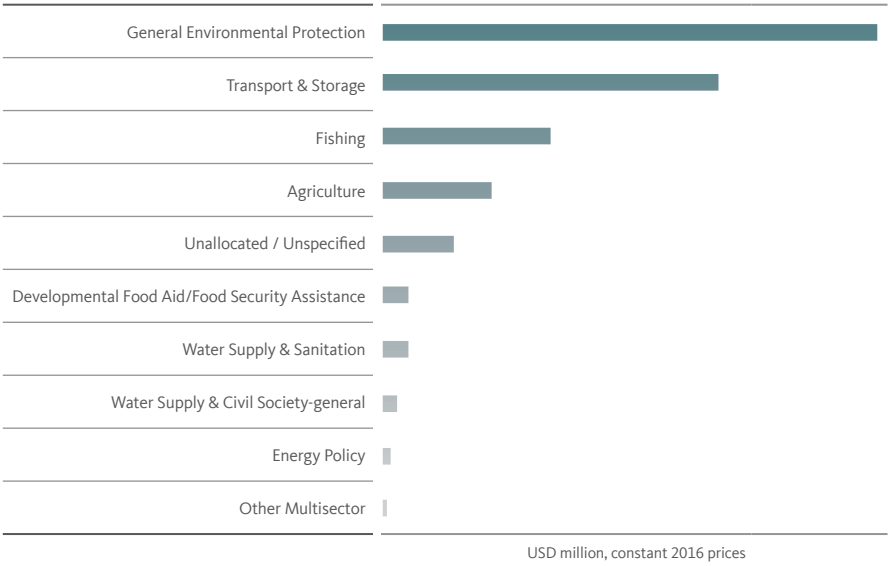


Source : OECD

Finance to activities for general environmental protection and transport take significant amount of total volume in climate-related development finance. This is worthy of notice because the water and energy sector accounts for a weighty proportion in general. Finance in the water and energy sector in Cambodia represents a relatively small proportion.

↘ Figure 8

Top 10 Sectors : Climate-related development finance in Cambodia



Source : OECD

Korean ODA in Cambodia

During the Korean ODA history, the period of 1987-2016, Cambodia is the second largest ODA recipient of Korea[8]. During the period, Korean ODA to Cambodia recorded USD 601 million in total including both grant and loan support (KOICA, 2018). The Ministry of Foreign Affairs, the Ministry of Strategy and Finance, KOICA, EDCF and many other government bodies and local governments provided financial and technical assistance in various sectors.

KOICA's support to Cambodia in the form of grant finance during 1991[9]-2016 accounts for USD 212 million (KOICA, 2018). During the period, KOICA implemented 46 technical assistance projects and invited 2,421 people to Korea for capacity building. In 2016, technical assistance activities worth USD 23 million were delivered. During the EACP period, KOICA also provided financial and technical support for developing national green growth strategies in collaboration with the Global Green Growth Institute (GGGI).

Case Projects

During 2009-2012, KOICA supported development of off-grid solar power plants in Cambodia under the EACP framework. The project delivered two sets of 30kw off-grid solar plants with batteries to rural areas. The scale of project is small compared to general renewable energy projects but this supporting activity is meaningful in that it is considered as an early stage renewable energy project in Cambodia. It also helped enhance the living conditions of rural households.

8. Vietnam is the largest ODA recipient of Korea.
9. KOICA was established in 1991, headquarters based in Seongnam-si, Korea.

↘ Figure 9

Picture of KOICA Solar Plants Project

Source : KOICA, MK News

During 2012-2014, KOICA worked with UNIDO[10] to transfer green technologies to Cambodia. KOICA provided USD 0.9 million to UNIDO to deliver technical support for environmentally sound technologies and relevant capacity building for industries in Cambodia. Pollution hot spots were identified, assessed and chronologically analyzed, and the transfer of environmentally sound technologies (TEST) was conducted in the Cambodian section of the Mekong River.

Another remarkable cooperation project is based on a trilateral partnership among KOICA, UNIDO and Samsung Electronics. During 2012-2014, the partnership project worked towards creating green job opportunities and ensuring effective e-waste management in Cambodia. Due to rapid economic growth and increased use of electronic devices in Cambodia, e-waste became an environmental challenge.

↘ Figure 10

Picture of KOICA-UNIDO-Samsung Partnership Project

Source : KOICA, Samsung News

This project was aimed at strengthening the capacity to handle e-waste and increasing decent job opportunities in the e-waste management market. This project is unique in that multilateral funding activity worth USD 1 million attracted private sector participation. Leveraged by grant funding, UNIDO and Samsung co-financed USD 50,000 and USD 300,000 to the project respectively. The post-project evaluation found that this project created more than 300 decent job opportunities in the e-waste management area. The environmental benefit created from the project will last for a long period.

Although the project delivered meaningful development impact, it was an early stage public-private-partnership (PPP) model in that the private participation remained at the corporate social responsibility (CSR) level even though participation of Samsung Electronics was a symbolic

10. United Nations Industrial Development Organization. UNIDO's headquarters is based in Vienna, Austria.

component of the project. Advanced PPP models, especially in climate change and development area, should seek private sector facilitation by creating a strong link with the sector's core business.

Way Forward

The Ministry of Environment of Cambodia recently urged KOICA to collaborate in (1) pollution control in the city and urban area that is attributed to traffic jam; (2) housing construction with environmental standard and equipped with materials favorable to environment; and (3) education of environmental knowledge. These areas have some correlations with the Korean CPS areas such as transport and education. Identifying the overlapping areas of interest and developing model projects would strengthen future development partnership between Cambodia and Korea.

Climate actions and related projects often require large-scale investment. If this is the case, KOICA's grant financing alone is not enough to design a project that can ensure development effectiveness. Thus, it is suggested that a project should be developed at scale with multi-financing structure. Since the Green Climate Fund (GCF) is the major financing mechanism for implementing the Paris Agreement, it is highly recommended to make use of the fund. The fund also emphasizes country ownership; funded activities are country-driven and demand-driven.

GCF utilization is important because it is one of fastest and soundest ways to unlock private finance to climate-related projects. The fund has the ability to engage with both public and private sectors in transformational climate-sensitive investments. It is also worthy to note that KOICA is seeking accreditation to the fund so that KOICA can leverage its own grant financing resources and blend them with other financial resources. KOICA's future climate action will be taken place based on various partnerships including multilateral climate finance and private sector engagement.

5. Policy Recommendations

Cambodia is one of the most vulnerable countries to the impacts of climate change. The government of Cambodia well understands the challenge and has reflected it in its national development strategies. Specific action plans are further required to meet the targets accordingly. International development cooperation agencies including KOICA have its supporting targets and climate action strategies. Because the impact of climate change is a globally shared one, international cooperation is necessary.

KOICA supported a number of case projects for climate actions in Cambodia. Although meaningful results were achieved in each targeted area, it is difficult to say that these activities brought a development paradigm shift towards climate-friendly development pathway in Cambodia. Considering that climate actions should be long-term based, consistent and coherent supporting activities are required in the future. Donor coordination is also important to maximize development effectiveness.

On top of that, the most important is country ownership and a strong will to change the paradigm. Development assistance should be country-driven and demand-driven at any time. As Cambodia has various demands

on different issues, focused policy and implementing efforts are needed in climate actions. National planning and documentation stage was successfully completed, and now is the time to move on to the next stage: implementation. Strong policy drive and public support is essential. The role of national climate change governance is also critical. Public budgeting and ODA portfolio management should consider national climate actions.

Although KOICA and development supporting agencies deliver financial and technical assistances, they are not able to meet all the needed climate actions alone due to limited resources. Therefore, mainstreaming climate change and environmental consideration into national development activities is also important. For example, pre-screening on environmental impact and post-evaluation will help environmentally sound development in the long -term.

Designing innovative and multi-financing structured projects is highly recommended. Utilization of climate finance such as GCF is strongly suggested for the future projects. Innovative partnership approaches should be also taken into account to promote private sector participation. Eventually, climate actions at scale are required, and successful models should be replicated nationwide. This will enable and facilitate further actions required at different levels not only for responding to climate change but also for long-term sustainable development in Cambodia.

References

RGC. (2014). Cambodia climate change strategic plan 2014 – 2023, 1–42.

RGC. (2015). Intended Nationally Determined Contribution, 1–16.

RGC. (2014). National Strategic Development Plan 2014-2018. Royal Governament of Cambodia, 232.

RGC. (2014). National Strategic Development Plan 2014-2018, 317 pp.

The Government of Korea. (2016). Country Partnership Strategy to Cambodia.

The Government of Korea. (2017). The Republic of Korea's Country Partnership Strategy for Cambodia 2016-2020, (March), 1–15.

Open Development Cambodia. (2018). SDG 13 Climate action. Retrieved from https://opendevelopmentcambodia.net/topics/sdg13-climate-action/

Dany, V., Bowen, K. J., & Miller, F. (2015). Assessing the institutional capacity to adapt to climate change: a case study in the Cambodian health and water sectors. Climate Policy, 15(3), 388–409. https://doi.org/10.1080/14693062.2014.937385

UNIDO. (2010). UNIDO to work with Korea International Cooperation Agency to transfer green technologies to Cambodia | UNIDO. Retrieved September 11, 2018, from https://www.unido.org/news/unido-work-korea-international-cooperation-agency-transfer-green-technologies-cambodia

Khmer Times. (2016). 10% of GDP Lost to Climate Change - Khmer Times. Retrieved September 11, 2018, from https://www.khmertimeskh.com/news/26780/10--of-gdp-lost-to-climate-change/

KOICA. (2018). Korean ODA to Cambodia. Internal Data and Documents.

OECD. (2016). CLIMATE-RELATED DEVELOPMENT FINANCE IN 2016 THE DEVELOPMENT ASSISTANCE COMMITTEE: ENABLING EFFECTIVE DEVELOPMENT. Retrieved from http://oe.cd/development-climate.

Voice of America. (2015). Underprepared Cambodia Vulnerable to Climate Change. Retrieved September 9, 2018, from https://www.voanews.com/a/changing-climate-has-major-impacts-for-under-prepared-cambodia/3075404.html

Cambodia, O. (2016). Climate change | Open Development Cambodia (ODC). Retrieved September 9, 2018, from https://opendevelopmentcambodia.net/topics/climate-change/

AKP. (2018). Cambodian Minister of Environment Receives Country Director of KOICA Cambodia Office. Retrieved September 9, 2018, from http://www.koicacambodia.org/wp-content/uploads/2018/03/cambodian-minister-of-environment-receives-country-director-of-koica-cambodia-office.pdf

AKP. (2018). Ministry of Environment and KOICA Join a Campaign of Using Eco Bag. Retrieved September 9, 2018, from http://akp.gov.kh/archives/115260

OECD. (2016). CLIMATE-RELATED DEVELOPMENT FINANCE IN 2016 THE DEVELOPMENT ASSISTANCE COMMITTEE: ENABLING EFFECTIVE DEVELOPMENT. Retrieved from http://oe.cd/development-climate.

UNFCCC. (2015). ADOPTION OF THE PARIS AGREEMENT. Retrieved from https://unfccc.int/sites/default/files/english_paris_agreement.pdf

IPCC. (2014). IPCC Fifth Assessment Report. Retrieved August 17, 2018, from https://www.ipcc.ch/report/ar5/

IPCC. (2014). Climate Change 2014 Synthesis Report Summary Chapter for Policymakers. Ipcc, 31. https://doi.org/10.1017/CBO9781107415324

Stifung, K. A. (2017). Climate Report 2017 in the G20 Countries, 2015–2018.

Kharas, H. (2015). Aid and Climate Finance, 24–28. https://doi.org/10.1007/s10640-015-9883-3

OECD. (2018). OECD Centre on Green Finance and Investment - Organisation for Economic Co-operation and Development. Retrieved August 17, 2018, from http://www.oecd.org/cgfi/

OECD. (2017). Climate Adaptation, Finance and Development - OECD. Retrieved August 17, 2018, from http://www.oecd.org/development/climate-change-development.htm

OECD. (2018). Climate change - OECD. Retrieved August 17, 2018, from http://www.oecd.org/environment/cc/

GCF. (2018). Green Climate Fund Website. Retrieved August 17, 2018, from https://www.greenclimate.fund/home

Samsung Newsroom. (2015). KOICA-UNIDO-Samsung Parnership Project Created 301 Green Jobs. Retrieved September 12, 2018, from https://news.samsung.com/kr/

VI

Life Below Water

11.

Reduce Marine Pollution, Sustainably Manage and Protect Marine and Coastal Ecosystems, Regulate Harvesting and End Overfishing

11

Seak Sophat[1)]
Phat Chandara[2)]

Reduce Marine Pollution, Sustainably Manage and Protect Marine and Coastal Ecosystems, Regulate Harvesting and End Overfishing

Introduction

Human activities are a major factor devastating the world's biodiversity and accelerating the present extinction rate to 1000-10,000 times compared to the natural rate (Lovejoy, 2007). Various forms of destruction on marine species have been discovered such as overexploitation and harvesting, dumping of waste, pollution, introduction of alien species, land reclamation, dredging and global climate change (Snelgrove, 1999). Jambeck et al. (2015) illustrated that the amount of plastic in the environment has increased since 1995 between 4.8 and 12.7 million tons of land-based plastic waste. The increasing amount of plastic waste in the ocean and sea is causing a severe impact on marine pollution and degradation of biodiversity. Moreover, Ethan and Harry (2008) indicated there are stocks that are classed as subject to overfishing, which means that the mortality rate is above a particular threshold. In response to the declination of marine fisheries and the ecosystem, dozens of laws, regulations, policies, framework, and strategic planning have been established. Worldwide initiatives were launched by the Global Partnership on Marine Litter (GPML), the Honolulu Strategy and G7 countries as the global efforts for reducing and preventing marine litter and mitigating its impacts (Ansje et al., 2017).

Cambodia is ranked as a country with one of the richest and highest in biodiversity in Asia. According to Try (2003), 476 species of marine fish, 20 species of marine crabs, 42 species of marine gastropods and 24 species of marine bivalves have been identified in Cambodia. Marine and coastal natural resources in Cambodia have been major sources of livelihoods and incomes of the coastal people. Current development of coastal zones into recreation zones, port facilities, agricultural purposes, and modern settlement areas is increasing at remarkable speed and enabling Cambodia's economic growth. However, these anthropogenic activities and economic growth have caused severe impacts on marine and coastal biodiversity and environment of Cambodia, in terms of pollution and destruction. Although the management system of marine and coastal ecosystem in Cambodia has been in place for many years, the capacity of this system has remained poorly addressed and enhanced mainly due to poor technical capacity, law enforcement, and financial resources.

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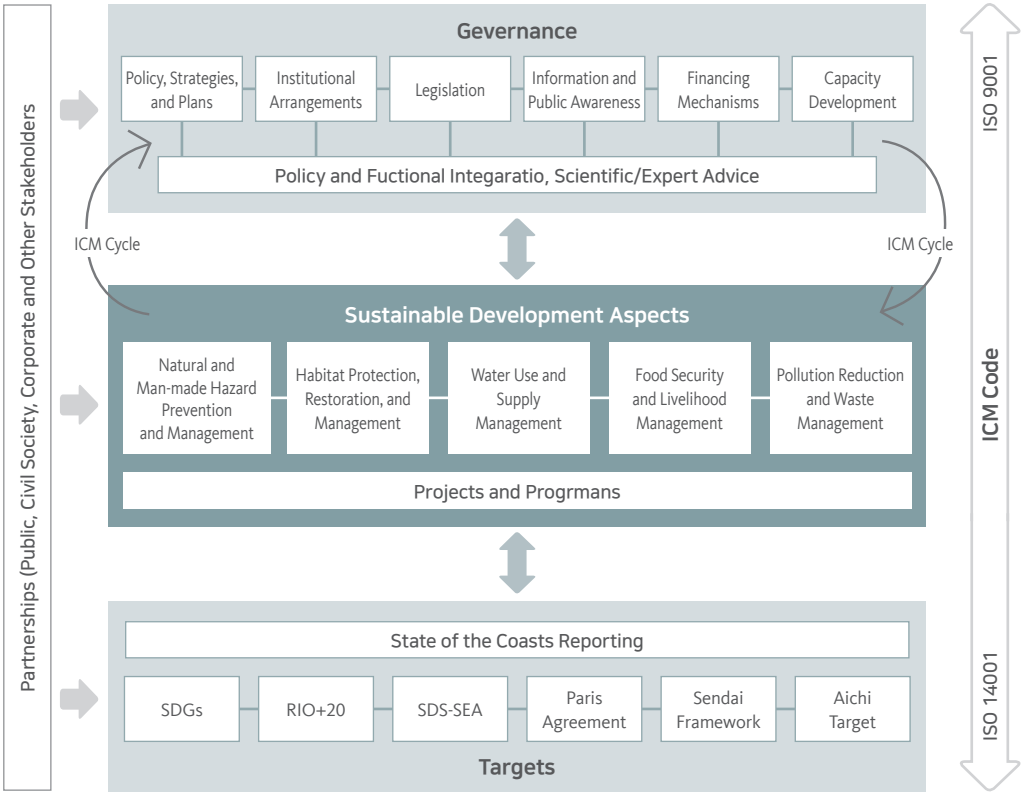
Methodology

This paper uses literature review as a major methodology in writing. The literature on the reduction of marine pollution and sustainable marine ecosystem management is considered worldwide citing in this whole paper, from Cambodia and region.

To understand the implication of the governance system on marine and coastal ecosystem management, ICM Framework was developed by the Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) in 2018. The literature on ICM and environmental management makes clear the need for sound scientific information, as well as the importance of applying appropriate tools as ICM practice has evolved, the tools, methodologies and techniques available to support its implementation have also increased. These include the wide range of natural and social science-based tools and methodologies that can provide reliable information based on which policy, management and technological interventions can be built.

↘ Figure 1

Framework for Sustainable Development of Coastal Areas through ICM implementation (SDCA)



Source : PEMSEA (2018)

Results And Discussion

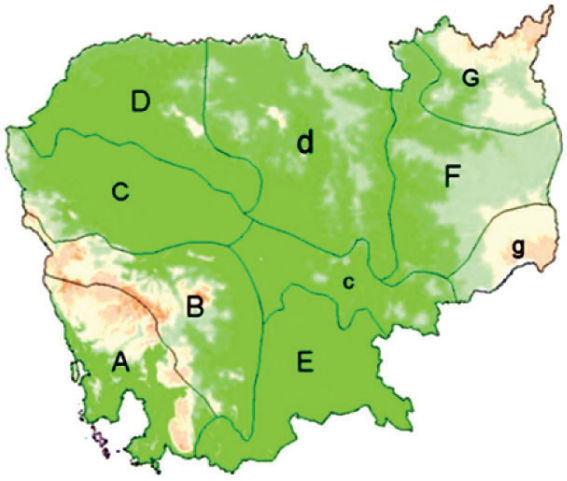
Cambodia's Marine and Coastal Ecosystem, Physical and Geographical Conditions

Cambodia's coastline extends about 440 km in the Gulf of Thailand. The coastline is characterized by sandy beaches, cliffs and mangrove forests. The coastline has four provinces namely Kep, Kampot, Preah Sihanouk and Koh Kong (see Figure 3). A large part of Cambodia's coastline has remained pristine among the Southeast Asian countries' coastline which has high potential for tourism development and destination.

The coastal zones of Cambodia are classified into Coastal Cardamom (Zone A), and Lower Mekong Floodplain (E) (Figure 2) (FA and DANIDA, 2003). The Coastal Cardamom (A) Gene-Ecological Zone comprises only 9% of Cambodia's land-cover, yet it represents one of the more distinctive and species-rich ecozones of Indochina. This zone stretches across the coastal piedmont and windward slopes of the Cardamom Mountains, and encompasses a series of discontinuous, but geologically related ranges, including the Cardamom Mountains, Kirirom Plateau and Elephant Mountains (Phnom Damrei). The southern boundary of this zone follows Cambodia's southern coastal zone from Koh Kong to Kampot, while the Northern boundary is defined by high ridges and slopes that drain rainfall into the Gulf of Thailand. This zone is now gazetted for protection, owing primarily to high species diversity in the region. Nevertheless, the lower coastal foothills have suffered extensive degradation during the past two decades.

↘ Figure 2

Distribution of Gene-Ecological Zones



Coastal Cardamoms (A)
Northern Cardamoms (B)
Tonle Sap Floodplain (C)
Redlands (c)
Northwestern Lowlands (D)
Central Lowlands (d)
Lower Mekong Floodplain (E)
Eastern Mekong Basin (F)
Central Annamites (G)
Southern Annamites (g)

Source: FA & DANIDA (2003)

Current Status of Cambodia's Marine and Coastal Ecosystems

Cambodia's Marine Resources

The coastal and marine ecosystems including fisheries, mangrove forests, coral reefs, seagrass beds (see table 1), salt marshes and estuaries are extremely important to Cambodia's economic development as well as local people's livelihoods. The off-shore area is reported to have tremendous oil and gas deposits, but these resources are under study and exploration to assess their natural stocks before exploitation plan can be laid out. Table 1 outlines the biological resources which include mangrove, seagrass,

and coral reef. Most of these biological resources are under careful protection like in the form of Protected Areas or marine park. At present, 3,831 hectares, accounting for approximately 11 percent of total seagrass beds are under management. As indicated in the Strategic Planning Framework for Fisheries: 2010-2019, 9,000 hectares, representing around 27 percent of total seagrass beds will be put under management in 2019 (DFC-FiA, 2013).

↘ Table 1

Distribution of mangrove, seagrass and coral reef in Cambodia

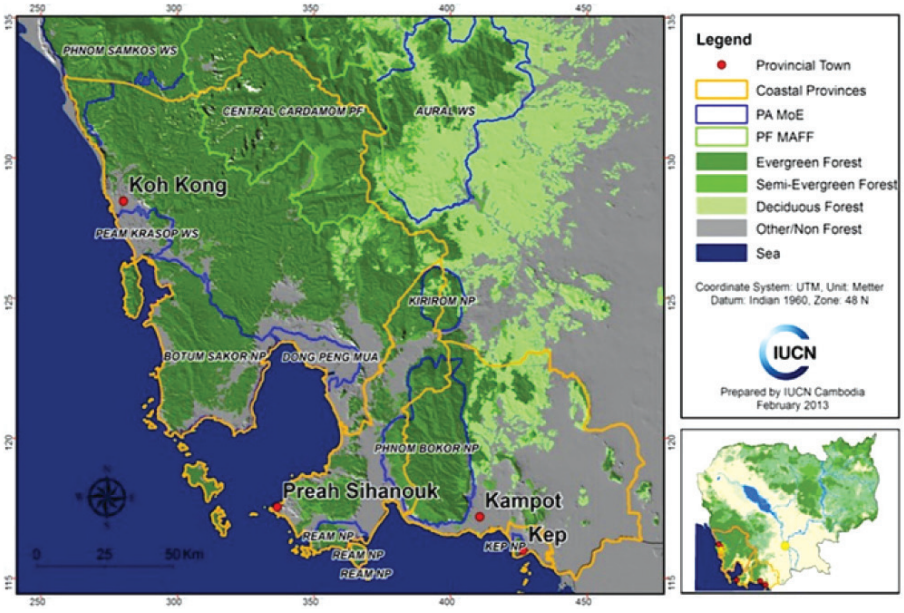
Hectare (ha)

Coastal Provinces	Mangrove (FiA, 2010)	Seagrass (DFC-FiA, 2013)	Coral reef
Koh Kong	62,000	3,993	602
Preah Sihanouk	13,500	1,486	1,198
Kampot	1,900	25,240	953
Kep	1,005	3,095	52.5
TOTAL	78,405	33,814	2,805.5

Source: Fishery Administration (FiA), 2010; and DFC-FiA, 2013.

↘ Figure 3

Coastal provinces of Cambodia



Source: IUCN (2013)

According to a coastal study conducted by ADB (2000), coastal and marine biodiversity provides substantial benefits of estimated US$12 million annually to local communities and the country. Cambodian coastal waters are considered among the richest areas in biodiversity resources, including significant aquatic resources and marine endangered species, such as green turtles, dolphins, sharks, coral reefs and sea-grasses, mangroves, groupers, shrimps, tortoises (endangered and rare species) and dugongs (UNEP, 2005). MoE (2009) has indicated that the marine catch was estimated between 30,000-50,000 tons per year.

Not only is Cambodia a country with rich marine biodiversity, but it also has valuable mineral resources – oil and gases. In recent years, the Royal Government of Cambodia (RGC) decided to extract oil, gases and mineral resources for development and to generate revenue for the country. Cambodian EEZ (Exclusive Economic Zone) is divided into six offshore blocks (A to F) and nineteen onshore blocks (I to XIX). There are also four areas in the "Overlapping Claims Area" (OCA) between Cambodia and Thailand. Whilst, Sea-grass beds and coral reefs occur throughout the coastal zone of Cambodia – mostly located in Kampot and Kep Provinces (see table 1). Based on the MoE (2002), about 70 species belonging to 33 genera and 11 families have been identified in Cambodia's waters.

Population, Transportation, and Socio-Economics Development

Based on the census (2013), coastal settlements in Cambodia are about 7.38% (844,861 people) with a population density of 49 people per km2. NIS (2013) illustrated that Kampot province has the highest population percentage (4.62%), followed by Preah Sihanouk Province (1.36%). Significantly, NIS (2013) has indicated that the four provinces host only 960,480 residents, which account for 6.8% of Cambodia's total population. According to the NIS (2013), the coastal region which comes third in terms of population concentration accounts for 6.97 percent of the country's population in 2013 as against 11.43 percent in 2008.

According to MoE (2009), the revenue generated from marine fisheries is estimated at US$ 30-50 million a year. Running behind marine fisheries, tourism plays a crucial role in generating revenue for Cambodia. Tourism is one of the fast growing sectors in Cambodia owing to rich cultural assets, natural resources, diversity of landscapes and coastal scenic view (ADB, 2009). Tourism's contribution to GDP increased three-fold during 2009-2012 and reached US$ 2.2 billion in 2012. The number of foreign tourist arrivals was estimated at 4.2 million in 2013 (MOT, 2014) and is expected to reach 6.5 million by 2018 (NSDP, 2014). Coastal areas are one of the most popular tourist destinations and are among tourism plan defined by tourism development strategy. Foreign and domestic tourist arrivals are on the increase due to the premier white sandy beaches and beautiful intact islands. Ream National Park, mangrove forests, seagrasses and coral reefs are also suitable for ecotourism development. Its 119.5 km beaches possess a number of good quality beaches suitable for tourism development, namely O Chheuteal beach, Sokha beach, Independence beach, Hawaii beach, Otres beach, Samdech Hun Sen beach, Victory beach, Prek Troeng beach, and Koh Pous (ADB, 2009). There are 22 islands under the jurisdiction of Preah Sihanouk administration, 10 of which has been open for visit and overnight stay.

Cambodia has two major international ports, Sihanoukville and Phnom Penh. Sihanoukville, situated on the Gulf of Thailand, is Cambodia's only major deep sea port. Because of its draft restrictions and the relatively low cargo volume, Sihanoukville caters to feeder ships from Singapore as the regional shipping hub. The Sihanoukville port is planned for renovation in order to host large cargo ships from around the world that would attract enough traffic and would allow economic operation of such ships. Sihanoukville also handles oil tankers and other general cargo vessels from Thailand, Malaysia, and around the region. Its biggest traffic types by tonnage are containers (45%), cement (32%), and oil products (18%) (ADB,

2012). Besides, Sihanoukville Port is located in the newly established Sihanouk province, while Cambodia's seaports are located mainly in Koh Kong and Kampot provinces (MPWT, 2009).

Urban and Infrastructure Development, Recreation, Management Issues and Implications

Marine and Coastal Ecosystem Issues and Problems

• Sea Pollution

As a developing country, Cambodia has relatively invested and attracted national and international investors with urbanization and industrialization sectors. Urban environmental issues in Cambodia, are recently becoming critical and having a great effect on living conditions of local people in the nation. Majority of the investment areas are settlements in the coastal zone of Cambodia (MoE, 2009). Several investment areas have been identified such as the operational cement factories, breweries, handicraft manufacturing, petroleum storage, local and international port services, hotels, and restaurants. The increase of development activities in the coastal areas of Cambodia have caused many environmental issues due to the absence of clear mandates for incorporating environmental inputs into the planning and zoning activities, as the same as, integrated planning, research and monitoring. Without this integration, physical coastal ecosystem will be affected. However, these unmanaged activities also affect coastal water quality and water pollution, which led to the fragility of marine and coastal ecosystem in Cambodia (MoE, 2009). Moreover, PIC (2017) mentioned that major problem of sea pollution in Cambodia, recently occurred due to poor management of wastewater treatment in major city along the coastal provinces, including Preah Sihanouk, Krong Khemmarak Phumin (Koh Kong province), Kep and Kampot. Same survey has indicated that urban development – including building hotel or running hotel business is major source of sea or marine pollution in Cambodia, representing about 32% after the pollution from household.

• Destructive, Over-Fishing and Mining

However, overfishing, erosion, destructive fishing practices, habitat loss, pollution, climate change, and other human impacts (such as tourism) has resulted in the destruction and modification of coastal habitats around the world, reducing their ability to provide these services and threatening biodiversity. Coastal habitats are tightly interlinked so that the loss of one habitat can have flow-on effects that degrade and reduce the services provided by linked habitats (UNEP, 2006). In 2015, UNIDO conducted a survey on environmental impact assessment on marine fisheries resources; as high as 82% of the interviewed respondents has indicated that illegal fishing activities along the coastal zone of Cambodia has indeed increased over the past two decades. Not only local illegal fishing activities have been recorded, but overseas trawlers have also seen in the coastal zone of Cambodia. Foreign trawlers generally came without any authorization and catch all types of marine fishes with prohibited fishing materials (Rizvi and Singer, 2011).

Destructive fishing practices (motorized push-net, shallow water trawling, and weighted bottom nets which rip up and destroy sea-grass

meadows, dynamite and cyanide fishing) is a major threat to coral reefs in Cambodia (MoE, 2009). Collection of coral reefs for trade and industrial waste disposal are second threat and pressure on current reefs in Cambodia. Tun et al. (2004) indicated that in between 1982 and 2007 the extraction of marine fisheries in Cambodia has been increased exponentially. About 5000 mt to over 50,000 mt of marine fisheries resources have been caught during this period. In 2015, UNIDO conducted a survey on "Environmental Impact Assessment of Marine Fisheries Related Activities in Cambodia". The survey suggested that out of the variety of total fish catch, about 39% was shrimp; however, fishermen did not sort out any of fish – every higher economic and non-targeted marine species were caught at the same time. Interestingly, the survey by UNIDO (2015) has found that about 66% and 29.5% of the fishermen (in the surveyed) answered with higher perception that fish catch and fish size has decreased, respectively – due to the current practices of fishing. The PIC (2017) concluded that illegal marine fishing activities in Cambodia formed up with several pictures including fishing using destructive fishing nets (73%), fishing by using trawling with larger boats (37%), illegal fishing by vessels from other countries (17%), and pollution of coastal waters (10%).

• Coastal Erosion

FiA (2014) indicated that erosion is the most common impact of sea-level rise on the coastal morphology of Cambodia. Cambodia's 440 km coastline is becoming increasingly sensitive to erosion due to the removal of coastal vegetation, agricultural development and other human activities. According to the ODC (2016), in 2002, there was a total of 83,700 hectares of mangroves in Cambodia. Due to the exploitation, land exploitation, development of the seashore areas, and poor land management, those mangroves species are still being harmed. According to statistical record by FAO (2010), total land areas of mangrove in Cambodia have significant declined due to human activities from 79,638 hectares (1990) to 55,704 hectares (2010). Also, MoE (2002) has found that approximately 995 hectares of mangrove areas have been destroyed annually in Cambodia due to the conversion activities.

Significantly, records of extreme meteorological events that could cause coastal erosion (such as typhoons) are not available in Cambodia. With the increase of climate change-induced extreme weather events, and of sea level rise, it is expected that coastal erosion will become more serious.

• Recreation and Infrastructure Development

The increase of tourists in the coastal areas of Cambodia generally creates an opportunity for Cambodians to earn income not only for subsistent but also for elevating the livelihood standard that befit upper middle-income country by 2030. In Cambodia's current development process, several recreation areas have been newly established along the coastal areas. IUCN (2011) reported that the increase of recreational areas in the coastal area of Cambodia will lead to more waste disposal and unorganized littering – with no proper mandate of management. Moreover, land use conflicts between agriculture, protected areas and tourism will occur within higher influx of tourist and new settlement encroachers to clear the coastal forest for settlement and farmland. Additionally, improper diving, snorkeling, and anchoring practices will put pressure on coral reefs.

According to IUCN (2011), coastal areas of Cambodia are faced with the salinization of surface and groundwater resources. In addition, even a minor rise in sea-level will increase coastal erosion and may eventually lead to the inundation of economically important coastal infrastructure such as ports and coastal resorts. Based on this study, the encroachment for infrastructure development in the coastal areas of Cambodia will lead to the degradation of mangrove ecosystem through the development of marine ports and other physical development structures.

Current Marine and Coastal Ecosystem Management

• Policy, Strategy, Law and Regulation

Sustaining healthy coastal and marine ecosystems that provide goods and services require good governance and comprehensive resource management. Cambodia has thus far adopted several laws and many regulations to ensure the coastal and marine environments are in good shape and continue to provide satisfied services to enable Cambodia's economic growth and better people's livelihoods, particularly by banning activities polluting the marine and coastal environments. Below are laws and regulations relevant to the protection and management of coastal and marine domains:

The Royal Decree on Creation and Designation of 23 Protected Areas (01 November, 1993) was announced for addressing the process of national resource management in line with the United Nation List of National Parks and Protected Areas. Moreover, on 24 December, 1996, the Law on Environmental Protection and Natural Resources Management has been adopted for protecting and improving environmental quality and people's health by curbing, reducing and managing pollutions; conducting an environmental impact assessment before releasing the government's decision on a proposed project; ensure conservation, development, management and sustainable and suitable uses of natural resources; and suppress all activities that are harmful to the environment. Additionally, on 21 May, 2006, the law on fisheries has been established to manage, protect, conserve, use, exploit and restore the flooded forests and develop the fisheries sector to ensure long-term sustainability of environmental, social and economic benefits. Furthermore, the law on protected areas (15 February, 2008), a sub-decree on the establishment of the national climate change committee (24 April, 2006), and a sub-decree on community fisheries management (March 2007) have been established for the conservation of natural resources, including marine resource in Cambodia.

As stated in the law on Protected Areas Management, the marine protected area (MPA) is one of the regulatory measures to protect and conserve marine lives. The MPA can help enhance the sustainability of aquatic species and their ecosystem, but at the expense of reducing the amount of fish available for harvest by local farmers. Engagement with fishers can enhance the understanding of the goals of the policy, improve enforcement and usage of proper gear type, and assist in the management of the protected area boundaries and fishing seasons.

The government's Rectangular strategy (now Phase 3 of 6th term government) is used for improving good governance in Cambodia, which is covering the sustainable protection of natural resources.

The 2nd corner of the rectangular strategy is also focused on further rehabilitation and construction of physical infrastructure in the coastal areas. Moreover, Cambodia has also developed national law, policies and strategies for protecting and strengthening the sustainable use of marine ecosystems such as port policy and administration system, national strategy for maritime security, national disaster strategic objective, and national maritime transportation policy (Nhem, 2016).

• Strategic Management Plan

Given the real situation in Cambodia, several policies, strategies and national plans for coastal zone management have been initiated such as: national strategic development plan (2009-2013), coastal environmental management action plan (2007-2011), strategic national plan for disaster risk reduction (2008-2013), Cambodia climate change strategic plan (2013-2023), strategic planning framework for fisheries (2010-2019), and national action plan for coral reef and seagrass management in Cambodia (2006-2015). These are legal instruments that have been in effect since the past decade.

• Financial Issues

Management of marine and coastal resources in Cambodia urgently needs strong participation of all stakeholders. The Ministry of Environment is playing an important role in managing and monitoring the development issues of the coastal areas in Cambodia. However, financial support for conserving and monitoring coastal areas of Cambodia is significantly limited. MoE (2009) illustrated that main financial support for development and rehabilitation of the coastal areas in Cambodia are loans from ADB and WB. Studying marine biodiversity is quite important and a priority for a proper conservation strategy. However, due to the lack of financial support, Cambodia has limited inventory data about marine species, biodiversity, oil and gases, and mineral resources in all coastal and marine areas.

• Pollution and Waste Management

Currently, the Sub-Decree on Solid Waste Management (1999) is a keystone regulation for managing, controlling, and responding to all solid waste issues in Cambodia. In the sub-decree, article 3 has defined some technical terms regarding waste as follows:

- Solid waste refers to hard objects, hard substances, and products or refuse, which are useless and disposed of;
- Household waste is the portion of solid waste which does not contain toxins or hazardous substances and is discarded from dwellings, public buildings, factories, markets, hotels, commercial buildings, restaurants, transportation, recreation sites, etc.; and
- Hazardous waste refers to substances that are radioactive, explosive, toxic, inflammable, pathogenic, irritating, corrosive, oxidizing or other chemical materials which might cause danger to human and animal health or damage plants, public property and the environment.

In effect, following the Sub-decree No. 36, there came a 2003 Inter-Ministerial Prakas (regulation) of Ministry of Interior (MoI) and MoE No. 80 on Solid Waste Management in Province/Municipality. Significantly, in accordance with the RGC commitment to transfer waste management function to the municipal/district level, the NCDD in cooperation with the

MoE reviewed relevant legal frameworks on Waste Management and proposed to the RGC to adopt the Sub-decree No. 113 on Solid Waste Management in Urban Areas in August 2015. In Cambodia, there are three waste sources such as municipal solid waste (household and commercial wastes), hazardous waste (factory and industrial wastes), and medical waste (hospital and clinic wastes). In the coastal areas of Cambodia, waste collection services are conducted by three different agencies: Kampong Som Waste Management – KSWM (Preah Sihanouk Province), Global Action for Environmental Awareness – GAEA (Kampot Province), Tim Rim Rathanak Contractor (Koh Kong Province). Although solid waste in the coastal areas of Cambodia is managed by different contractors, an only main city such as Preah Sihanoukville (Preah Sihanouk Province), Krong Khemmerak Phumin (Koh Kong Province), Kampot (Kampot Province) and Kep (Kep Province) have solid waste collection services. Moreover, in October 2017, the Royal Government of the Kingdom of Cambodia issued Sub-Decree No. 168 GNKR. BK on the Management of Plastic Bags aiming to reduce wastage and protect the environment as well as the country's landscape. The new Sub-Decree also aims to encourage citizens to reduce the usage of plastic bags by replacing them with more nature-friendly alternatives. According to Article 14 of the new Sub-Decree, plastic bags for carrying shall be prohibited for importation, local production, distribution, and use unless the thickness is measured from 0.03 millimeters with a base width from 25 centimeters or 10 inches. A permit from the MoE is required for production and importation of plastic bags except for non-business importation of less than 100 kilograms. Relatively, the newly sub-degree declared that plastic bag fee is US$ 0.10 per bag. However, the implementation of the sub-decree is limited; while only several super-markets in Cambodia have applied such as Aeon Mall and City Mall.

• Application of SDG

In order to ensure sustainable use and development of coastal areas in Cambodia, the National Committee on Management and Development of Cambodian Coastal Areas has been initiated which at this moment mostly focuses on priority areas. These are such as sea observation and monitoring of acidification, vulnerability of coastal zone and marine sedimentary, climate change adaptation and impact prediction in coastal areas, marine environment, ecosystem, and biodiversity conservation, capacity building on ICM, coastal tourism development and tourism resources management, marine policy and law, prevention and mitigation of coastal disasters, solid waste management and marine pollution. In recent context, Cambodia Sustainable Development Goals (CSDG) has been initiated for improving good governance and sustainable economic growth. The 14th goal of CSDG states clearly that conserving and sustainably using the oceans, seas, and marine resources for sustainable development are potentially needed.

• Institutional Arrangement

Magnus and Albert (2001) have identified that there are several main government institutions whose activities are concerned with the use and management of natural resources and the environment of Cambodia's coastal areas. Significantly, there are state and non-state actors that

have been engaged in managing and monitoring these areas. These include: the Ministry of Agriculture, Forestry and Fisheries (MAFF), Ministry of Environment (MOE), Ministry of Mines and Energy (MME), Ministry of Industry and Handicraft (MIH), Ministry of Tourism (MoT), Ministry of Public Works and Transport (MPWT), Ministry Rural Development (MRD), Ministry of Land Management, Urbanization and Construction, Ministry of National Defense, etc.

MAFF has shared major responsibilities in managing and controlling coastal and marine ecosystem in the coastal zone of Cambodia. Fisheries Administration is a key player for ensuring safeguard welfare of people and the marine ecosystem.

Although MAFF is given the significant role of protecting marine and coastal ecosystem in Cambodia, the contribution and participation from line ministries are strongly needed. Line ministries working on marine and coastal protection are Ministry of Mines and Energy (MME), Ministry of Industry and Handicraft (MIH), Ministry of Tourism (MoT), Ministry of Public Works and Transport (MPWT), Ministry Rural Development (MRD), Ministry of Land Management, Urbanization and Construction, Ministry of Environment (MoE), and Provincial Authorities. The provincial authorities are under the direct control of the Ministry of Interior. The provincial authorities are the main government authorities that oversee local government administration, promote economic development and strengthen law enforcement through coordination. The provincial authorities are divided into districts, which are then divided into communes and villages.

Proposed Future Management Strategies to Reduce Marine Pollution, Sustainably Manage and Protect Marine and Coastal Ecosystems, Regulate Harvesting and End Overfishing

Although Cambodia has adopted several policies, regulations and laws on marine ecosystem protection and conservation, the sustainable use of marine and coastal resources remains limited. Based on the literature review, the authors have discovered several lessons learned and future strategic plans to prevent pollution and land degradation for sustainable management and protection of marine and coastal ecosystem in Cambodia as the following:

- Pollution Policies on Marine and Coastal Ecosystems

Although Cambodia has several strategies on managing marine and coastal pollution, those existing regulatory policies focus on controlling activities that pollute and degrade the environment through permissions, and performance or emission standards are typically found to be inadequate in controlling pollution and reducing land degradation. The reasons are complex including a lack of monitoring and enforcement, conflicts of interest in which regulators are also beneficiaries of the economic activities they are charged with overseeing (e.g. local regulators also own fish farms), inadequate penalties of noncompliance, overlapping and potentially conflicting jurisdiction among government agencies. Significantly, classification of penalties level shall be clearly established through the amount of pollutant payment quotas set up by the ministry in charge like MoE.

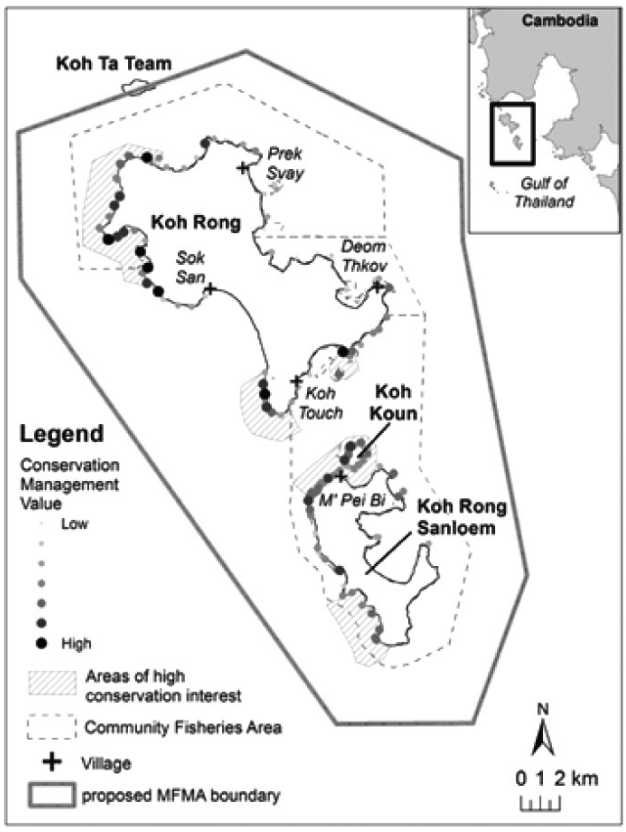
- Implication of Current Pollution Management on Marine and Coastal Ecosystem

Understanding of the relationship between economic activities and their impacts on the environment is often low and requires coordination of research between economists and scientist to provide the baseline information needed, as well as an understanding of correlation and any causal relationships that can be asserted. Private actions will never be enough to address losses of ecosystem goods and services associated with pollution and land degradation. While the cases show that there are many different forms of regulation already in place, they are often ineffective. Therefore, the role of incentive-based policies should be applied for this case. Although MoE has released the new sub-decree on plastic waste management, it seems less effective because the scope of this sub-decree is still limited and is applied only to the super-market level.

Overlapping of the marine and coastal conservation zones is a key constraint for the current conservation in Cambodia. Likely, Marine Fisheries Management Area (MFMA) at Koh Rong Sanloem under the management of Ministry of Agriculture, Forestry and Fisheries were overlapping with Marine Park (MP) under administrative management of MoE. The overlapping has brought many issues on the management system.

↘ Figure 4

Location of Koh Rong Sanloem – Preah Sihanouk Province



Source: Boon et al. (2014)

Learning from this case, clear coastal zonation and environmental education related to marine and coastal ecosystem pollution are strongly recommended and needed, as a priority action for tackling current issues.

- Resource Use Regulations (Fisheries, Mangrove, Coral Reef, Sea Grass, Minerals, Transportation, Infrastructure Development, and Recreation)

So far, marine resources in Cambodia have not yet been fully studied and inventoried. Therefore, marine species in Cambodia are withdrawn without proper monitoring. Following this reason, certain inventory mechanism should be considered for sustainable use of marine resources in Cambodia. Moreover, greater awareness of the impact of economic activities on the environment needs to be communicated, not just to those who are creating pollution and environmental degradation but also to those who are affected.

- Marine and Coastal Ecosystem Governance

Efforts to restore damaged ecosystems can be very cost-effective, but barriers to these projects - in the form of agency institutional capacity to identify and process eligible sites, regulatory complexity and constraints, and funding - need to be addressed to accelerate the restoration of vital coastal and marine ecosystems such as mangrove forests. Moreover, it is vital to estimate the environmental consequences of a large-scale development before the development is allowed to proceed. Doing so may help decision makers decide whether to approve such developments, change their scale and location, or build in mitigation of strategies from the beginning, not after the damages have occurred.

Recently, community-based natural resource management is globally accepted as a key and effective approach for managing sustainable natural resources. In Cambodia, community-based marine resource management is also considered as important approach for conserving marine resources, while several conservation sites have been designated, including Peam Krosoap Wildlife Sanctuary (Koh Kong Province). Boon et al. (2014) indicated that there are three community fisheries (CFi) covering 18,672 hectares at Koh Rong Archipelago playing significant role and protecting marine resources in Preah Sihanouk Province. These above two evidences confirm that community-based marine resources protection is key element contributing to sustainable protection of marine resources in Cambodia.

Conclusion and Recommendation

This paper illustrated the implication of marine ecosystem management strategies for ensuring the sustainability of Cambodia. The paper wishes to highlight improving the governance system and promoting policy implementation for sustainable use and protect of marine and coastal ecosystem in Cambodia, especially reducing pollution and negative impacts from development and economic activities. MoE (2009) has officially announced the marine ecosystem in Cambodia has significant contributed to improving the livelihoods of local people. Our results suggest that conservation of marine ecosystem in Cambodia has achieved positive environmental and social outcomes within the legal support by national laws and regulations. Cambodia has adopted laws, policies, and regulations such as national strategic development plan (2009-2013), coastal environmental management action plan (2007-2011), strategic national

plan for disaster risk reduction (2008-2013), Cambodia climate change strategic plan (2013-2023), strategic planning framework for fisheries (2010-2019), and national action plan for coral reef and seagrass management in Cambodia (2006-2015).

Despite the fact that laws, policies and regulations have been identified, we suggest that the implementation of marine ecosystem protection and conservation in Cambodia is still limited. According to the FAO (2010), about 23,934 hectares of mangrove forest area in Cambodia has been cleared and converted to other land uses. A similar finding by MoE (2009) indicates that intensive shrimp farming, charcoal production, and fuel-wood extraction are the main threats to Cambodia's mangrove. For strengthening the conservation movement toward ensuring the sustainability of Cambodia, we have several suggestions as the following:

1. The integration of community-based marine resource management should be more promoted and provided with more subsidies by the government and all concerned donors.
2. New ICM approach for the conservation and protection of Cambodia's marine ecosystem should be encouraged, and put into implementation with the technical and administrative support from the government; and
3. Continuing to promote awareness of sustainable marine conservation to local people in all coastal provinces of Cambodia.

References

BOON P., Y., (2014). Zoning Cambodia's first Marine Fisheries Management Area. Marine Protected Area Zoning. Phnom Penh, Cambodia.

DoF (2001). Fisheries data collection, 1980-2000, Department of Fisheries, Ministry of Agriculture, Forestry and Fisheries, Cambodia. February 2001.

FAO., (2010). Global Forest Resources Assessment 2010: Country Report: Cambodia. Rome, Italy.

Jambeck JR, Geyer R, Wilcox C, Siegler TR, Perryman M, Andrady A, Narayan R, Law KL: Plastic waste inputs from land into the ocean. Science 2015, 347:768-771.

Lovejoy, T.E., 2007. Biodiversity: what is it? In: Reaka-Kudla, M.K., Wilson, D.E., Wilson, E.O. (Eds.), Biodiversity II: Understanding and Protecting our Biological Resources. Joseph Henry Press, Washington DC, pp. 7–14.

Magnus T., and Albert, M., S., 2001. Institutional Issues and Perspectives in the Management of Fisheries and Coastal Resources in Southeast Asia. World Fish Center. Malaysia.

MoE (2009). Cambodia Environment Outlook. ISBN: 978-974-300-197-0., Phnom Penh, Cambodia.

Nhem Savong., 2016. Policies, Institutional Framework, and Challenges related to Maritime Safety in Cambodia. Expert Group Meeting on Improving Maritime Transport Safety in the ESCAP Region. Bangkok, 2nd September 2016. Thailand.

Olewier M., Francisco A.. H., and Ferrer J. A. (ed) (2016). Marine and Coastal Ecosystem Valuation, Institutions, Policy in Southeast Asia. Springer.

Open Development Cambodia., (2016). Marine and Coastal Areas. https://opendevelopmentcambodia.net/topics/marine-and-coastal-areas/ ., Access 30 August 30, 2018.

PIC. (2017). Situation of Marine Fisheries and the Establishment of Fishing Community. Parliamentary Institute of Cambodia (PIC). Phnom Penh, Cambodia.

Rizvi, A.R. and Singer, U., 2011: Cambodia Coastal Situation Analysis: Building Resilience to Climate Change Impacts – Coastal Southeast Asia, Gland, Switzerland: IUCN. 58 pp.

Snelgrove, P.V.R., (1999)9. Getting to the bottom of marine biodiversity: sedimentary habitats. BioScience 49, 129–138.

Snelgrove, P.V.R., (1999)9. Getting to the bottom of marine biodiversity: sedimentary habitats. BioScience 49, 129–138.

Try, I., (2003). Fish stocks and habitats of regional, global and transboundary significance in the South China Sea (Cambodia). In: Reversing environmental degradation trends in the South China Sea and Gulf of Thailand. UNEP and Global Environment Facility.

UNEP. (2016). GEO-6 Regional Assessment for Asia and the Pacific. United Nations Environment Programme, Nairobi, Kenya.

UNIDO. (2015). Environmental Impacts Assessment of Marine Fisheries Related Activities in Cambodia. United Nations Industrial Development Organization (UNIDO). Phnom Penh, Cambodia.

Yoong, S. 2011. Cambodian Sand Dredging Threatens Environment, Ecotourism Industry. Huffington Post, Aug 22, 2011

VII

Life on Land

12.
Re-assessment of Forest Caron Stocks and Mitigation Potentials in Cambodia

13.
Biodiversity Conservation in Cambodia

12

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Re-assessment of Forest Caron Stocks and Mitigation Potentials in Cambodia

Abstract

Adoption of the Paris Agreement suggests the urgent need for developing countries to establish a forest reference emission level (FREL) if they wish to seek financial support to reduce carbon emissions from deforestation and forest degradation. Analysis of past trends of deforestation is important for establishing a FREL, but so far only a handful of studies exist on such analysis at the commune level. We used the available data of forest cover in 2002 and 2006 and recently available data in 2006, 2010, and 2014 along with updated forest inventory data to analyze forest cover and carbon stock changes according to seven forest types in Cambodia. Carbon stocks were estimated in four carbon pools, namely aboveground, belowground, litter and deadwood pools. This analysis formed the basis for determining the FREL at national and provincial levels in Cambodia. We found that carbon emissions due to deforestation were 82.2 $TgCO_2$ yr^{-1}, but carbon sinks (removals) due to an increase in forest cover were 72.3 $TgCO_2$ yr^{-1}, representing the net emission loss of 9.9 $TgCO_2$ yr^{-1} between 2002 and 2006. Carbon loss between 2010 and 2014 was estimated at 139.9 $TgCO_2$ yr-1, suggesting that deforestation was accelerated during the 2010-2014 period. Taking the trend of deforestation between 2002 and 2006 and 2006, 2010, and 2014 as baselines, FREL for a 30-year timeframe was estimated. FRELs at national level were estimated to be 26.8 to 69.2 $TgCO_2$ yr^{-1} or up to 36% of the total greenhouse gas emissions in Cambodia. Latest data suggests that FRELs could range from 82.2 – 116.5 $TgCO_2$ yr^{-1} due to rapid deforestation during 2006-2014. Our study provides a first look at how to set subnational and national FRELs for Cambodia using a retrospective approach. Such a framework could form a useful basis for Cambodia to adopt the national and subnational FRELs, for which effective policies can be developed to address the drivers of deforestation and forest degradation.

1. Introduction

International efforts have been made to reduce tropical deforestation and forest degradation because of the concern over the threats to the livelihood of forest-dependent community, loss of biodiversity, and climate change and its effects on sustainable development. Accordingly, a number of agreements have been reached. Most notably, the adoption of the REDD+ scheme, which is an initiative referring to Reducing Emissions from Deforestation and forest Degradation PLUS (+) forest conservation,

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sustainable management of forests, and enhancement of forest carbon stocks in developing countries (Christoff, 2008) in the Bali Action Plan at the thirteenth conference of the parties (COP13) to the United Nations Framework Convention on Climate Change (UNFCCC) in 2007, emphasize that accounting for carbon emissions from deforestation and forest degradation is increasingly important (Margono et al., 2014; Pedroni et al., 2009; Pelletier and Goetz, 2015). In addition, Decision CP.16/1/Add. 1/par. 71 of the UNFCCC requires developing countries to develop four elements if they aim to undertake REDD+ activities for financial compensation (Sandker et al., 2015): 1) a national strategy or action plan; 2) a national forest reference emission level (FREL) and/or forest reference level (FRL); 3) a robust and transparent national forest monitoring system for the monitoring and reporting of the REDD+ activities; and 4) a system for providing information on how the safeguards are addressed or respected. The UNFCCC has defined FREL as the benchmark for carbon emissions to assess a country's performance in implementing REDD+ activities (Sandker et al., 2014). FREL could be developed using the UNFCCC's guideline provided at the COP17 (Herold et al., 2012). In addition to establishing a national FREL, Decision 12/CP.17 also acknowledges the importance of establishing subnational or provincial FRELs as an interim measure (Herold et al., 2012). The adoption of the Paris Agreement at the COP21 (Brauers and Richter, 2016) along with the submission of the Intended Nationally Determined Contribution (INDC) by parties to the UN convention, especially by developing country parties, suggests the urgent need for the development of FREL.

Until recently, a number of studies have attempted to estimate carbon emissions from deforestation and forest degradation in the tropics to provide the needed information for establishment of the baseline emissions, against which mitigation measures and performance can be assessed. Based on recent studies, carbon emissions from tropical deforestation are estimated to account for between 8-10% (Achard et al., 2014; Baccini et al., 2012; Houghton et al., 2012) to as high as 20-26% of global carbon emissions (Houghton, 2003; Pan et al., 2011). Despite progress in the study of carbon emissions in the tropics globally, only a handful of studies have attempted to quantify the country-level baseline emissions for the purpose of determining the FRELs. For instance, Romijn et al. (2013) discussed the impacts of different forest definitions on setting up the FRELs in Indonesia. They found that FRELs varied from 484.6 $TgCO_2$ to 753.3 $TgCO_2$. Using national data of forest cover changes and the standard partial equilibrium model, Busch et al. (2009) discussed the impacts of setting up the FRELs on cost per reduction unit under six FREL scenarios for tropical countries. Although previous studies provide useful information on the magnitudes of carbon emissions and the range of possible FRELs in the concerned countries, none of them focused on developing the FRELs for national or subnational level using commune-level data, especially in Cambodia. Such small-scale data are important for understanding forest cover and carbon stock changes and for measuring the implementation performance of the REDD+ activities at small, regional, subnational, and national levels.

Cambodia is a non-Annex I country (low-income developing countries with no legal binding on emission reductions by 2020) to the UNFCCC. Cambodia ratified the UNFCCC in December 1995 and the Kyoto Protocol in August 2002. Cambodia submitted its INDC to the UNFCCC in September 2015 proposing to reduce 3.1 million tCO_2e, compared to the 2010 emission level, by 2030 (Uy, 2015a). Apart from introducing policies to reduce emissions from energy and transport sectors, Cambodia has actively participated in reducing carbon emissions from deforestation and forest degradation through the REDD+ scheme. Although Cambodia has made remarkable progress in preparation for the full implementation of the REDD+ activities (Chuop, 2015), FRELs are presumably still under development. Thus it is impossible to know what methods and data are being used and how FRELs are decided in Cambodia. Using limited available data, this paper aims to analyze forest cover and carbon stock changes at the commune level and discuss the timely important issue of FREL development. We hope to stimulate discussions on future carbon emissions in various provinces in Cambodia and how FRELs may be determined in the respective provinces. This study uses 2002 and 2006 forest cover data to analyze forest cover change starting from the commune level in Cambodia. Changes in forest cover and carbon stocks in four carbon pools according to seven forest categories are analyzed to provide a basis for estimating carbon emission and removal (carbon sequestration) in Cambodia. We also discussed the causes of deforestation, carbon emissions, and policy implications for the establishment of national and subnational FRELs in Cambodia.

2. Study Methods and Materials

Although remote sensing is commonly used to estimate carbon emissions from tropical forests at various scales (Asner et al., 2011, Zolkos et al., 2013, Hansen et al., 2013), data were not available for the current study. Forest cover spatial data produced by Cambodia's Forestry Administration (hereinafter "FA", FA is a government agency responsible for forest management in Cambodia) (FA, 2008, Pak et al., 2010) were used to estimate the baseline emissions and the FRELs. Recently available data used by the Cambodian government for estimating its FREL, and later on submitted to the UNFCCC in 2016 (UNFCCC, 2016) are also analyzed.

Introduction to Forest Cover Change and REDD+ in Cambodia

Forests have been the main source of timber harvesting and revenues in Cambodia (Kim et al., 2006, Singh, 2012) in addition to providing habitats for 2,308 species, 123 species, 545 species, 63 species, 88 species, and 874 species of known vascular plants, mammals, birds, amphibians, reptiles, and fish found in Cambodia. However, clearing of natural forests for industrial plantations (Neef et al., 2013, Davis et al., 2015) has posed great concerns over the loss of natural forests and their ecosystems whose healthy functions are important for sustaining Cambodia's agriculture-dependent economic development. Due to deforestation and forest degradation, 31 species of vascular plants, 37 species of mammals, 24 species of birds, 3 species of amphibians, 13 species of reptiles, and 28 species of fish are classified as threatened species (Kapos et al., 2010).

Cambodia has experienced a rapid decline in forest cover over the last 10 years. Official data show that forest cover in Cambodia was 10.4 million ha in 2010, declining from 11.1 million ha in 2002 (Leng, 2011), representing an annual loss of 92,562.7 ha (0.8%) between 2002 and 2010. Other studies estimated forest cover at 10.2 million ha in 2010 and 9.6 million ha in 2015 (FAO, 2015). Deforestation and forest degradation were responsible for 50.3 $TgCO_2$ per year of carbon emissions between 1993 and 2003 in Cambodia (Sasaki, 2006). Recent data suggests that Cambodia lost about 4.6% per year between 2010 and 2014 (UNFCCC, 2016). As part of its efforts to reduce deforestation and forest degradation, Cambodia submitted its Readiness Preparation Proposal or R-PP to the Forest Carbon Partnership Facility (FCPF) of the World Bank in late 2008, which was accepted in early 2009. In October 2009, Cambodia joined the UN-REDD programme as a partner country. Subsequently, Cambodia has received a total grant of US$ 3.8 million from the FCPF, in addition to about US$ 2.3 million from the UN-REDD program, for developing and enhancing the government's capacity to address deforestation and forest degradation, as well as for measuring, reporting and verifying emission reductions in Cambodia. Until recently, one REDD+ project in Oddar Meanchey Province was verified by the Verified Carbon Standard (VCS) and the Climate, Community & Biodiversity Alliance (CCBA) in 2013. Another REDD+ project in Mondulkiri was validated by CCBA in November 2015, and three more REDD+ projects are under different stages of preparation (Bradley and Shoch, 2013).

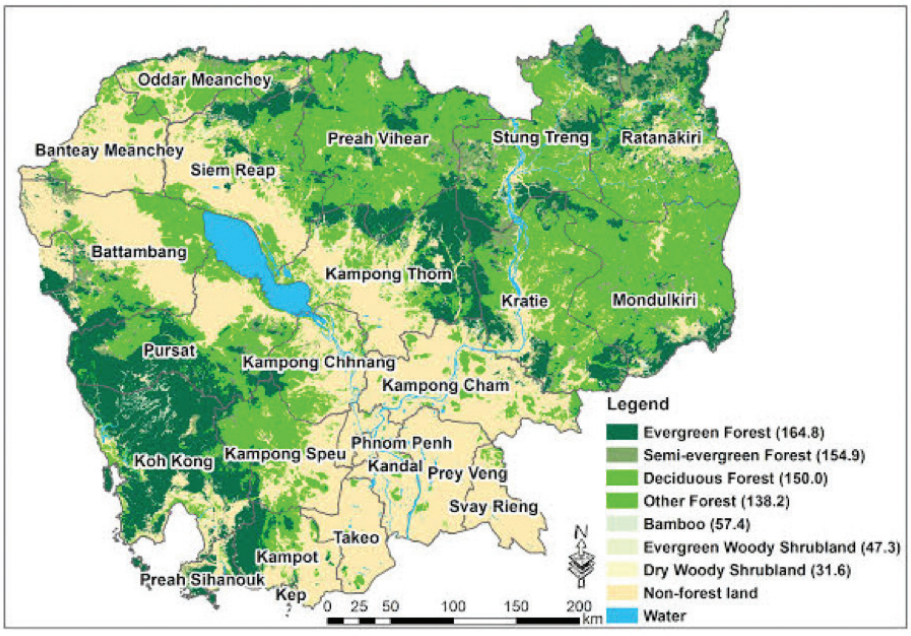
Data Availability and Land Use Classification.

Data on forest cover at the commune level in Cambodia were available only for 2002 and 2006. We used these data to determine the trend of past change of forest cover. Methods for the analysis of forest covers in 2002 and 2006 were reported by FA (2008) and Pak et al. (2010). According to Pak et al., (2010), FA employed the method of visual analysis digitization using ArcView software, ERDAS 9.1 with a minimum mapping unit of 25 ha in addition to using the satellite band SPOT-4 432. To ensure accuracy, FA sent three teams to ground truth 102 points throughout the country. In very remote areas, Quickbird images were used in lieu of site visits. Assessment of forest cover change between 2002 and 2006 was done from commune to national levels. Cambodia defines administrative boundaries by village, commune, district, and provincial boundaries. Village boundaries are not clearly defined as villages or even commune are often merged or newly created as directed by the government.

The FA classified forest cover in 2002 and 2006 into seven forest land-use categories, namely evergreen, semi-evergreen, deciduous, other forests, bamboo, dry woody shrubland, and evergreen woody shrubland. Figure 1 shows forest cover according to seven forest land use categories, non-forest land and surface water. Evergreen forest is a category containing multi-story forests, where more than 80% of tree species keep their leaves during the entire year. This category includes lowland tropical rain forests, hill evergreen forests and dry evergreen forests. The semi-evergreen forest category incorporates a variable

percentage of evergreen and deciduous trees. It includes mixed evergreen and mosaic forests. The deciduous forest category contains forests, where more than 80% of tree species shed their leaves during the dry season spanning from November to April. It consists of dry mixed deciduous forests and dry dipterocarp forests. The other forests category contains different types of forests, including forest re-growth, inundated forest re-growth, inundated forests, mangrove forests, forest plantations, and inundated mosaic forests. Forest regrowth is a naturally regenerated forest found mainly in the remote abundant areas. Inundated forests are found along the fresh water ways such as long the Tonle Sap Great Lake, the Mekong River and its tributaries. Mangrove forests are found along the coastal areas. Forest plantation includes rubber, pine, teak, and other forms of tree crops. Although mangrove and inundated forests may contain higher carbon stocks in the soil (Donato et al., 2011, Kurnianto et al., 2015), the areas of the two forest types in this category are not available. The evergreen woody shrubland category is a mixture of shrubs, grass, and trees, but tree cover remains between 10-20%. The dry wood shrubland category is similar to that of wood and shrub evergreen, but it is found in dry plains or on plateaus, as well as on dry and sun exposed slopes. The bamboo category is bamboo forest usually found in the southeastern part of Cambodia. The non-forest land category contains grass lands, mosaics of cropping, agriculture land, barren lands, rock outcrops, urban areas, water, wetlands, and other areas that were covered with clouds in the satellite imagery, and are therefore not considered in this study.

↘ Figure 1



Forest cover map by province according to nine land use categories
Numbers in the parenthesis of the Legend are the initial values of carbon stocks (aboveground, belowground, litter, and deadwood) used in our study. Cambodia may use different or same values for its official reporting purposes.

Communes, Districts, and Provinces in Cambodia

In 2006, Cambodia had 23 provinces and one capital. Each province is composed of districts; each district consists of communes; and each commune consists of villages. There were 168 districts divided into 1,618 communes in 2006. Since Phnom Penh (consisting of seven districts) contained no forests, it was not included in our study. Due to civil wars and administrative reforms, many villages in Cambodia still do not have fixed administrative boundaries, making it impossible to find consistent data of forest cover by villages even in the forest cover data 2002 and 2006. In our study, forest areas by category at the commune level were summed to calculate forest areas at the district level. Carbon stocks by forest category at district, provincial, and national levels were then calculated for both years.

Carbon Pools

The International Panel on Climate Change (IPCC, 2006) recommends five carbon pools for greenhouse gas inventories in the forest sector. Due to lack of information, only four of the five carbon pools were considered in this study: aboveground biomass, belowground biomass, deadwood, and litter. Based on 12-year data in the primary forests and deforested lands in the lowland tropical rain forest in Southeast Asia, a recent study found no change of soil carbon in both land types (Yonekura et al., 2010). Due to data limitation and for simplicity, carbon in soil is not included.

Total vegetation carbon stocks (CS) in 2002 and 2006 were estimated by summing the four carbon stocks by land use categories as follows:

$$CS = \sum_{k=1}^{23} \sum_{i=1}^{161} \sum_{e=1}^{7} FA_{e,i,k} \times CS_e \qquad (1)$$

where, $FA_{e,i,k}$ is the area of forest category *e* in district *i*, and province *k* (ha) (Phnom Penh and its seven districts were excluded in our study because it contained no forest cover); CS_e is the carbon stocks in forest category *e* ($MgC\ ha^{-1}$). Again, the carbon stocks include aboveground biomass, belowground biomass, deadwood, and litters.

Annual carbon emissions (CE) between 2002 and 2006 are obtained using the stock-change method (method 2) of the IPCC Guidelines (IPCC, 2006):

$$CE = \frac{[CS_{2006} - CS_{2002}]}{2006\text{-}2002} \times \frac{44}{12} \qquad (2)$$

where, CS_{2002} and CS_{2006} are total carbon stocks in 2002 and 2006, respectively obtained through Eq. (1) ($TgCO_2$ and 1 $TgCO_2$ is one million tCO_2); the ratio 44/12 is the molecular weight ratio of carbon dioxide to carbon.

Forest Reference Emission Level (FREL)

FREL is an important component of the REDD+ scheme. Developing countries must develop FREL for their respective countries before they can obtain financial compensation, which is based on reduced emissions (reductions) or increased carbon stocks (carbon sequestration or removals). Developing countries need to lower their emissions from deforestation and forest degradation below the FREL to qualify for

financial compensation. FRELs are the CO_2 emissions from deforestation and forest degradation in the absence of project activities undertaken to reduce deforestation and forest degradation. FRELs can be developed based on the past trends of deforestation, a "retrospective approach", or future trends a "prospective approach" (Huettner et al., 2009). The former can be done using available data and extrapolating into the future, but the latter is more dynamic, taking into consideration the national circumstances of the countries in question. For this study, a retrospective approach is used.

In this study, FREL was calculated at the provincial level, which can be considered as a subnational FREL, while the sum of FRELs at the provincial level is the national FREL. To avoid confusion with the official FRELs that only the government in developing countries can decide, we used the terms of total FREL and subtotal FREL instead of national FREL and subnational/ provincial FREL, respectively. The national and subnational FRELs will be determined and decided by developing countries, where different datasets, methods and/or approaches may be used.

To estimate FREL, removals, and FRL, the annual increase or decrease of forest area by category must be estimated. Using the retrospective approach (past trend) as a baseline, the following equations are used to derive forest area changes:

$$FAD_{e,k}(t) = FA_{e,k}(t_o) \times e^{a_{e,k} \times t} \quad (3)$$

$$FAI_{e,k}(t) = FA_{e,k}(t_o) \times t^{a_{e,k}} \quad (4)$$

where, $FAD_{e,k}(t)$ is the area of forest category *e* in decreasing trend (ha); $FAI_{e,k}(t)$ is the area of forest category *e* in increasing trend (ha); $FA_{e,k}(t_0)$ is the initial area of forest category e i.e. area in 2002 (ha); $a_{e,k}$ is the change rate of area of forest category *e*. If a<0 (decrease), Eq. (3) is used, Eq. (4) otherwise. Eq (4) is used with the assumption that increase in the area of forest category *e* will slow down when land availability for such increase is reduced. If a=0, there is no change in the forest area; *t* it the time step (1 year). The timeframe of the modelling period is from 2002 to 2030. This timeframe is consistent with the end of the Paris Climate Agreement (2020-2030). t_0 is for the year 2002. Using recent data (2006, 2010, and 2014), FREL is also estimated starting from 2006 until 2030 to take into consideration Cambodia's official FREL submitted to the UNFCCC in 2016 (UNFCCC, 2016).

The Gain-Loss Method (IPCC, 2006) was used to obtain carbon emissions by forest category:

$$CE_{e,k}(t) = \left[FAD_{e,k}(t_2) - FAD_{e,k}(t_1)\right] \times CE_e \times \frac{44}{12} \quad (5)$$

$$CI_{e,k}(t) = \left[FAI_{e,k}(t_2) - FAI_{e,k}(t_1)\right] \times CSI_e(t) \times \frac{44}{12} \quad (6)$$

where, $CE_{e,k}(t)$ is the carbon emissions from deforestation of forest category e ($MgCO_2$ $year^{-1}$); $CI_{e,k}(t)$ is the carbon sequestration (it is sometimes called removals) due to increase in area of forest category *e* ($MgCO_2$ $year^{-1}$); CS_e is the carbon stocks of forest category *e* (MgC ha^{-1}). According to the methodology used by the VCS for REDD+ projects; CS_e can be used as the constant average value for forests with a decreasing trend over time (VCS 2009; Estrada 2011). It is therefore assumed to be constant for this study

over the modeling period; $CSI_{e,k}(t)$ is the carbon stocks in increasing trend due to natural regrowth or plantations (MgC ha^{-1}). Forest with increasing trend is usually protected (Soares-Filho et al., 2010), abandoned (Poorter et al., 2016), or planted forests (Pan et al., 2011). Therefore, carbon stocks in forests with an increasing trend in this study are assumed with the following logistic equation:

$$CSI_e(t) = \frac{CSI_{MAXe} \times CSI_e(t_o) \times e^{r_e \times t}}{CSI_{MAXe} + CSI_e(t_o) \times (e^{r_e \times t} - 1)} \quad (7)$$

where, $CSI_e(t_0)$ is the initial carbon stocks of forest category *e* having an increase in area (MgC ha^{-1}); $CSI_{MAXe}(t)$ is the maximum carbon stocks of forest category *e* having an increase in area (MgC ha^{-1}); r_e is the growth rate of forest category *e* with increasing trend.

Subsequently, forest reference emission level for each province can be estimated by

$$FREL_K(t) = \frac{\sum_{e=1}^{7} CE_{e,k}(t)}{1000000} \quad (8)$$

where, $FREL_K(t)$ is the forest reference emission level in the province *k* at time *t* ($TgCO_2$ yr^{-1}), $CE_{e,k}(t)$ is provided in Eq. (5).

and the Total FREL for Cambodia is therefore

$$FREL_{CAMBODIA}(t) = \sum_{k=1}^{24} FREL_K(t) \quad (9)$$

where, $FREL_{CAMBODIA}(t)$ is the total FREL for the whole country at time *t* ($TgCO_2$ yr^{-1}).

Carbon gained due to increases in forest area or carbon sequestration in provincial level are derived by

$$RM_K(t) = \frac{\sum_{e=1}^{7} CI_{e,k}(t)}{1000000} \quad (10)$$

where, $RM_K(t)$ is the carbon sequestration (removals) in the province *k* at time t ($TgCO_2$ yr^{-1}), $CI_{e,k}(t)$ is provided in Eq. (6).

Total carbon sequestration (or removals) for Cambodia are therefore

$$RM_{CAMBODIA}(t) = \sum_{K=1}^{24} RM_k(t) \quad (11)$$

where, $RM_{CAMBODIA}(t)$ is the total Removals (sequestration) for the whole country at time *t* ($TgCO_2$ yr^{-1}).

The forest reference level (FRL_k) for each province can be obtained by $FRL_k = FREL_k + RM_k$. Estimates of FRL for the whole of Cambodia can be determined from $FREL_{CAMBODIA} + RM_{CAMBODIA}$. FRL provides an indication of the magnitude of net carbon emissions, where financial incentives are provided for carbon credits from a reduction in emissions below the FREL or from carbon sequestration (i.e. enhancement of forest carbon stocks).

For estimating carbon emissions from deforestation, initial carbon stocks for each forest category shown in Table 1 and Figure 1 are assumed to be constant over the 30-year period of the project cycle. This assumption is based on the fact that the natural increase in biomass through growth is equally removed by local use either for housing or

cooking energy. This assumption is consistent with the REDD+ methodology of the VCS (VCS, 2009; Estrada, 2011). In contrast, sequestration due to an increase of forest area is estimated differently in each case because regenerated forests or plantations have lower initial carbon stocks, but higher biomass growth rates than natural forests (Aryal et al., 2014). Equation (7) was used to estimate the increment of carbon stocks for any forest category of increasing area. As forest biomass for young regrowth/ regenerated forests (including plantations) is usually small (Poorter et al., 2016), we assume that the initial carbon stocks are 10% of the mean carbon stocks in respective forest categories. Mean annual increments (MAI) in tropical countries range from 0.1-0.9 MgC ha^{-1} yr^{-1} in Panama (Meyer et al., 2013), 1.3 ha^{-1} yr^{-1} in Amazonia forests (Mazzei et al., 2010), 1.6 MgC ha^{-1} yr^{-1} in Northern Borneo (Berry et al., 2010), and 2.3 MgC ha^{-1} yr^{-1} in Kampong Thom province of Cambodia (Top et al., 2004). A recent study using about 1500 sample plots in 45 forest sites of secondary forests in the Neotropics found a MAI of 3.0 Mg C ha^{-1} yr^{-1} (Poorter et al., 2016). For this study, MAIs for all forest categories (forests with an increasing trend) were assumed to be 1.5 MgC ha^{-1} yr^{-1}. The $r_{e,k}$ was obtained by dividing MAI by the initial carbon stock values of respective forests showing an increasing trend. Maximum carbon stocks of increased forests are assumed to have reached the same level of mean carbon stocks prior to the commencement of the project.

↘ Table 1

Initial carbon stocks for forest land use category by pools in 2002

Land Use Categories (j)	Carbon Pools (MgC ha^{-1})				Total CS_j	
	Above ground	Below ground	Dead Wood	Litters	(MgC ha^{-1})	($MgCO_2$ ha^{-1})
Evergreen Forest	96.2[a1]	27.8	27.2	13.6	164.8	604.3
Semi-Evergreen	98.1[b1]	29.8	14.5	12.4	154.9	567.9
Deciduous Forest	95.1[c1]	28.9	14.1	12.0	150.0	550.2
Bamboo	36.4 [d1]	11.1	5.4	4.6	57.4	210.4
Other Forest	87.6 [e1]	26.6	13.0	11.0	138.2	506.9
Evergreen Woody Shrubland	30.0 [f1]	9.1	4.4	3.8	47.3	173.6
Dry Woody Shrubland	20.0 [g1]	6.1	3.0	2.5	31.6	115.7

* Note

a1 : based on the mean stand volume of 194.0 m^3 ha^{-1} from 162 sample plots (20m x 60m) in evergreen forests in Kampong Thom (Kim-Phat et al. 2000) and from 120 sample plots (20m x 60m) in evergreen forests in Preah Vihear Provinces (Kao and Iida, 2006) in Cambodia. Carbon stocks (92.2) were derived by 194.0 * 0.57 (wood density) *1.74 (biomass expansion factor) * 0.5 (carbon content) using the formula of Brown (1997)

b1 : based on Chheng et al. (2016) who estimated the average carbon stocks of 98.1±3.6 MgC ha^{-1} from 179 sample plots (25m x 40m) in semi-evergreen forests in Kratie, Rattanakiri, and Stung Treng provinces in Cambodia.

c1 : based on the average stand volume of 191.7 m^3 ha^{-1} from six sample plots in a deciduous forest in Mondulkiri province in Cambodia (Khun et al., 2012). Carbon stocks, 95.1 = 191.7*0.57*1.74*0.5. A recent report based on data from 41 clusters (3 plots per cluster) in Seima protection forests estimated the average carbon stocks for open forest (comprising of mixed deciduous forest, deciduous dipterocarp forest and open woodland) to be 150.7 MgC ha^{-1} (±15.6% CI90) (FA, 2013) or only 0.7 MgC higher than our estimate in Table 1

d1 : We used the average biomass of bamboo forest in Bangladesh for this study (Altrell, 2007) because no data is available for bamboo forests in Cambodia.

e1 : Based on (Sasaki, 2006)

f1 : Based on the mean biomass of shrubland in the Brazilian Savanna Woodland (De Miranda et al., 2014), but this biomass is very similar to average stocks of semi-natural woody scrubland located in Seima Protection Forest in eastern Cambodia (FA, 2013).

g1 : Dry Woody Shrubland is subject to frequent fires. Its carbon stocks were assumed to be 10 MgC smaller than that of Evergreen Woody Shrubland

Carbon stocks in belowground, dead wood, and litters in Table 1 were calculated in proportion to aboveground biomass based on (Kiyono et al., 2010) for litters and deadwood and Khun et al. (2012) for belowground biomass.

3. Results

Forest Cover and Carbon Stocks Changes

An analysis of forest cover change by commune according to seven forest categories showed that forest cover in Cambodia was 11.4 million ha, occupying about 62.7% of the country's total land area in 2002. Forest cover declined to 10.9 million ha in 2006. The annual rate of loss was 132,038.6 ha or about 1.2% between 2002 and 2006 (Table 2). This rate of change is in agreement with that estimated (1.2%) by FAO's forest resource assessment project for the period 2000-2015 (FAO, 2015). Annual loss rate (1.2%) in Cambodia is similar to forest cover changes during the 1990s and 2000s in Indonesia and Malaysia (Miettinen et al., 2011; Stibig et al., 2014). Analysis of recent data shows a sharp decrease in forest cover between 2010 and 2014 at about 4.6% or 483,435 ha year-1 (Table 3). In the government report submitted to the UNFCCC in 2016, oil palm plantation and rubber plantation were not included in the forest category.

Among the three main forest types in Cambodia, semi-evergreen forest area decreased 1.6% per year (23,114.3 ha yr-1); deciduous forest, 0.7% per year (35,258.7 ha); and evergreen forest, 0.3% per year (12,903.6 ha) of their areas between 2002 and 2006. Between 2010 and 2014, evergreen forest lost 4.2%, semi-evergreen forest 5.1%, and deciduous forest 5.7% annually. Semi-evergreen forests contain several commercial timber species. Because they are located close to populated areas, this forest type is subject to both logging and land clearing. Although deciduous forest contains less commercial timber species, this forest can be easily accessible by local people and land migrants. In addition, economic land concessions are commonly found in deciduous forests. Therefore, deciduous forests are subject to timber extraction for charcoal making, land clearing, and burning for industrial crop plantation (Forest Trends 2015). Over the same period, the other forest category experienced a significant loss at 2.2% or about 23,489 ha per year despite the increase in the area of rubber plantation (Hang, 2009). Although detailed data are not available, specific decline or increase by forest types in this forest category is unknown. Dry woody shrubland and evergreen woody shrubland categories dramatically lost 18.3% per year and 8.9% per year, respectively over the same period between 2002 and 2006. These last two categories are commonly found in accessible areas. They are also subject to annual clearing and burning for crop cultivation and claims of ownership rights. Other forest types, especially flooded forests along the Mekong and Tonle Sap rivers are commonly cleared for rice and crop plantations (Evans et al., 2004).

Changes in forest cover and carbon stocks by forest category (2002-2006)

↘ Table 2

Forest Category	Total Area			Change	
	2002	2006	2002-2006	yr^{-1}	% yr^{-1}
Evergreen Forest					
Area (ha)	3,720,475.3	3,668,860.7	-51,614.6	-12,903.6	-0.3%
Carbon Stocks (TgC)	613.1	604.6	-8.5	-2.1	-0.3%
Semi-Evergreen Forest					
Area (ha)	1,455,080.1	1,362,622.7	-92,457.4	-23,114.3	-1.6%
Carbon Stocks (TgC)	225.4	211.1	-14.3	-3.6	-1.6%
Deciduous Forest					
Area (ha)	4,833,118.7	4,692,084.1	-141,034.6	-35,258.7	-0.73%
Carbon Stocks (TgC)	725.0	703.8	-21.2	-5.3	-0.7%
Other Forest					
Area (ha)	1,065,679.6	971,313.7	-94,366.0	-23,591.5	-2.2%
Carbon Stocks (TgC)	147.3	134.2	-13.0	-3.3	-2.2%
Bamboo					
Area (ha)	28,950.5	35,799.9	6,849.4	1,712.4	5.9%
Carbon Stocks (TgC)	1.7	2.1	0.4	0.1	5.9%
Dry Woody Shrubland					
Area (ha)	138,931.6	36,975.2	-101,956.4	-25,489.1	-18.3%
Carbon Stocks (TgC)	4.4	1.2	-3.2	-0.8	-18.3%
Evergreen Woody Shrubland					
Area (ha)	150,014.6	96,439.9	-53,574.7	-13,393.7	-8.9%
Carbon Stocks (TgC)	7.1	4.6	-2.5	-0.6	-8.9%
All forests					
Area (ha)	11,392,250.4	10,864,096.1	-528,154.3	-132,038.6	-1.2%
Carbon Stocks (TgC)	1,723.9	1,661.5	-62.4	-15.6	-0.9%
Percentage of total land area	62.7%	59.8%			

* Note : Data of forest cover in 2002 and 2006 were obtained from the Forestry Administration of Cambodia

↘ Table 3

Forest cover change in Cambodia between 2006 and 2014

Forest Category	Area (ha)			Annual Changes (ha)			(%)
	2006	2010	2014	2006 -2010	2006 -2014	2010 -2014	2010 -2014
Evergreen Forest	3,710,271	3,573,925	2,973,903	-34,087	-92,046	-150,006	-4.2%
Semi-evergreen forest	1,453,441	1,391,117	1,108,320	-15,581	-43,140	-70,699	-5.1%
Deciduous Forest	4,613,417	4,498,397	3,480,532	-28,755	-141,611	-254,466	-5.7%
Flooded Forest	597,355	524,005	481,078	-18,338	-14,535	-10,732	-2.0%
Forest Regrowth	216,123	249,341	228,560	8,305	1,555	-5,195	-2.1%
Bamboo	129,837	130,930	130,678	273	105	-63	0.0%
Mangrove	32,060	31,443	33,002	-154	118	390	1.2%
Rear Mangrove	27,519	27,371	25,906	-37	-202	-366	-1.3%
Pine Forest	8,157	8,157	8,196	0	5	10	0.1%
Pine Plantation	1	11	3,709	3	464	925	8404.5%
Tree Plantation	43,547	17,214	44,289	-6,583	93	6,769	39.3%
Forest Area	10,831,728	10,451,911	8,518,173	-94,954	-289,194	-483,435	-4.6%
Oil Palm Plantation	35	5,055	36,311	1,255	4,535	7,814	154.6%
Rubber Plantation	78,148	137,307	484,316	14,790	50,771	86,752	63.2%
Grassland	600,006	473,281	351,337	-31,681	-31,084	-30,486	-6.4%
Agriculture	1,000,634	1,275,444	2,787,413	68,703	223,347	377,992	29.6%
Paddy Filed	3,668,981	3,859,452	4,133,474	47,618	58,062	68,506	1.8%
Rock	219	668	2,054	112	229	347	51.9%
Sand	8304	10,459	40,581	539	4,035	7,531	72.0%
Built-up ara	37436	43,800	328,820	1,591	36,423	71,255	162.7%
Village	248,126	296,513	42,166	12,097	-25,745	-63,587	-21.4%
Water	438,410	458,658	813,839	5,062	46,929	88,795	19.4%
Wood shrub	1,248,649	1,148,126	622,190	-25,131	-78,307	-131,484	-11.5%
Non-Forest	7328948	7708763	9,642,501	94,954	289,194	483,435	

Rainfall is an important climatic variable affecting plant distribution (Borchert, 1998). Our analysis found that about 22.2% and 30.6% of evergreen forest and evergreen woody shrubland were found in Koh Kong Province, where mean annual rainfall exceeds 2000 ㎜, respectively (ADB, 2014). Except for Koh Kong Province, many other provinces have an annual rainfall of less than 2000 ㎜ (ADB, 2014). Semi-evergreen forests were found in Stung Treng Province, accounting for 19.6% of the total area of semi-evergreen forests, while deciduous forests were mainly found (19.2%) in Preah Vihear Province. About 16.9% of other forests (mainly inundated forests along the Tonle Sap great lake and rivers) were found in Kampong Thom. About 26.4% of bamboo forests occurred in Mondulkiri Province, and 20.4% of Dry Woody Shrubland were found in Ratanakiri Province.

Oddar Meanchey, Banteay Meanchey, Battambang, and Siem Reap provinces had the highest forest cover losses: 15,309.5 ha, 14,276.9 ha, 13,909.8 ha, and 13,901.8 ha, respectively. Altogether, deforestation in these four provinces accounted for 43.5% of the total deforestation in Cambodia between 2002 and 2006 (Table 4). Land migrants were largely responsible for deforestation in the above provinces (Dulioust, 2011). Between 2002 and 2008, provinces with less forest cover such as Takeo, Prey Veng, and Kandal had an outflow of people seeking lands in the provinces of Oddar Meanchey, Banteay Meanchey, and Battambang (Dulioust, 2011), which were previously under the control of Khmer Rouge guerillas, whose movement ended with the death of Pol Pot (its leader) in 1998. In Pailin alone, migrants from other parts of Cambodia sharply elevated the population by 28% between 2002 and 2008. About 74% of the 70,486 people in this province were migrants whose daily subsistence came from logging, mining, and land clearing (Dulioust, 2011). A rapid increase of tourists in Siem Reap Province, the location of the world heritage Angkor Archaeological Park, resulted in an inflow of migrants seeking better employment from the boom of tourism industry and construction of hotels to accommodate the increasing tourists (Gaughan et al., 2009).

Generally, clearing forest under the umbrella of economic land concession (ELC) is the main driver of deforestation and forest degradation in Cambodia (Davis et al., 2015, Dhiaulhaq et al., 2014, Poffenberger, 2009). Other drivers of deforestation include illegal logging, agricultural expansion, and population growth (Michinaka et al., 2015, Poffenberger, 2009).

↘ Table 4

Forest cover change by province (2002-2006)

Forest Category	Forest Area (ha)		Area Change (ha)		
	2002	2006	2002-2006	Annual	Rate
Oddar Meanchey	521,411.2	460,173.4	-61,237.8	-15,309.5	-2.9%
Banteay Meanchey	160,220.0	103,112.6	-57,107.4	-14,276.9	-8.9%
Battambang	593,027.9	537,388.8	-55,639.1	-13,909.8	-2.3%
Siem Reap	541,449.0	485,841.8	-55,607.2	-13,901.8	-2.6%
Pailin	87,394.8	51,403.3	-35,991.5	-8,997.9	-10.3%
Ratanakiri	1,002,551.5	967,892.8	-34,658.7	-8,664.7	-0.9%
Kratie	972,377.6	940,827.5	-31,550.1	-7,887.5	-0.8%
Kampong Cham	192,198.1	165,377.4	-26,820.7	-6,705.2	-3.5%
Preah Vihear	1,337,064.3	1,310,675.7	-26,388.6	-6,597.2	-0.5%
Stung Treng	1,084,352.8	1,059,570.9	-24,781.9	-6,195.5	-0.6%
Koh Kong	1,021,633.4	1,000,916.5	-20,716.9	-5,179.2	-0.5%
Mondulkiri	1,266,408.4	1,249,653.0	-16,755.4	-4,188.8	-0.3%
Kampong Spueu	427,668.9	412,148.0	-15,520.9	-3,880.2	-0.9%
Takeo	30,028.8	15,607.2	-14,421.6	-3,605.4	-12.0%
Kandal	31,467.4	18,854.0	-12,613.4	-3,153.4	-10.0%
Kampong Thom	656,059.4	644,433.3	-11,626.1	-2,906.5	-0.4%
Kampot	237,723.4	228,368.7	-9,354.8	-2,338.7	-1.0%
Pursat	899,202.8	891,559.5	-7,643.4	-1,910.8	-0.2%
Kampong Chhnang	216,349.9	211,052.9	-5,297.0	-1,324.2	-0.6%
Preah Sihanuk	86,316.0	84,320.1	-1,996.0	-499.0	-0.6%
Keb	4,765.8	3,629.1	-1,136.7	-284.2	-6.0%
Svay Rieng	12,921.2	11,980.8	-940.4	-235.1	-1.8%
Prey Veng	9,656.1	9,307.3	-348.8	-87.2	-0.9%
Total	11,392,248.8	10,864,094.6	-528,154.3	-132,038.6	
Annual change rate				-1.2%	

In 2002, total carbon stocks in forests were estimated to be 1,723.9 TgC (1 TgC = one million tonne C), of which aboveground, belowground, litter, and deadwood pools account for 61.6%, 18.4%, 11.9%, and 8.1%, respectively of the total carbon pools. Total carbon stocks declined to 1,661.5 TgC in 2006. Carbon loss due to deforestation was estimated at 82.2 $TgCO_2$ annually between 2002 and 2006. Over the same period, annual carbon gains were -72.3 $TgCO_2$ (the negative sign refers to carbon sequestration or removals). Specifically, carbon gains due to the increase in evergreen forest and bamboo exceeded carbon loss from deforestation, resulting in carbon gains of -20.1 $TgCO_2$ and -0.4 $TgCO_2$, respectively (Table 5). Because carbon loss from the decline of deciduous forests was partially compensated by an increase of the same forest types, the loss of semi-evergreen and other forests was responsible for annual carbon emissions of 10.9 $TgCO_2$ and 10.7 $TgCO_2$, respectively

between 2002 and 2006. Over the same period for the whole of Cambodia, forest cover change was responsible for carbon emissions of about 9.9 $TgCO_2\ yr^{-1}$ (Table 4). Nevertheless, the amount of these overall emissions vary depending on the approach used to calculate the emissions. If we derived the overall emissions in Cambodia by simply multiplying annual forest loss with carbon density, the overall emissions are an estimated 57.2 $MgCO_2\ yr^{-1}$ between 2002 and 2006. The magnitude of overestimation demonstrates why any estimation of country-level emissions should be based on detailed district or commune-level data. Separate calculations of both carbon emissions and sequestration should be performed to avoid overestimation of carbon emissions in any country.

↘ Table 5

Annual carbon emissions or sinks due to forest cover changes (2002-2006)

Forest Category		Total Area	Change				
		(ha yr^{-1})	Above	Below	Litters	Deadwood	Total
Increase in forest area and carbon removals	Evergreen	24,347.4	-24.9	-7.2	-7.0	-3.5	-42.6
	Semi-evergreen	1,949.7	-2.1	-0.6	-0.3	-0.3	-3.4
	Deciduous	3,384.1	-11.2	-3.4	-1.6	-1.4	-17.6
	Other forest	11,421.4	-4.5	-1.4	-0.7	-0.6	-7.1
	Wood shrub evergreen	4,649.9	-0.5	-0.2	-0.1	-0.1	-0.8
	Bamboo	3,703.6	-0.5	-0.1	-0.1	-0.1	-0.8
	Total	49,456.0	-43.7	-12.9	-9.8	-6.0	-72.3
Decrease in forest area and carbon emissions	Evergreen	-37,251.0	13.1	3.8	3.7	1.9	22.5
	Semi-evergreen	-25,064.0	9.0	2.7	1.3	1.1	14.2
	Deciduous	-38,642.8	13.5	4.1	0.2	1.7	21.2
	Other forest	-35,012.9	11.3	3.4	1.7	1.4	17.7
	Wood shrub evergreen	-18,043.5	2.0	0.6	0.3	0.2	3.1
	Wood shrub dry	-25,489.1	1.9	0.6	0.3	0.2	2.9
	Bamboo	-1,991.2	0.3	0.1	0.0	0.0	0.4
	Total	-181,494.5	51.0	15.3	9.3	6.6	82.2
Overall carbon emissions or removals	Evergreen	-12,903.6	-11.7	-3.4	-3.3	-1.7	-20.1
	Semi-evergreen	-23,114.3	6.9	2.1	1.0	0.9	10.9
	Deciduous	-35,258.7	2.3	0.7	0.3	0.3	3.6
	Other forest	-23,591.5	6.8	2.1	1.0	0.9	10.7
	Wood shrub evergreen	-13,393.7	1.5	0.4	0.2	0.2	2.3
	Wood shrub dry	-25,489.1	1.9	0.6	0.3	0.2	2.9
	Bamboo	1,712.4	-0.2	-0.1	0.0	0.0	-0.4
Total		-132,038.6	7.3	2.4	-0.5	0.7	10.0

* Note : "+" (plus) refer to carbon emissions while "–" to carbon sequestration (carbon uptake by an increase in land area)

FREL, Removals, and FRL

Forest Reference Emission Level (FREL) is an important benchmark of emissions, against which developing countries need to reduce carbon emissions. The more emissions they reduce, the more financial support they would receive because REDD+ schemes base payment on performance (Norman & Nakhooda, 2014). If the FREL is set high, developing countries would receive more financial incentives when actual emissions are greatly reduced. Otherwise, if FREL is set low, developing countries may risk not being able to reduce emissions below the FREL.

Until recently, there was no globally agreed upon approach for deciding FRELs. Brazil, the first country that submitted a FREL to the UNFCCC in 2014, used a historical average of gross emissions from deforestation over a 10-year period between 1996 and 2005 in the calculation. Thereafter, baseline deforestation was recalculated every five years. For example, the baseline for 2011-2015, would be calculated as the mean of the annual gross deforestation from 2001-2010; the baseline for 2016-2020, as the mean of the annual gross deforestation from 2006-2015 (Sandker et al., 2014). In our study and base data of 2002 and 2006, we recalculated the baseline emissions every five years (i.e. between 0-5, 6-10, 11-15, 16-20, 21-25, and 26-30) and took the average as the FRELs for the respective period. Over a 30-year period, total FRELs were estimated to be 69.2, 51.9, 42.1, 35.4, 30.5, and 26.8 $TgCO_2\ yr^{-1}$ for each respective interval above (Table 6).

↘ Table 6

Total and total FRELs in Cambodia based on 2002 and 2006 forest cover statistics

Provincial Names	Subtotal FRELs (in 1000 $MgCO_2\ yr^{-1}$)					
	0-5	6-10	11-15	16-20	21-25	26-30
1. Battambang	10,852.4	7,677.1	5,738.2	4,362.0	3,366.9	2,636.5
2. Oddar Meanchey	6,333.9	5,032.6	4,247.3	3,651.7	3,176.1	2,785.8
3. Preah Vihear	6,229.6	5,411.9	4,925.2	4,558.7	4,261.4	4,007.8
4. Siem Reap	5,805.7	4,981.6	4,393.3	3,895.9	3,466.3	3,091.6
5. Banteay Meanchey	5,617.3	3,390.7	2,219.8	1,486.8	1,013.6	700.4
6. Kampong Thom	5,450.1	4,214.2	3,380.1	2,728.8	2,214.4	1,805.5
7. Rotanak Kiri	4,725.1	4,228.2	3,897.6	3,625.8	3,389.3	3,176.5
8. Pailin	3,760.8	2,069.2	1,248.5	773.5	490.9	318.9
9. Koh Kong	3,520.4	2,412.9	1,742.0	1,272.4	940.0	703.1
10. Kampong Cham	2,900.1	1,516.1	849.9	478.7	271.0	154.1
11. Kratie	2,682.9	2,218.4	1,991.7	1,841.7	1,731.4	1,644.7
12. Kampong Spueu	2,343.0	2,198.3	2,077.1	1,963.9	1,857.7	1,757.9
13. Stung Treng	2,007.8	1,836.2	1,737.2	1,667.2	1,613.8	1,570.1
14. Takeo	1,199.8	358.8	122.3	41.9	14.6	5.2
15. Kampot	1,196.0	957.4	802.6	685.6	594.6	521.7
16. Kandal	1,184.8	681.4	415.7	254.1	155.5	95.3
17. Mondol Kiri	1,049.3	563.6	359.3	250.6	187.5	147.7

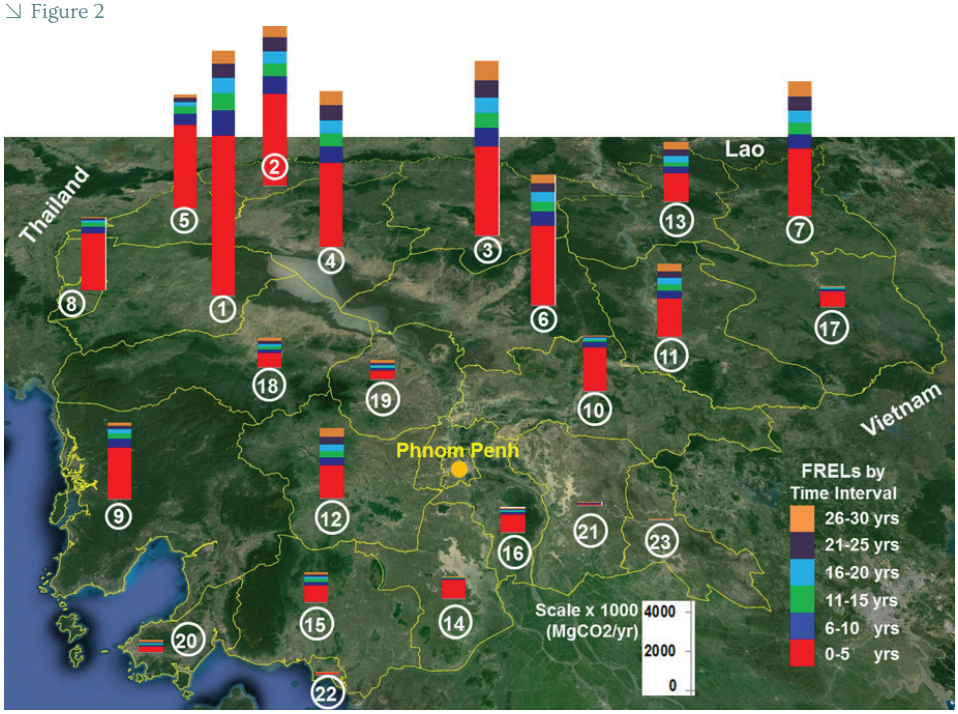
Provincial Names	Subtotal FRELs (in 1000 $MgCO_2$ yr^{-1})					
	0-5	6-10	11-15	16-20	21-25	26-30
18. Pursat	1,046.5	923.6	854.9	802.2	757.4	717.5
19. Kampong Chhnang	645.2	618.7	597.2	577.4	558.8	541.2
20. Preah Sihanuk	409.5	387.2	368.2	350.2	333.2	317.2
21. Prey Veng	132.4	112.0	96.1	82.6	70.9	60.9
22. Keb	104.3	55.6	33.5	21.0	13.5	9.0
23. Svay Rieng	33.6	20.0	15.4	13.1	11.7	10.7
24. Phnom Penh	-	-	-	-	-	-
Total FRELs	69,230.8	51,865.7	42,113.0	35,385.7	30,490.5	26,779.2

*Note : 0-5, 6-10, 11-15, 16-20, 21-25, and 26-30 are intervals in years for assessing FRELs. UK's 2013 emissions were taken from the Statistical Release of the Department of Energy and Climate Change (2015)

Cambodia submitted its Intentionally Determined National Contribution (INDC) to the UNFCCC in 2015. The INDC proposed to reduce carbon emissions by 27%, relative to the emission level in 2005. The reduction is equivalent to 3.1 $TgCO_2$ by 2030 (Uy, 2015b). This reduction target is only about 4.5-11.6% of the FRELs. Seven provinces, namely Battambang, Oddar Meanchey, Preah Vihear, Siem Reap, Banteay Meanchey, Kampong Thom, and Rotanak Kiri provinces have higher FRELs (Table 6) accounting for about 65.0-68.7% of the total FREL over a period of 30 years (Fig. 2). As clearing forests by land migrants and clearing under the form of ELC are the main drivers of deforestation in these provinces (Dulioust, 2011; Gaughan et al., 2009; Davis et al., 2015; Dhiaulhaq et al., 2014; Poffenberger, 2009), controlling illegal migrants and requiring ELC holders to reforest before clearing could result in significant reductions in carbon emissions.

↘ Figure 2

Distribution of FRELs by province in Cambodia according to six intervals



* Note : Numbers correspond to the names of the provinces shown in Table 5. This map suggests that deforestation and related emissions are found in the northern part of Cambodia. Background map was produced using Google Earth Pro.

Figure 3 shows the percentage of subtotal FRELs by provinces in Cambodia according to the six periods listed above. Although Battambang had a higher share of FRELs in the first five years (0-5), its share declines as forest area declines. In contrast, shares of FRELs in Preah Vihear, Rotanak Kiri, Siem Reap, and Oddar Meanchey increase because these four provinces maintain a large area of forest cover (Fig.1).

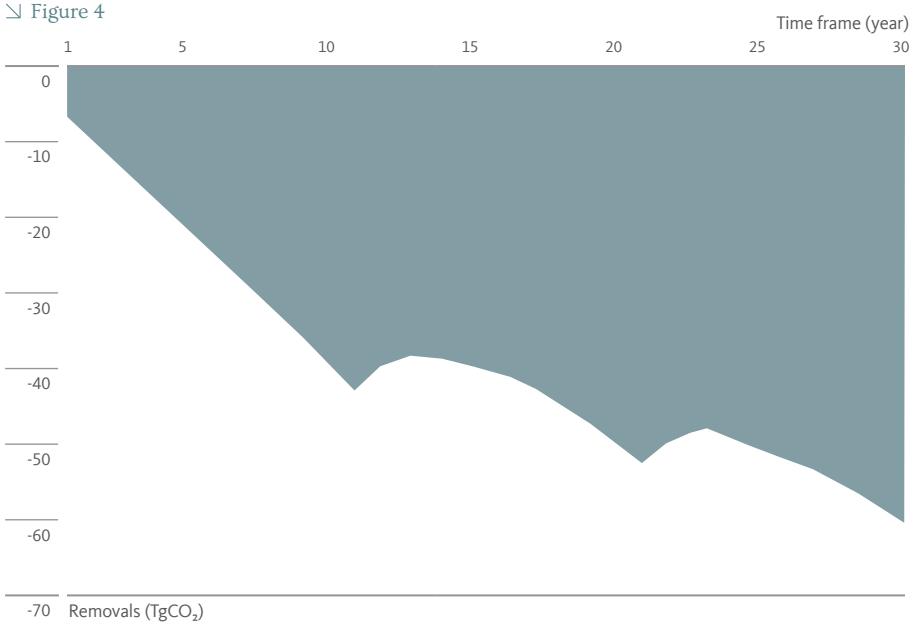
↘ Figure 3

Changes of the percentage of subtotal FRELs by province in six intervals

In addition to reducing carbon emissions, the REDD+ scheme also provides financial incentives for increasing carbon stocks in the forests, which is referred to as carbon sequestration or removals. Although forest area generally declines, some forest categories were predicted to increase in the next 30 years. As a result, carbon sequestration (or loss) can be achieved in Cambodia, depending on the degree that these forests are harvested, cleared or protected. In the case of forest plantations in the tropics, a system of 10-year cutting and replanting rotation is commonly practiced (FAO, 2000). In fact, many plantations in the tropics have the cutting rotation of between 5 to 15 years depending on planted species (Brown, 2000). Similarly, naturally regrown forests have been subject to cycle in and out of deforestation (Nelson et al., 2000), suggesting that naturally regrown forests are also subject to clear cut and regrow. For our study, we assumed that forests with the increasing trend are clear cut and re-planted every 10 years starting from the year 10th of the initial year of the model (i.e. in 2002). With the assumption of cutting and replanting every 10 years, we estimate carbon sequestration (removals) at -16.1, -35.5, -39.5, -47.4, -50.0, and -58.3 $TgCO_2$ yr^{-1} for 0-5, 6-10, 11-15, 16-20, 21-25, and 26-30 intervals, respectively (Fig. 4.). This level of carbon sequestration suggests that future emissions in the Cambodian forest sector could be compensated by an increase in forest cover if the current rate of forest cover increase is maintained (i.e. deforested areas are replanted).

↘ Figure 4

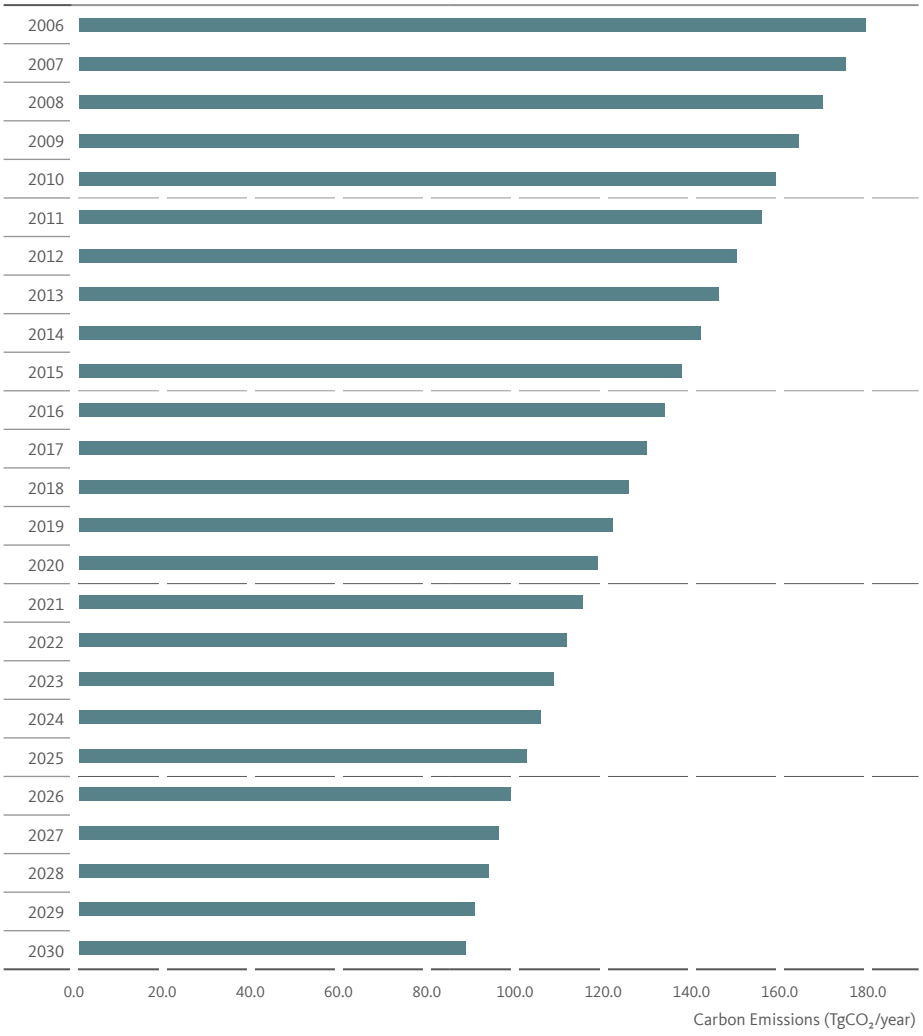
Total carbon sequestration (removals) due to an increase in forest area over a 30-year period



Using new data of forest cover in 2006, 2010, and 2016, annual emissions from deforestation in Cambodia were 54 $TgCO_2$, 164 $TgCO_2$, and 275 $TgCO_2$ between 2006 and 2010, 2006 and 2014, and 2010-2014, respectively. Highest emissions were observed during the 2010-2014 period. Using regression analysis, we projected emissions due to deforestation until 2030 (Figure 5). Based on our projection, emissions during the Paris Agreement between 2020 and 2030 would be 100.7 $TgCO_2$. Depending on the government's decision, this level of emissions could be used as FREL, against which emission reductions need to be achieved before any performance-based payment can be achieved.

↘ Figure 5

Annual carbon emissions due to deforestation in Cambodia between 2006 and 2030



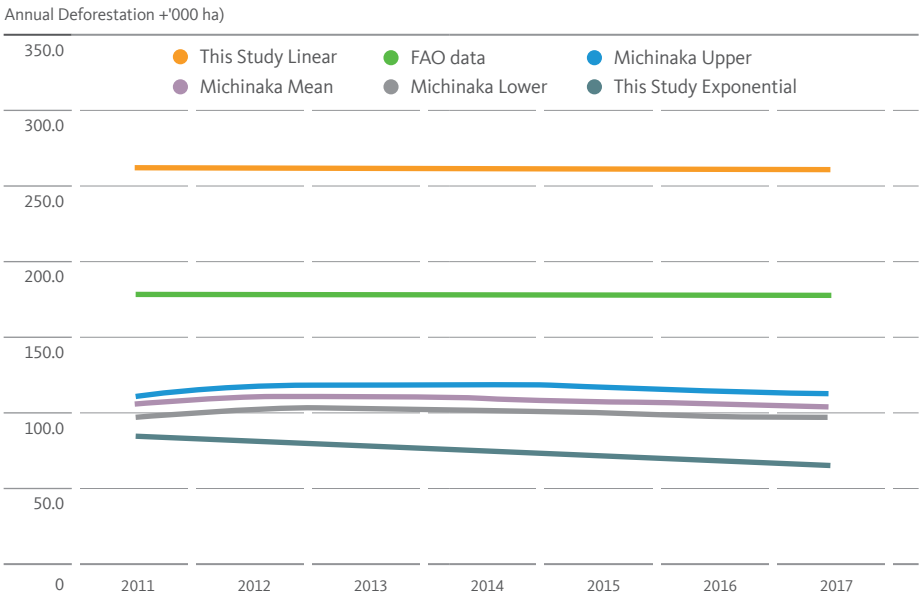
4. Discussions

It is possible that data limitation and the approaches used to estimate the FRELs biased our results. Obtaining forest cover statistics at the commune level in Cambodia is difficult because deforestation and illegal logging are politically sensitive issues among political parties (McCargo, 2005). To provide a range of future deforestation rates, we compared the results of this study with that of Michinaka et al. (2015), who used panel data analysis to estimate future deforestation rates in Cambodia. As seen in Figure 6, their mean deforestation approximately 101,400 – 117,400 ha between 2011 and 2018, or about 18-35% higher than in our study over the same period. If we used a linear projection with the available data, mean annual deforestation increase to 264,077.2 ha, which is even higher than that projected by Michinaka et al. (2015). Furthermore, if we extrapolate linearly using forest cover data in Cambodia in 1992, 1996, 2002, and 2005 (FAO, 2015), mean annual deforestation is 179,940.0 ha over the same period (2011 and 2018). Nevertheless, a linear projection is likely an unrealistic approach because such a projection will result in further deforestation, even if forests no longer exist.

In Vietnam, forest cover change showed an exponential decline between 1943 and 1990 before it stabilized then reversed its trend (Pham et al., 2012). Similarly, an exponential trend was also observed in Thailand between 1961 and 1998, before the trend reversed (Ongprasert, 2016). Studies also confirm that global deforestation has slowed as total forest area declined (Boucher 2014, FAO, 2015). These comparisons suggest that the estimation of deforestation and related carbon emissions is affected by the choice of approach and data availability. The more data available showing past trend of forest cover, the better relationship can be established to estimate FREL (Sandker et al., 2015).

↘ Figure 6

Annual deforestation affected by methods used for future projection



* Note :
Linear fitting line for "FAO" is y = -155.3*x + 13302, R^2 = 0.9957
Linear fitting line for "This Study Linear" is y = -132.0*x + 11392.2, R^2 = 1
Michinaka_Lower and Michinaka_Upper refer to lower and upper bounces of the 95% confidence interval (Michinaka et al. 2015)

Another bias may result from our assumption of a decline in the trend of forest cover in Cambodia and the effect of short-term data series. Using a retrospective approach, we assumed that both deforestation and forest plantation will continue at the current rate into the next 30 years, at a time when total forest cover will decline to about 50% of the country's total land area. Although forest transition theory suggests that the decline in forest cover should reverse to an increase after a threshold level has been reached (Mather, 2007, de Jong, 2010, Redo et al., 2012), the decline trend in our study is likely to continue even after this 30-year period of time span until the forest reaches about 20%, unless great efforts by the Cambodian government are undertaken. Previous studies suggest that a trend reversal is likely to occur when forest cover reaches about 20% of the country's total land area. For instance, forest cover changes in Vietnam reversed (beginning increasing) after it reached 24.9% in 1990 (DeJong et al., 2006). In Thailand, a reversal in the trend of forest cover change occurred when it reached 25.1% in 1999 (Lakanavichian, 2001). Therefore, our assumption should be revised when more data are gathered.

Furthermore, FRELs are affected by the adopted definitions of forests. Adopting definitions of forests for the future climate regime has an

important role to play in determining whether the forest is deforested or degraded (Romijn et al., 2013; Sasaki and Putz, 2009). Accordingly, both the FREL and the amount of carbon sequestration are affected by which definitions are adopted. Currently, Cambodia uses a definition of forest as having a minimum canopy of 10% on areas greater than 0.5 ha, and with a tree height of 5 m (Sasaki and Putz, 2009). Any change of these thresholds will result in significant changes in reported forest cover, and therefore, FRELs in Cambodia. For example, the annual loss of forest cover in Cambodia would be 124,691 ha, 123,327 ha, and 121,653 ha if 10%, 15%, and 25% of tree canopy cover are used, respectively in the calculation (Hansen et al., 2013).

5. Conclusion

Using data of forest cover at the commune level, this study estimated the forest cover changes and carbon stock changes, carbon emissions due to deforestation, carbon sequestration due to an increase of forest cover, and FRELs at subnational and national levels over a period of 30 years in Cambodia. Carbon emissions due to deforestation were significantly compensated by the carbon sequestration due to an increase in forest cover in some communes throughout Cambodia. Our study shows that overestimation of net carbon emissions can be avoided by using data of specific forest types determined at small scales such as at the commune or district level. Estimation of carbon emissions is strongly affected by the choice of estimation approach and data availability. Using a retrospective approach, this study provides a first look at how to estimate and set subnational and national FRELs for Cambodia. Our results could stimulate discussion about determining the FRELs at subnational and national levels, which will eventually be done by the Cambodian government. Our approach can be replicated, but detailed data by forest type at the administrative boundary (i.e. commune or similar) will reduce the uncertainty for predicting future deforestation baseline, which is important for estimating and deciding the FRELs. Having subnational and national FRELs allows developing countries to introduce effective policies to address the drivers of deforestation and forest degradation, which will eventually result in carbon emission reductions. In addition to reducing emissions from deforestation, protecting the natural regrowth of forests and reforestation on the degraded lands could enhance carbon stocks and therefore provide additional sources of income in developing countries.

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References

Achard, F., Beuchle, R., Mayaux, P., Stibig, H.J., Bodart, C., Brink, A., Carboni, S., Desclée, B., Donnay, F., Eva, H.D., Lupi, A., Raši, R., Seliger, R., Simonetti, D., 2014. Determination of tropical deforestation rates and related carbon losses from 1990 to 2010. Glob. Chang. Biol. 20, 2540–2554. doi:10.1111/gcb.12605

ADB 2014. Greater Mekong Subregion Biodiversity Conservation Corridors Project – Pilot Program for Climate Resilience Component – Cambodia. ADB TA 7459 REG (Accessed 11/3/2016: https://goo.gl/wxl38T)

Altrell, D. 2007. National Forest and Tree Resources Assessment 2005–2007, Bangladesh. Bangladesh Forest Department, Ministry of Environment and Forest: 118pp.

Aryal, D.R., De Jong, B.H.J., Ochoa-Gaona, S., Esparza-Olguin, L., Mendoza-Vega, J. 2014. Carbon stocks and changes in tropical secondary forests of southern Mexico. Agric Ecosyst Environ 195, 220–230.

Asner, G.P., Mascaro, J., Muller-Landau, H.C., Vieilledent, G., Vaudry, R., Rasamoelina, M., Hall, J.S., van Breugel, M.2011. A universal airborne LiDAR approach for tropical forest carbon mapping. Oecologia 168, 1147–1160

Baccini, A., Goetz, S.J., Walker, W.S., Laporte, N.T., Sun, M., Sulla-Menashe, D., Hackler, J., Beck, P.S. a., Dubayah, R., Friedl, M. a., Samanta, S., Houghton, R. A. 2012. Estimated carbon dioxide emissions from tropical deforestation improved by carbon-density maps. Nat. Clim. Chang. 2, 182–185. doi:10.1038/nclimate1354

Berry, N.J., Phillips, O.L., Lewis, S.L., Hill, J.K., Edwards, D.P., Tawatao, N.B. 2010. The high value of logged tropical forests : lessons from northern Borneo. Biodiversity and Conservation 19, 985-997.

Busch, J., Strassburg, B., Cattaneo, A., Lubowski, R., Bruner, A., Rice, D., Creed, A., Ashton, R., Boltz, F. 2009. Comparing climate and cost impacts of reference levels for reducing emissions from deforestation. Environmental Research Letters, 4 (2009), p. 044006

Boucher, D. 2014. How Brazil has dramatically reduced tropical deforestation. Solutions 5(2) 66-75

Borchert, R. 1998. Responses of tropical trees to rainfall seasonality and its long-term changes. Climatic Change 39, 381–393.

Bradley, A. and Shoch, D. 2013. Survey and Analysis of REDD+ Project Activities in Cambodia. Report of the Lowering Emissions in Asia's Forests (LEAF) program. Winrock International. (Accessed 11/5/2016. http://goo.gl/Va4PJS)

Brown C. 2000. The global outlook for future wood supply from forest plantations. FAO Working Paper, GFPOS/WP/03; 2000. 156 p.

Brauers, H. Richter, P. 2016. The Paris Climate Agreement: Is it sufficient to limit climate change? DIW Roundup: Politik im Fokus, No. 91

Chuop, P. 2015. Progress of REDD+ Readiness in Cambodia. Paper presented at the International Workshop on REDD+ on 02-03 July 2015. Tokyo, Japan.

Chheng, K., Sasaki, N., Mizoue, N., Khorn, S., Kao, D., Lowe, A. 2016. Assessment ofcarbon stocks of semi-evergreen forests in Cambodia. Global Ecology and Conservation 5, 34–47.

Christoff, P., 2008. The Bali roadmap: Climate change, COP 13 and beyond. Env. Polit. 17, 466–472. doi:10.1080/09644010802065807

Davis, K.F., Yu, K. Rulli, M.C., Pichdara, L., D'Odorico, P. 2015. Accelerated deforestation driven by large-scale land acquisitions in Cambodia. Nature Geoscience 8, 772-775.

Dulioust, J. 2011. Economic Development in Cambodia's Peripheral Regions - Case Study on the links between migrations, agricultural expansion, and deforestation in the Pailin Province. (Accessed 09/3/2016. http://goo.gl/19gX1i)

Dhiaulhaq, A., Yasmi, Y., Gritten, D., Kelley, L., Chandet, H. 2014. Land grabbing and forest conflict in Cambodia: Implications for community and sustainable forest management. In Pia Katila, Glenn Galloway, Wil de Jong, Pablo Pacheco, Gerardo Mery (editors) Forests under pressure: Local responses to global issues. Department of Energy and Climate Change (2015) 2013 UK Greenhouse Gas Emissions, Final Figures: Statistical release. 44pp, London, Open Government Licence. IUFRO World Series Vol. 32, 205-2018

de Miranda, S.D.C., Bustamante, M., Palace, M., Hagen, S., Keller, M., Ferreira, L.G., 2014. Regional variations in biomass distribution in Brazilian Savanna Woodland. Biotropica 46, 125–138. doi:10.1111/btp.12095

de Jong, W., Do, D.S., Trieu, V.M. 2006. Forest Rehabilitation in Vietnam: Histories Realities and Future. Center for International Forestry Research (CIFOR), Bogor, Indonesia (2006)

de Jong W (2010) Forest rehabilitation and its implication for forest transition theory. Biotropica 42, 3–9.

Donato, D. C., Kauffman, J. B., Murdiyarso, D., Kurnianto, S., Stidham, M., and Kanninen, M. 2011. Mangroves among the most carbon-rich forests in the tropics. Nat. Geosci., 4, 293–297, doi:10.1038/ngeo1123

Estrada, M. 2011. Standards and methods available for estimating project-level REDD+ carbon benefits: reference guide for project developers. Working Paper 52. CIFOR, Bogor, Indonesia.

Evans, P.T., Marschke, M., Paudryal, K. 2004. Flood forests, fish, and fishing villages in Tonle Sap, Cambodia. Asia Forest Network, Bohol, Philippines. 50pp

FA 2008. Cambodia forest cover - Forest cover map change 2002-2006. Forestry Administration, Phnom Penh, 26pp.

FA 2013. Reduced emissions from deforestation and degradation in Seima protection forest. Project Designed Document. Verified Carbon Standard and CCB Standards 2013, Version 1.3 (validation version), 269pp.

FAO 2000. The global outlook for future wood supply from forest plantations. Working paper: GFPOS/WP/03. FAO, Rome, 156pp.

FAO 2015. Global Forest Resources Assessments. FAO, Rome.

Forest Trends 2015. Conversion Timber, Forest Monitoring, and Land-Use Governance in Cambodia. Forest Trends Report Series - Forest Trade and Finance. Washington, DC, 96 pp.

Gaughan, A.E., Binford, M.W., Southworth, J. 2009. Tourism, forest conversion, and land transformations in the Angkor basin, Cambodia. Applied Geography 29, 212–223

Hang, S.C. 2009. Export competitiveness of the Cambodian rubber sector relative to other Greater Mekong Subregion suppliers: A simple descriptive analysis. ARTNeT Greater Mekong Subregion (GMS) Initiative. Discussion Paper Series, No. 1, July 2009. (Access 21/4/2016. http://goo.gl/bty49W)

Hansen, M.C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S.V., Goetz, S.J., Loveland, T.R., Komardeey, A., Egorov, A., Chini, L., Justice, C.O., Townshend, J.R.G. 2013. High-Resolution Global Maps of 21st-Century Forest Cover Change. Science 342(6160):850-853. doi: 10.1126/science.1244693

Herold, M., Verchot, L., Angelsen, A., Maniatis, D., Bauch, S., 2012. A step-wise framework for setting REDD + forest reference emission levels and forest reference levels. CIFOR infobriefs 1–8.

Houghton, R.A., House, J.I., Pongratz, J., Van Der Werf, G.R., Defries, R.S., Hansen, M.C., Le Quéré, C., Ramankutty, N. 2012. Carbon emissions from land use and land-cover change. Biogeosciences 9, 5125–5142. doi:10.5194/bg-9-5125-2012

Houghton, R.A., 2003. Revised estimates of the annual net flux of carbon to the atmosphere from changes in land use and land management 1850-2000. Tellus B 55, 378–390. doi:10.1034/j.1600-0889.2003.01450.x

Huettner, M., Leemans, R., Kok, K., Ebeling, J., 2009. A comparison of baseline methodologies for "Reducing Emissions from Deforestation and Degradation." Carbon Balance Manag. 4, 4. doi:10.1186/1750-0680-4-4

IPCC 2006. IPCC Guidelines for National Greenhouse Gas Inventories. Prepared by the National Greenhouse Gas Inventories Programme. Editors: Eggleston, H.S., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. (Japan: Institute For Global Environmental Strategies).

Kapos, V., Ravilious, C., Leng, C., Bertzky, M., Osti, M., Clements, T., Dickson, B. 2010. Carbon, biodiversity and ecosystem services: Exploring co-benefits. Cambodia. UNEP-WCMC, Cambridge, UK.

Kao, D., Iida, S., 2006. Structural characteristics of logged evergreen forests in Preah Vihear, Cambodia, 3 years after logging. For. Ecol. Manage. 225, 62–73. doi:10.1016/j.foreco.2005.12.056

Khun, V., Lee, D.K., Hyun, J.O., Park, Y.D., Combalicer, M.S. 2012. Carbon storage of Dipterocarpus tuberculatus, Terminalia tomentosa and Pentacme siamensis in Seima Protection Forest, Cambodia. Journal of Environmental Science and Management 68-76 (Special Issue 1-2012).

Kim Phat, N., Ouk, S., Uozumi, Y., Ueki, T., 2000. Stand dynamics of Dipterocarp trees in Cambodia's evergreen forest and management implications- A case study in Sandan district, Kampong Thom. Jpn. J. For. Plan. 6, 13–23.

Kim, S., Sasaki, N., Koike, M., 2006. Assessment of non-timber forest products in Phnom Kok community forest, Cambodia. Asia Eur. J. 6, 345–354.

Kiyono, Y., Furuya, N., Sum, T., Umemiya, C., Itoh, E., Araki, M., Matsumoto, M., 2010. Carbon stock estimation by forest measurement contributing to sustainable forest management in cambodia. Japan Agric. Res. Q. 44, 81–92. doi:10.6090/jarq.44.81

Kurnianto, S., Warren, M., Talbot, J., Kauffman, B., Murdiyarso, D., Frolking, S. 2015. Carbon accumulation of tropical peatlands over millennia: a modeling approach. Glob. Chang. Biol., 21, 431–444

Lakanavichian, S. 2001. Impacts and effectiveness of logging bans in natural forests: Thailand. In FAO. Forests out of bounds: impacts and effectiveness of logging bans in natural forests in Asia-Pacific. Bangkok, FAO Regional Office for Asia and the Pacific.

Leng, C. 2011. Forest cover monitoring assessment in Cambodia. Report presented at the Technical Working Group of Forestry and Environment, Cambodia. 31 March 2011. FA, Phnom Penh

Margono, B.A., Potapov, P. V, Turubanova, S., Stolle, F., Hansen, M.C., 2014. Primary forest cover loss in Indonesia over 2000–2012. Nat. Clim. Chang. 4, 1–6. doi:10.1038/NCLIMATE2277

Mather, A. S. 2007. Recent Asian forest transition in relation to forest transition theory. Int. For. Rev. 9, 491–502.

Mazzei, L., Sist, P., Ruschel, A., Putz, F.E., Marco, P., Pena, W., Ferreira, J.E.R., 2010. Above-ground biomass dynamics after reduced-impact logging in the Eastern Amazon. For. Ecol. Manage. 259, 367–373. doi:10.1016/j.foreco.2009.10.031

McCargo, D. 2005. Cambodia: getting away with authoritarianism? Journal of Democracy 16, 98–112

Meyer, V., Saatchi, S.S., Chave, J., Dalling, J.W., Bohlman, S., Fricker, G. A., Robinson, C., Neumann, M., Hubbell, S., 2013. Detecting tropical forest biomass dynamics from repeated airborne lidar measurements. Biogeosciences 10, 5421–5438. doi:10.5194/bg-10-5421-2013

Michinaka, T., Matsumoto, M., Miyamoto, M., Yokota, Y., Sokh, H., Lao, S., Tsukada, N., Matsuura,T., Ma, V. 2015. Forecasting forest areas and carbon stocks in Cambodia based on socio-economic factors. International Forestry Review 17, 66-75

Miettinen, J., Shi, C., Liew, S.C., 2011. Deforestation rates in insular Southeast Asia between 2000 and 2010. Glob. Chang. Biol. 17, 2261–2270. doi:10.1111/j.1365-2486.2011.02398.x

Neef, A., Touch, S., Chiengthong, J. 2013. The politics and ethics of land concessions in rural Cambodia. J. Agric. Environ. Ethics 26, 1085–1103

Nelson, R.F., Kimes, D.S., Salas, W.A., Routhier, M. 2000. Secondary forest age and tropical forest biomass estimation using Thematic Mapper imagery. Bioscience 50, 419–431

Norman, M., S. Nakhooda, S. 2014. The State of REDD + Finance. Center for Global Development, Working Paper, 378. Washington, DC. (Accessed 24/4/2016 http://goo.gl/yyYzxE)

Ongprasert, P. 2016. Forest management in Thailand. Royal Forest Department, Ministry of Natural Resources and Environment. Bangkok, 23 PP. Online document accessed on 21 April 2016.

Pak, C., Leng, C., and Sar, S. 2010. Forest cover monitoring assessment in Cambodia. Paper presented at the Samarinda Workshop on 8-13 November 2010, Indonesia. (Accessed 07/8/2015, http://goo.gl/pT28DI)

Pan, Y., Birdsey, R. A., Fang, J., Houghton, R., Kauppi, P.E., Kurz, W. A, Phillips, O.L., Shvidenko, A., Lewis, S.L., Canadell, J.G., Ciais, P., Jackson, R.B., Pacala, S.W., McGuire, a D., Piao, S., Rautiainen, A., Sitch, S., Hayes, D. 2011. A large and persistent carbon sink in the world's forests. Science 333, 988–993. doi:10.1126/science.1201609

Pham, T.T., Moeliono, M., Nguyen,T.H., Nguyen, H.T., Vu, T.H. 2012. The context of REDD+ in Vietnam: Drivers, agents and institutions. Occasional Paper 75. CIFOR, Bogor, Indonesia.

Pedroni, L., Dutschke, M., Streck, C., Porrúa, M.E. 2009. Creating incentives for avoiding further deforestation: the nested approach. Clim. Policy 9, 207–220. doi:10.3763/cpol.2008.0522

Pelletier, J., Goetz, S.J. 2015. Baseline data on forest loss and associated uncertainty: advances in national forest monitoring. Environ. Res. Lett. 10, 021001. doi:10.1088/1748-9326/10/2/021001

Poffenberger, M. 2009. Cambodia's forests and climate change: Mitigating drivers of deforestation. Nat. Resour. Forum 33, 285–296. doi:10.1111/j.1477-8947.2009.01249.x

Poorter, L. et al. 2016. Biomass resilience of Neotropical secondary forests. Nature 530, 211–214

Redo, D., Grau, H. R., Aide, T. M., Clark, M. L. 2012. Asymmetric forest transition driven by the interaction of socioeconomic development and environmental heterogeneity in Central America. Proc. Natl. Acad. Sci. U.S.A 109: 8839–8844.

Romijn, E., Ainembabazi, J.H., Wijaya, A., Herold, M., Angelsen, A., Verchot, L., Murdiyarso, D., 2013. Exploring different forest definitions and their impact on developing REDD+ reference emission levels: A case study for Indonesia. Environ. Sci. Policy 33, 246–259. doi:10.1016/j.envsci.2013.06.002

Sandker, M., Lee, D., Crete, P., Sanz-Sanchez, M. 2015. Emerging approaches to Forest Reference Emission Levels and/or Forest Reference Levels for REDD+. UN-REDD Programme, FAO, UNDP, UNEP. FAO, Rome 54 pp.

Sasaki, N. 2006. Carbon emissions due to land-use change and logging in Cambodia: A modeling approach. J. For. Res. 11, 397–403.

Sasaki, N., Putz, F.E. 2009. Critical need for new definitions of "forest" and "forest degradation" in global climate change agreements. Conserv. Lett. 2, 226–232.

Singh, S. 2014. Borderland practices and narratives: illegal cross-border logging in northeastern Cambodia. Ethnography 15, 135–159

Soares-Filho B, Moutinho P, Nepstad D, Anderson A, Rodrigues H, et al. (2010) Role of Brazilian Amazon protected areas in climate change mitigation. Proc. Natl. Acad. Sci. U.S.A 107, 10821–10826.

Stibig, H.-J., Achard, F., Carboni, S., Raši, R., Miettinen, J., 2014. Change in tropical forest cover of Southeast Asia from 1990 to 2010. Biogeosciences 11, 247–258. doi:10.5194/bg-11-247-2014

Top, N., Mizoue, N., Kai, S. 2004. Estimating forest biomass increment based on permanent sample plots in relation to woodfuel consumption: A case study in Kampong Thom Province in Cambodia. J. For. Res. 9, 117–123. doi:10.1007/s10310-003-0064-9

UNFCCC (2016) Initial Forest Reference Level for Cambodia under the UNFCCC Framework. Online document accessed on 05 October 2018 [http://bit.ly/2NpQDpV].

Uy, K. 2015a. Experience and challenges in preparing INDC (intended nationally determined contribution). Paper presented at the Asia and the Pacific Regional Workshop – 2015 - Promoting the CDM and the Market Mechanisms for Pre and Post 2020. Manila, 29-30 September 2015.

Uy, K. 2015b. Joint crediting mechanism in Cambodia. Paper presented at the East Asia Low Carbon Growth Dialogue on 7 December 2015. Paris, France. (Accessed 21/4/ 2016. http://www.mofa.go.jp/files/000118241.pdf)

VCS 2009. REDD Methodological Module "Estimation of baseline carbon stock changes and greenhouse gas emissions from unplanned deforestation". Version 1.0 – April 2009. (Accessed 18 April 2016. http://goo.gl/gHk3Ra)

Yonekura, Y., Ohta, S., Kiyono, Y., Aksa, D., Morisada, K., Tanaka, N., Kanzaki, M. 2010. Changes in soil carbon stock after deforestation and subsequent establishment of "Imperata" grassland in the Asian humid tropics. Plant and Soil 329, 495–507

Zolkos, S.G., Goetz, S.J., Dubayah, R. 2013. A meta-analysis of terrestrial aboveground biomass estimation using lidar remote sensing. Remote Sens. Environ., 128, 289–298

13

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Biodiversity Conservation in Cambodia

1. General Overview of Biodiversity Conservation in Cambodia

Lying in southern Indochina, Cambodia has an area of 181,000 km². Two-thirds of the country are dominated by lowlands along the Mekong River and the Tonle Sap (Great Lake), which are the most populated sites and where most agricultural lands are situated. The three mountainous regions in the southwest, north and northeast are less populated and remain rich in forest resources.

The climate in Cambodia is dominated by the southwest monsoon, which blows from May to September, and the dry northeast monsoon from October to April. Wetlands cover 30 percent of Cambodia, of which the principal ones are the Mekong River and its environs, and the lake of Tonle Sap with its surrounding swamp forests. The Mekong crosses the country from the Lao border in the north to Vietnam in the south. Forest and woodland covers an estimated 62 percent of the land.

As one of the most biodiverse countries in Southeast Asia, Cambodia is home to 162 mammal species. A total of 601 bird species have been recorded from Cambodia, with 7 on the new global Evolutionally Distinct and Globally Endangered (EDGE) list. The two most important areas for conservation of globally threatened bird species in Cambodia are the Boeung Tonle Sap and its inundation zone and the northern deciduous dipterocarp forest plains. The recent inventory in Cambodia also indicates a diversity of 1,357 fish species across both fresh and salt water systems, 173 reptile species, 72 amphibian species, 671 invertebrates, and 3113 plant species.

Cambodia has 7 national parks, 10 wildlife sanctuaries, 3 protected landscapes, 3 multiple use areas, 6 protection forests, and 8 fish sanctuaries.

Nearly 40 percent of Cambodia's land is protected, however, illegal timber harvesting and wildlife poaching remain serious threats to preserving Cambodia's precious natural resources. Additionally, forest land conversion for agriculture, overexploitation of key species, mine exploration and undervaluing of ecological services such as soil fertility, carbon sequestration and watershed stability also contribute to Cambodia's rapid deforestation rate.

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2. Cambodia's Latest Progress in Biodiversity Conservation

In 1995, Cambodia acceded to the United Nations Convention on Biological Diversity (CBD). Article 6 of the UN CBD demands the prepartion of National Biodiversity Strategy and Action Plan by each signatory country and to ensure that this strategy is mainstreamed into the planning and activities of all those sectors whose activities can have an impact in both positive and negative on biodiversity. As a party to the Convention and part of its fulfillment of the obligations under this Convention, Cambodia had developed and adopted its NBSAP in 2002 and has used it as the principal instruments for implementing the Convention at the national and sub national levels, aiming to achieve "equitable economic prosperity and improved quality of life through sustainable use, protection and management of biological resources".

Progress of NBSAP

The 2002 NBSAP provided Cambodia with a framework for action at all levels so as to enhance the country's ability to conserve biodiversity, use its biological resources sustainably, ensure the productivity, diversity and integrity of its natural systems and, as a result, its ability to reduce poverty and improve the quality of life of all Cambodians. The 2002 NBSAP proposed a series of strategic objectives and priority actions that were addressed under 17 themes corresponding to important sectors in Cambodia. Since the adoption of its NBSAP, Cambodia has noted progress in each of the 17 themes, under which 81 strategic objectives and associated indicators were identified, as well as 98 priority actions.

At the 10th CBD Conference of the Parties meeting in 2010, the adopted decision X/2 (para (c)) urged Parties to review and, as appropriate, update and revise their NBSAPs in line with the Strategic Plan for Biodiversity 2011-2020 adopted at that meeting, and with the guidance outlined in its decision IX/8. The Aichi Biodiversity Target 17 reiterated this request. Cambodia initiates its review process in July 2012 and completed it in December 2015 under the coordination of the General Directorate of Administration for Nature Conservation and Protection (GDANCP), the General Secretariat of National Council for Sustainable Development (NCSD), and the Ministry of Environment (MOE).

Through this updated NBSAP, Cambodia's vision for biodiversity is that by 2050, Cambodia's biodiversity and its ecosystem services are valued, conserved, restored where necessary, wisely used and managed so as to ensure equitable economic prosperity and improved quality of life for all in the country. To realize this vision, Cambodia has adopted the four overall strategic objectives: a) Identify, inventory, monitor and enhance awareness about genetic resources, species, habitats or ecosystems and related ecosystem services that are important for sustainable development and poverty eradication in Cambodia, as a priority for conservation and sustainable use; b) Identify and describe the direct and indirect factors and processes that are negatively impacting Cambodia's priority biodiversity components; and apply, as appropriate, preventive and corrective measures; c) Maintain or strengthen measures that have a positive impact on biodiversity and thus enhance the benefits to all

in Cambodia from biodiversity and associated ecosystem services, for an equitable economic prosperity and improved quality of life; d) Strengthen the enabling environment for the implementation of the strategy.

The updated NBSAP consists of 498 key actions identified to achieve 78 strategic objectives under 24 themes, with a focus on strengthening the ongoing management of selected bio-ecological regions and endangered species, application of a landscape approach to the management of selected protected areas, and the application of internationally agreed upon instruments such as CITES, and capacity development to address both in-situ and ex-situ conservation.

Key progress and achievement of the 17 themes are listed in NBSAP.

Key dimensions and indicators of the GGEI

↘ Table 1

Theme	Types of Indicators, Indices Referenced
Protection of Natural Resources	- 26% of the national land and inland waters were designated as protected areas and conservation areas - Important legal and policy documents have been approved
Animal Wildlife Resources	- Sub decree promulgated on the List of Cambodia's national animals and tee species - Published the 2030 Phyto-sanitary control and other relevant MAFF notifications for protecting some animal species
Freshwater Fisheries and Aquaculture	- Developed the framework of the 10-year Strategic Plan 2009-2019, the first three-year-rolling on Fishery Sector Development Action Plan 2009-2011 - Inland fish exploitation increased by 10.6% in 2013 - Marine fish exploitation increased by 11%
Coastal and marine Resources	- An integrated coastal zone management system in the coastal area to protect the environment was created by the Cambodian government
Forest and Wild Plan Resources	- More plans have been included in the Forest Resource Management and Conservation Program
Agriculture and Animal Production	- Agricultural extension services been strengthened by the MAFF
Energy Resources	- Energy efficiency program for households included
Mineral Resources	- Conducted environmental impact assessment to ensure the sustainability of development projects related to community environment
Industry, Technology and Services	- Cambodia signed the Cartagena Protocol on Biosafety in 2003, adopted its biosafety law in 2007 - Developed the National Ecotourism Policy and Strategic Plan 2010
Environmental Security	- Adoption of the Natural Resource and Environmental Protection Law and the Biosafety Law
Land-use Planning	- Carried out various institutional capacity building programs
Water Resource	- In progress
Climate Change and Biodiversity	- Developed the 2006 national adaptation program of action on climate change, the 2007 second national communication to the UNFCCC and Cambodia climate change strategic plan ()2014-2023
Community Participation	- Carried out events on the conservation and protection of natural resources
Awareness, Education, Research Coordination and Development	- Carried out trainings on biodiversity conservation at various locations
Legislation and Institutional Structure	- Passed several new laws - Signed bilateral and multiple agreements, including the Biosafety Protocol
Quality of Life and Poverty Reduction	- Set up the National Information Center to cover indigenous practices - A commune database was developed by the Ministry of Planning

National Report of CBD

Cambodia's Fourth National Report to the CBD, submitted on 29 March 2009, highlighted significant progress, including the designation and management of extensive national key habitats for protection with boundary markers, and the development of management plans. Five national wildlife rescue centers and zoos were established throughout the country for ex-situ conservation. Progress was made in capacity-building and tools were developed for the management of resources using a landscape approach that takes into account various economic activities. Efforts to promote national awareness have been taking place on a semi-regular basis, while legal actions were taken to address illegal hunting. Fisheries reform began in 2000 and was followed with the adoption of a new fisheries law, the national fisheries policy, and the implementation of guidelines for a structural change in the sector. Significant aquatic habitats have been designated as 'protected' through a community-based approach. About 1,530,981 hectares of forest have been designated for protection and a comprehensive national forest program has been finalized. A water governance dialogue among the three countries of Cambodia, Lao PDR and Vietnam has been conducted to seek more effective approaches to integrated water resource management.

The Fifth National Report to the CBD was submitted on 18 August, 2014. The report provides updates on measures taken for the implementation of the Convention and the effectiveness of these measures in Cambodia. As part of the review of the NBSAP, the report put a greater emphasis on ecosystem services and National Biodiversity Targets and Indicators. It also highlighted agricultural production, sustainable use and management of natural resources, and maintaining biodiversity. There is significant legislation related to biodiversity but there is also significant overlap across legislation creating confusion in implementation and difficulty in enforcement.

3. Biodiversity Laws and Policies

Since becoming a party to the CBD and the Cartagena protocol, Cambodia has passed many new laws, and some of the relevant laws and strategies have been adopted since 2002:

a) Fisheries Law adopted in 2006 requires fishery management–based on the ecosystem approach and gives emphasis to conservation of fish habitats

b) The 2007 Law on Water Resources Management of the Kingdom of Cambodia defines the rights and obligations of water users, states the fundamental principles of water resource management and identifies the institutions with the authority to implement and enforce the law and regulate the participation of users in the sustainable development of water resources. The principle of Integrated Water Resource Management requires coordinated multi-sectoral water use planning including the need for conservation of biodiversity and ecosystems. However, there is still a long way to go with regards to the implementation of the concept;

c) The 2010 Rural Water Supply, Sanitation and Hygiene Strategy 2010-2025 defines the water supply, sanitation and hygiene services to be made available to people living in rural areas,as well as the institutional arrangements and financial, human and other resources necessary to sustainably provide these services. The underlying purpose is to accelerate progress toward the achievement of the Cambodian Millennium Development Goals (CMDGs) in 2015 and the Sector Vision in 2025; and

d) The Sub-Decrees on Water Pollution Control (1999), and on Solid Waste Management (1999);

e) Protected Areas Law (2008);

f) Bio safety Law (2008);

g) Law on Crop Seed Management and Rights of Plant Breeders (2008)

In line with the NBSAP, other related biodiversity policy documents have been developed such as the National Poverty Reduction Strategy (NPRS), 2003 - 2005; the National Strategic Development Plan (NSDP), 2006 - 2010; the Ministry of Agriculture, Forestry and Fisheries (MAFF) Action Plan, 2004 - 2008; and the Ministry Environment (MoE) Strategic Plan (2009 - 2013).

The 2003 National Water Supply and Sanitation Policy contains explicit provisions regarding sanitation and hygiene improvement and advocates for a dramatic increase in rural sanitation coverage between 2015 and 2025, from the 30% targeted in the original 2015 CMDG to 100% rural sanitation coverage 10 years later. This will require investment, focused attention, and new and innovative approaches.

4. Current Status of National Activities Related to Biodiversity Conservation

The government has sought to mainstream biodiversity concerns through CEPA campaigns, allocation of budgets for biodiversity conservation, and Champion for Biodiversity programs and Payment for Ecosystem Services (PES). Efforts taken by the government to safeguard biodiversity include creating relevant laws on genetic resources, updating the National Red List, increasing the number of protected areas and expanding ex situ programs. Moreover, the government of Cambodia has updated its National Biodiversity Strategy and Action Plan (NBSAP) and crafted the Cambodia Climate Change Strategic Plan (CCCSP) 2014–2023. The focus has been given to the sustainable management of agriculture, aquaculture, forestry, and protected areas and issues such as solid waste management and IAS (e.g., Mimosa pigra).

Implementation of biodiversity conservation programs are further enhanced with active participation of local communities and indigenous peoples, the development of a national Clearing-House Mechanism (CHM) and creation of a Biodiversity Trust Fund have all contributed to the implementation of biodiversity conservation programs in the country. The Ministry of Environment has developed a set of 20 biodiversity targets and corresponding indicators that support the country's vision to contribute to the achievement of the Aichi Targets. These targets and indicators are categorized based on the themes of Education, Legal Framework and Strategy, Conservation and Community, and Sustainable Use. The

updating process, however, is confronted with some challenges such as insufficient financial resources and technical capacity, and limited evidence on the value of biodiversity and ecosystem services. The full participation of local communities and indigenous people, national and international conservation and donor organizations, and stakeholders from other sectors of society in the NBSAP updating and revision process is recognized by the government as a key element in crafting an inclusive and comprehensive NBSAP.

Bokor Conservation Project (2001) aims to reduce illegal poaching activities within the national park; developed the government policy framework governing Cambodia's implementation of CBD which included the The Government Rectangular Strategy (2009-2013) and the Cambodia Millennium Development Goals (CMDGs 2003), the National Strategic Development Plan (NSDP 2006-2010), the National Environmental Action Plan (1998-2002); created the National Committee to Manage and Execute Forest Management Policy (NACOMFOP) chaired by the Prime Minister.

Cambodia's Tonle Sap Lake, Tonle Sap River, and the Mekong River, with their reverse directional flow, provide a unique natural resource for tourism development. Prek Toal, one of the core zones of the Tonle Sap Biosphere Reserve, is recognized as ASEAN's premier habitat for large water birds. Floating villages moving with the tide illustrate the lifestyles of the people around the lake. In November 2013, Cambodia adopted the Cambodia Climate Change Strategic Plan (CCCSP) 2014–2023, which is a collaborative and strategic approach focused on averting climate-related issues in agriculture and proactively takes on climate adaptation, GHG mitigation, and low-carbon development. The country's Tonle Sap Environmental Management Project/ Sustainable Livelihoods Project and the Economic and Social Relaunch of Northern Provinces (ECOSORN) embody a sustainable and integrated management approach for the Tonle Sap.

In Cambodia, projects were created to protect species such as the Indo-Chinese tiger (Panthera tigris corbetti), elephant (Elephas maximus), Eld's deer (Cervus eldii), wild water buffalo (Bubalus arnee), and hog deer (Axis porcinus). Some success has been noted as populations have increased through collaboration with the International Union for Conservation of Nature (IUCN), the Wildlife Conservation Society (WCS), the World Wildlife Fund (WWF), the Conservation International, the Fauna & Flora International (FFI), the Wildlife Alliance, and the Bird Life International, among others. Other programs include the Mekong Giant Catfish and Dolphin protection programs, Wild Vulture Feeding programs, and Rhino and Elephant Conservation Strategies.

5. Good Practice and Cases

Case Study 1: Multi-stakeholder – Participation in the Protection, Cambodia

Participation of various stakeholders, including government, non-government organizations, and local communities, in environment

conservation mark protected area management in the country's two ASEAN Heritage Parks, namely Preah Monivong (Bokor) National Park and Virachey National Park.

More popularly referred to as Bokor National Park, the Preah Monivong National Park was established by the Royal Decree on 1 November, 1993 and covers an area of 140,000 hectares (1,400 square kilometers) that span three southern provinces: Kampot, Kompong Spue and Preah Sihanouk. The area forms a part of the Elephant Mountains, which are contiguous with the Cardamom Mountain range to the northeast. The southern boundary of the Park is located less than one kilometer from the coastline of the Gulf of Thailand. The northern boundary forms a seven-kilometer link to Kirirom National Park, separated only by the National Highway. Mt. Bokor, at 1,079 meters (3,540 feet), is the Park's highest point. Virachey National Park was created under the Royal Decree Concerning the Creation and Designation of Protected Areas, issued on 1 November 1993, and managed by the Ministry of Environment. The Park occupies 332,500 hectares in the extreme northeast corner of Cambodia, adjacent to the borders of Lao PDR and Vienam. A high percentage of ethnic minority peoples live around the Park, which falls within the Taveng and Voeun Sai districts of Ratanakiri Province and the Siem Pang district of Stung Treng Province. The streams from the mountains of Virachey contribute significantly to the flow of the Mekong River.

Good Practices

Management authorities at Preah Monivong (Bokor) National Park involve various stakeholders in conservation activities. The Department of National Parks of the General Department of Administration for Nature Conservation and Protection under the Ministry of Environment collaborates with non-governmental organizations and other relevant program agencies, local authorities (provincial, district and commune levels), local communities and other local organizations in the conduct of different activities within the Park. Local communities, in particular, provide a solid fence in protecting the natural resources. A portion of the Park has been placed under community control so that communities can benefit from conservation activities.

In Virachey National Park, conserving and sustainably managing the park's natural and cultural resources is high on the agenda of park authorities. Ethnic minority peoples living around the Park and other local communities and stakeholders are involved in various management and conservation activities to ensure that the natural resources of Virachey National Park are nurtured and effectively conserved, and the cultural values are preserved.

Case Study 2: Festivals, Celebrations and Practices of the Indigenous and Local Communities on Biodiversity Conservation in Cambodia

Indigenous and local communities (ILCs) traditionally have a close relationship with the environment. Traditional customs of resource use, festivals and celebrations thus often highlight the significance of the environment and exhibit the indigenous group's sustainable use of natural resources.

For many years, ILCs have been ignored and pushed away from their ancestral lands.

However, efforts to further the recognition of ILC's rights have also led to a better appreciation of the intimate relationship between indigenous peoples and their environment. Indigenous groups traditionally rely on available natural resources for food, medicine and basic shelter. What the environment offers is used frugally, and shared with the community so that everyone benefits from the resources and to ensure that these are available for future use and future generations. These practices are often borne from the belief that the nature and resources are gifts from god, and thus must be shared among members of the community.

Centuries of resource use has allowed indigenous groups to gain an intimate knowledge of crop production, the relationship of species and seasons, breeding season of livestock and other wildlife, and understanding of plants and fruits that sustain or heal. Their understanding of the nature, the environment and species has allowed them to survive off the land for many years. Scientists and conservation managers are now beginning to understand that as traditional stewards of the environment, indigenous groups have the best knowledge of the land and the sea, and that the information they have passed on through generations best serves the sustainability of natural resources.

These days, traditional practices in various areas of conservation management are being encouraged among various protected areas including ASEAN Heritage Parks.

Good Practices

Conserving and sustainably managing the park's natural and cultural resources is high on the agenda of Park's authorities in Cambodia. Ethnic minority peoples living around the Park and other local communities and stakeholders are very much involved in various management and conservation activities to ensure that the natural resources of Cambodia, especially that of the Virachey National Park are nurtured and effectively conserved and the cultural values are preserved.

Case Study 3: Payments for Biodiversity Conservation, Cambodia

This case study provides an example of the Payments for Ecosystem Services (PES) scheme for the protection of nests of endangered bird species in the northern Plains of Cambodia.

The scheme provided conditional payments to local people to protect nests, since most of the species were highly threatened by the collection of eggs and chicks. The program was initiated in 2003 by the Wildlife Conservation Society in collaboration with the Cambodian Ministry of Environment and Forestry Administration.

The annual cost of the program is US $ 30,000, of which 71-78 percent were payments made to local people and 22-29 percent were monitoring costs. The average cost per protected nest ranges between US $ 66-120 per year. The effectiveness of the program was evaluated for the period 2009-2011 through a system of monitoring protected sites and unprotected control sites. WCS monitoring staff collected monthly data on the location of each active nest, dates of laying, hatching and fledging, habitat type, nest characteristics, and the number of birds, eggs, and chicks present for each species on each visit. Nests

were deemed to have failed if they became unoccupied prior to fledging. Monitoring staff investigated all cases of nest failure to determine the cause.

Protected sites are shown to have substantially higher nesting success rates than control sites. Over the course of the program, it is estimated that more than 2,700 nests have been protected. Payments significantly improved the success rates of protected nests in comparison with control sites, leading to population increases for at least three species. The program was deemed to be a highly effective conservation intervention to protect highly threatened globally significant biodiversity, in a way that was rapid to establish, cost-efficient and delivered significant benefits to local people.

However, payments did not influence other threats to species, such as land clearance, and have failed to arrest declines in at least one species' population. The average payment per protector was a significant contribution to incomes in remote rural villages. However, the program only benefited a small proportion of people, causing some local jealousies and deliberate disturbance of nesting birds. The program demonstrates that direct payments can be a highly effective conservation tool in those cases where payments correctly target the cause of biodiversity loss. The results also suggest that it is important to consider how decisions over beneficiaries are made, especially in situations where property rights over biodiversity are unclear, if payments are to be socially acceptable. This has important implications for the design of payment schemes in conservation more generally.

Case Study 4: Cost-Benefit Analysis of Forest Conversion in Cambodia

This case study provides an example of the use of cost-benefit analysis (CBA) to assess the relative costs and benefits of forest conservation in the Cardamom Mountains, Cambodia.

The case study is based on cost-benefit analysis (CBA) of two protected areas (wildlife sanctuaries) in the Cardamom Mountains, Cambodia. The analysis is based on market-based estimates of the revenues from immediate logging compared with ongoing protection with sustainable forestry, agriculture, non-timber forest products and carbon storage values. The results are dominated by two high values: the value of immediate timber extraction, on the one hand, versus the value of carbon storage, on the other. The central estimates show that (over 25 years at a 10 per cent discount rate) the value of the protection scenario exceeds that of the non-protection scenario by a small margin. This conclusion depends on a rather high value assumed for carbon storage: the carbon value from midpoint of IPCC Working Group III: US $ 73-183 per ton of carbon to achieve 'safe' levels. Actual carbon market values, and prices achievable for REDD+ projects, are not at this level. On the other hand there are important omitted values, notably global biodiversity conservation (non-use) values (which could be high for wildlife sanctuaries in tropical forests), and the costs/risks associated with deforestation's effects on erosion, flooding, and water quality/supply. The conclusion is that the protection of these areas may be globally optimal, but is locally costly: some financing mechanism will be essential to ensure ongoing conservation. This case is an example of

a CBA with quite a targeted aim: not so much to work out whether or not the areas should be protected, as to work out how much financing/ compensation will be required in order for local communities to support the protected status.

6. International Cooperation

As an ASEAN Member State, Cambodia takes an active role in various cooperative projects and mechanisms on biodiversity between ASEAN and China. See Table 2.

Cooperative Projects and Mechanisms on Biodiversity between ASEAN and China

↘ Table 2

Projects and Mechanisms	Objective	Activities
China-ASEAN Cooperation Plan on Biodiversity and Ecological Conservation (2 Phases)	- Enhance the ability and awareness of China and AMS - Construct a cooperation network	- Personnel Exchange - Seminar on ASEAN-China Partnership for Ecologically Friendly Urban Development
Project on Promoting ASEAN-China Cooperation on Biodiversity and Ecological Conservation	- Increase the capacity of ASEAN and China to develop and implement strategies and policies on biodiversity - Promote sustainable development	- Policy study on biodiversity cooperation potential
Strengthening the Capacity of South East Asian Countries for the Development and Implementation of the Biodiversity Strategic Plan 2011-2020 & Aichi Targets	- Enhance capacity through knowledge and experience sharing on use of policy tools and instruments	- Report Case Studies on Good Practices of Biodiversity Conservation - Workshop on the implementation and updating of NBSAP
China-ASEAN Peatland Conservation Cooperation	- Promote the exchange and cooperation on experiences and technologies of peatland conservation	- China-ASEAN Seminar on Peatland Conservation

Cambodia is an active member of the Agreement on the Coopeartion for the Sustainable Development of the Mekong River Basin. Cambodia cooperates fully with neighbor countries to fulfill common goals in a sustainable development perspective in terms of biodiversity and common natural resources conservation, such as the Pha Taem Protected Forest Complex in which Cambodia works closely with Thailand and Laos for cooperation in transboundary biodiversity conservation.

Cambodia government has integrated environmental issues, especially biodiversity and ecology into its national school curriculum, with the objective to upgrade knowledge and skills, and to change student behavior regarding biodiversity conservation and sustainable use, while

demonstrating its value to human health and sustainable development. The Japan International Cooperation Agency (JICA) and the UNDP are particularly active in assisting Cambodia in incorporating this environmental education program into its primary and secondary school curricula.

7. Challenges

Specific pressures and threats to biodiversity in Cambodia are as follows: pollutions, climate change, habitat loss, and unsustainable harvesting among others.

Threatens from Pollution and Contamination

Pollution is aggravated by the intensive and increasing use of chemical/inorganic fertilizers and pesticides. Several ASEAN Member States (AMS) are experiencing a decline in water quality, most especially in rivers and lakes. Eutrophication, characterized by algal bloom, is evident in some AMS, thus creating an ecological imbalance. Coastal and marine areas are affected by the occurrence of red tide that leads to toxic outbreaks of paralytic shellfish. Mining caused heavy toxic pollution not only on-site but also off-site such as in the coastal areas (ASEAN Biodiversity Outlook, 2010).

Threatens from Climate Change

The World Meteorological Organization (WMO) reported in July 2016 that global temperatures for the first six months of 2016 were the highest in history (WMO, 2016). Global temperature increases of 0.4 to 2.6 °C by 2055 and 0.3 to 4.8 °C by 2090 would be accompanied by rising sea levels, changes in precipitation patterns, substantial loss of summer Arctic sea ice, and increasing ocean acidification (SCBD, 2014).

The Intergovernmental Panel on Climate Change (IPCC) Working Group reported that "warming of the climate change system is unequivocal as evidenced by increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level". Likewise, the resilience of ecosystems maybe affected by the unprecedented combination of climate change resulting in associated disturbances like flooding, drought, wildfire, insect infestations and ocean acidification; land use change; pollution and over-exploitation of resources. The implications of climate change to ASEAN's biodiversity resources are predicted to be serious.

In terms of species, climate change may impact species population, distribution and habitats. The impacts include: 1) alterations of species densities (including altered community composition and structure); 2) range shifts, either poleward or upward in elevation; 3) behavioral changes, such as the phenology (seasonal timing of life cycle events) of migration, breeding, and flowering; 4) changes in morphology (body size); and 5) reduction in genetic diversity that leads to inbreeding depression (Sodhi et al., 2009).

In Cambodia, coastal and marine resources are affected by the inundation of low-lying areas. There is prevalent coral bleaching and degeneration of coral reefs and seagrasses due to climate change. Direct impacts of climate change include alteration in foraging and reproduction due to sea level rises; changes in species range; high juvenile mortality; massive die-offs; and shifts in distribution.

The effects of climate change in forests are evidenced by widespread pest and insect infestation; low seedling survival; increased population of invasive alien species and intensified soil erosion due to drought and flooding. The numbers of migratory birds and animals like marine turtles have been declining due to the effects of climate change.

In agriculture, climate change reduces crop yields and increases livestock mortality due to heat stress and droughts; increases loss of cultivated lands due to rising sea levels; and increases widespread pest and insect infestation.

↘ Table 3

Cambodia Policy Documents Related to Climate Change

Country	Nationally Determined Contribution (NDC)	National Biodiversity Strategy and Action Plan (NBSAP)	Fifth National Report to the Convention on Biological Diversity (CBD)
Cambodia (Ratified Paris Agreement on 6 February 2017)	- Reduce emissions by 27% by 2030 with international support. Increase forest cover to 60% of the national land area by 2030. - Climate change measures: Promote capacity through community-based adaptation actions and restore ecosystems to respond to climate change. - Implement management measures for protected areas to adapt to climate change. - Develop and rehabilitate flood dykes for agricultural and urban development. - Develop climate-proof agriculture systems to address changes in water variability and enhance crop yields. - Promote climate-resilient agriculture in coastal areas by building sea dykes and upscaling climate-smart farming systems. - Develop crop varieties suitable to agro-ecological zones (AEZ) and resilient to climate change. - Promote aquaculture	Target 10: Identification of size and distribution of habitats for threatened species. Target 15: Plans are being developed for reporting of coral reef status, locations, and protection.	The Cambodia Climate Change Strategic Plan (2014–2023) directs climate-smart development with the following objectives: - Promote climate resilience through food, water, and energy security. - Reduce vulnerability of sectors, regions, gender, and health to climate change impacts. - Ensure climate resilience of critical ecosystems, biodiversity, protected areas, and cultural heritage sites. - Promote low-carbon planning and technologies to support sustainable development. - Improve awareness and capacities for climate change responses. - Promote adaptive social protection and participatory approaches in reducing loss and damage. - Strengthen institutions and coordination for national climate change responses. - Strengthen collaboration and participation in regional and global climate change processes. Green growth and policies on climate change and energy efficiency in the industrial sector have been developed. The National Policy, Strategy and Action Plan on Energy Efficiency aims to improve energy efficiency in the industrial sector by 28%; strengthen capacity building in energy efficiency; and raise awareness of industry stakeholders on energy efficiency issues

Source: ASEAN Biodiversity Outlook 2

8. Future Priorities

To effectively implement the updated NBSAP and realize Cambodia's vision for biodiversity, priorities should be given in the following areas going forward,

a) Raising public awareness and knowledge in implementing the relevant legislations for biodiversity conservation and the Convention and the importance of biodiversity; Increasing and promoting stakeholders' awareness and knowledge on the Convention and their working programs;

b) Improving and building capacity for government and institution management regarding biodiversity at central and local levels;

c) Developing structure, systems and mechanisms to ensure that the programs and plans in relevant sectors are in line with implementation of the Convention;

d) Integrating biodiversity conservation in national, ministerial, and local plans, and mainstreaming the Convention and its programme of work from national to local levels (provincial and district/city) at the appropriate level, time and scale;

e) Enhancing the Convention and its program of work from national to local levels (provincial and district/city) at the appropriate level, time and scale;

f) Increasing regional cooperation mechanisms and strengthening diversification and effective management of funding sources for conservation of nature and biodiversity conservation;

g) Building skills and capacity, including an exchange of experiences and knowledge among the Parties to the Conventions.

References

ASEAN Center for Biodiversity. (2017). ASEAN Biodiversity Outlook 2.Phillipeans.

China-ASEAN Environmental Cooperation Center. (2016). Experiences and Good Practices in China and ASEAN on Biodiversity Planning and Implementation. Beijing: China Environment Press.

China-ASEAN Environmental Cooperation Center, & ASEAN Center for Biodiversity. (2013). Case Studies on Good Practices of Biodiversity Conservation in ASEAN and China.Beijing: Social Sciences Academic Press.

J E, Clarke.Biodiversity and Protected Areas Cambodia.

National Council for Sustainable Developmnet, Kingdom of Cambodia. National Biodiversity Strategy and Action Plan (2016).

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