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Climate actions and interactions with SDGs

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Contents

Climate actions and interactions with SDGs

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Key Messages

- Lots of synergies exist between climate actions and SDGs, but at the same time there are many real and potential trade-offs among SDGs and between objectives of different sectors. Existing institutions and processes that work within compartmentalised, non-integrated goals and boundaries result in trade-offs.

- Measures for the transport sector have close relationships with land planning. A low carbon transport system can change the flow of human activities, and thus contribute significantly to realise a low carbon world. Integrated low carbon development of urban and rural areas is indispensable for not only climate stabilisation but also preserving ecosystems.

- Developing new low carbon technologies and promoting recycling will contribute to enhanced utilisation of resources and improved environmental conditions. Several technological and structural changes in energy systems for low carbon development have been proposed and implemented, which need to be accelerated.

- Human resources are the key for climate actions. Upgrading the education system can help build awareness and consensus about the criticality and feasibility of low carbon actions. Establishing transparent and fair governance processes can make different stakeholders work in a coordinated fashion towards common actions. These changes can therefore channel cumulative human efforts in the desired direction of low carbon transition.

- Drastically higher levels of funds and investments for deep decarbonisation are required from businesses as well as governments. One challenge is how to provide the right incentives for businesses.

- Integrated planning and implementation with a long-term view are the bases for climate stabilisation.

Key words Climate action, NDC, SDG, climate policies, long-term strategies

Summary

World leaders agreed at COP21 to limit the average global temperature increase to well below 2°C compared to pre-industrial levels and to move forward to reduce greenhouse gas (GHG) emissions from human activities essentially to zero during the latter half of the 21st century[3]. In another historic UN summit in 2015 they adopted the 2030 Agenda for 17 Sustainable Development Goals (SDGs)[4]. Climate change is one of most important and urgent SDGs, as current actions will have a deep impact on the future environment and human activities. Moreover, many actions towards mitigating climate change can also help to achieve other SDGs such as ensuring access to affordable clean energy, promoting sustainable production and consumption activity patterns, and building resilient infrastructure.

1 Institute for Global Environmental Strategies, Japan 2 Integrated General Systems Analysis Laboratories, India
3 UNFCCC (2015) Adoption of the Paris Agreement, FCCC/CP/2015/L.9. https://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf
4 UN (2015)Transforming our world: the 2030 Agenda for Sustainable Development.
http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

During 2014–2016, worldwide energy-related CO_2 emissions plateaued after rising for decades, while the economies of major nations have grown, indicating a decoupling of GHG emissions from production and consumption[5]. However, progress in implementation thus far has fallen well short of achieving the COP21 climate goals. Likewise, the progress of different countries on various SDGs has been mixed. There is clearly an urgent need to undertake more drastic and early actions, and simultaneously work towards enhancing synergy among the actions for both climate mitigation and SDGs.

The aim of this report is to provide a guideline to plan and implement the strategies for designing and transitioning to a low carbon, sustainable society.

Ten climate (or low carbon) actions are discussed with the possibilities of their sub-actions being implemented. These actions are closely related with the actions required to achieve the SDGs. Synergies and trade-offs between climate and sustainable development actions and between different sectors are also examined.

In addition, some of the good low carbon practices and policy implications are discussed in the sectoral domains, such as energy, transport, industry, waste management, land use and forestry, and in the cross-cutting domains of technology innovation, financing and investments, carbon pricing, international cooperation, cities and sub-national level actions, country-specific capabilities, and bottom-up actions by citizens and other societal stakeholders. Barriers and challenges to implement low carbon policies are also discussed.

It is our hope that this information and discussion will help increase the level of ambition of NDCs and the sense of urgency of taking early actions.

5 IEA (2017) Snapshots of Global Photovoltaic Markets 2016. Report IEA PVPS T1-31:2017. International Energy Agency, France.

Ten Actions toward Low Carbon Society

Action 1 Urban Transport
Hierarchically Connected Comapct Cities

Action 2 Interregional Transport
Mainstreaming Rail and Water in Interregional Transport

Action 3 Resource & Materials
Smart Ways to Use Materials that Realise the Full Potential of Resources

Action 4 Buildings
Energy-Saving Spaces Utilising Sunlight and Wind

Action 5 Biomass energy
Local Production and Local Consumption of Biomass

Action 6 Energy System
Low Carbon Energy System Using Local Resources

Action 7 Agriculture & Livestock
Low Emission Agricultural Technologies

Action 8 Land use & Forestry
Sustainable Forestry Management

Action 9 Technology & Finance
Technology and Finance to Facilitate Achievement of LCS

Action 10 Governance
Transparent and Fair Governance That Supports Low Carbon Asia

Chapter 01

Introduction

World leaders agreed at COP21 to limit the average global temperature increase to well below 2°C compared to pre-industrial levels and to move forward to reduce greenhouse gas (GHG) emissions from human activities essentially to zero during the latter half of the 21st century (UNFCCC, 2015). In another historic UN summit, in 2015, the 2030 Agenda for 17 Sustainable Development Goals (SDGs) was adopted (UN, 2015). Climate change is one of the most crucial and urgent SDGs. This is because current actions will have a profound and everlasting influence on the future of the environment as well as the human race. Moreover, many actions aimed at tackling climate change will also help achieve other SDGs – such as ensuring access to affordable clean energy and building resilient infrastructure.

Many areas all over the world are experiencing the severe impacts of climate change. The latest scientific data, corrected for calibration errors in measuring sea level surface, confirm that sea levels are rising at an annually accelerating pace, from around 1.8 mm per year in 1993 to roughly 3.9 mm per year in 2017, as a result of global warming (Tollefson, 2017). This equates to about 75 cm over the next 100 years, a projection that concurs with those made by the IPCC in 2013. This is why early mitigation actions are so undeniably critical in nature.

Another factor adding impetus for early action is the need to avoid high carbon lock-in due to long-life infrastructure and power systems. At the same time, given the wide-ranging domestic conditions of resource availability and developmental priorities across different countries, it is necessary to align GHG mitigation policies and actions to domestic conditions in each country, to enhance their acceptability and effectiveness. A key challenge is the mobilisation of finances and human resources for use of low carbon technologies and infrastructures, which is another reason why climate actions need to be integrated with the actions of other SDGs.

Prior to COP21, the UNFCCC requested countries and parties to submit their Intended Nationally Determined Contributions (INDCs), which automatically became NDCs after the Paris Agreement was ratified, in the absence of new NDCs being submitted by countries. Submission of long-term low GHG emissions development strategies was agreed at COP21, and 152 parties had submitted NDCs as of August 2017 (UNFCCC, 2017a). France, Benin, USA, Mexico, Germany and Canada submitted long-term low greenhouse gas emission development strategies, which recommend many important actions (UNFCCC, 2017b).

The steps involved in drafting policies are illustrated in Figure 1.1, which start with clarifying the framework surrounding the problem and forming task forces as well as allocating resources. Next is assessing the background researches and setting timeframes, constructing LCS visions via data collection, preparing analytical methods, designing and quantifying LCS visions, designing feasible and likely LCS policies, projecting emissions of the baseline and policy scenarios to assess GHG and non-GHG mitigation effects of such LCS policies. The final step is to translate the outputs of this analysis into actual Actions and Programs, as well as to demonstrate and report results to policymakers. A follow-up evaluation of results then takes place before the steps (or revised steps) are replicated.

This report describes10 climate actions (see Table 1.1), shows the appropriate timings thereof and interrelations with SDGs, and discusses some of the good practices aimed at low carbon society and policy implications. It ends with an overview of the related barriers and challenges.

1. Beginning the story 1.1 Formulation of the region’ s top initiative 1.2 Construction of task force 1.3 Resource allocation	• Authorized task force • Human resource, budget plan, etc.
2. Framing setting 2.1 Background research 2.2 Framing setting	• Existing policies, plans and studies, national and regional circumstances, etc. • Timeframe, scope and boundary
3. Construction of LCS visions 3.1 Data collection and estimation 3.2 Localization of the methods 3.3 Design and quantification of LCS visions	• Related statistics, report and preliminary surveys • Adjusted methodologies, tools and software • Demography, macro economy, industrial structures, GHG emissions, etc.
4. Design of LCS policies and assessment of GHG and non-GHG mitigation effects by the policies 4.1 Design of feasible and likely LCS policies 4.2 Projection of baseline emissions and emissions of policy scenarios 4.3 Assessment of GHG and non-GHG mitigation effects by LCS policies	• Definition of the “baseline” • Identify parameters and indicators on GHG and non-GHG effects
5. Bridging outputs of the analysis to implementation 5.1 Formulation of Actions and Programmes for implementation 5.2 Demonstration and reporting the results to policy makers	• A priority list of actions and policies based on the analysis • Action Breakdown Structure and roadmap for realising LCS

Figure 1.1 Steps to develop LCS policies

Source (Gomi and Matsuoka, 2016)

Table 1.1 Actions considered in this report

Action	Sub-action
Action 1: Urban transport	Action 1.1: Compact cities with well-connected hierarchical urban centers (AVOID) Action 1.2: A seamless and hierarchical transport system (SHIFT) Action 1.3: Low carbon vehicles with efficient road-traffic systems (IMPROVE)
Action 2: Interregional transport	Action 2.1: Formation of industrial corridors using a low carbon transport system (AVOID) Action 2.2: Establishment of an intermodal transport system (SHIFT) Action 2.3: Reduction of CO_2 emissions from vehicles and aircraft (IMPROVE)
Action 3: resources and materials	Action 3.1: Production that dramatically reduces the use of resources Action 3.2: Use of products in ways that extend their lifespan Action 3.3: Development of systems for the reuse of resources
Action 4: Low carbon buildings	Action 4.1: Improvement of the energy-efficiency performance of buildings Action 4.2: Application of high-efficiency equipment to buildings including heating/cooling equipment Action 4.3: Visualization of energy-saving efforts
Actin 5: Biomass energies	Action 5.1: Sustainable co-production of biomass energy and food Action 5.2: Low carbon energy systems using local biomass resources in rural areas Action 5.3: Improvement of living environments with intensive biomass utilization
Action 6: Energy systems	Action 6.1: Promotion of sustainable local energy systems with renewables Action 6.2: Creation of smart energy supply and demand systems Action 6.3: Enhanced energy security by integrating low carbon energy sources into existing energy systems
Actin 7: agriculture and livestock	Action 7.1: efficient use of technologies Action 7.2: Highly efficient fertilizer application and residue management Action 7.3: Recovery and use of methane gas from livestock manure
Action 8: Land use and forestry	Action 8.1: Forest protection and effective plantation Action 8.2: Sustainable peatland management Action 8.3: Monitoring and management of forest fires
Action 9: technologies and finance	Action 9.1: Promote private-sector R&D for LCS Action 9.2: Establish adequate funding to support R&D and technology diffusion Action 9.3: Foster environmentally conscious consumers who choose low carbon products
Action 10: Governance	Action 10.1: Create an efficient administrative management framework Action 10.2: Establish fair and transparent business practices Action 10.3: Improve literacy with respect to environmental policies and technologies

Chapter 02

Climate actions

The realisation of Low Carbon Societies (LCSs) is imperative in order to achieve both sustainable economic growth and stabilisation of climate change. However, transitioning to LCS is no easy task due to the multi-faceted needs and values of each country, which will demand the cooperation of a wide range of stakeholders– policymakers, international aid agencies, private companies, local communities and NGOs– in drawing up long-term visions and strategies.

The framework of 10 Actions provides a guideline to plan and implement strategies for designing and transitioning to LCS, and considers the interrelationships between individual policies as well as the sequence in which they should be implemented. It also discusses the necessary actions to be taken by governments, private sectors, citizens, and international cooperation agencies on a priority basis (Low Carbon Asia Research Project, 2012, 2013).

Tables 2.1 to 2.10 show actions for NDCs implementation and further GHG emissions reduction with their expected levels of achievement by the year of 2030, 2040 and 2050.

2.1 Actions for urban transport (Action 1)

The key concept of urban transport is hierarchically connected compact cities in which three actions are considered: well-connected hierarchical urban centers (Action 1.1); seamless and hierarchical transport system (Action 1.2); and low carbon vehicles with efficient road-traffic systems (Action 1.3) (see Figure 2.1).

Action 1.1 focuses on designing low carbon infrastructure and facilities, including land use, of cities for low carbon transport to avoid GHG emissions (AVOID), Action 1.2 focuses on an intra-city traffic system in order to bring about a shift to low carbon transport utilisation (SHIFT), and Action 1.3 focuses on developing intra-city transport technologies to reduce GHG emissions (IMPROVE).

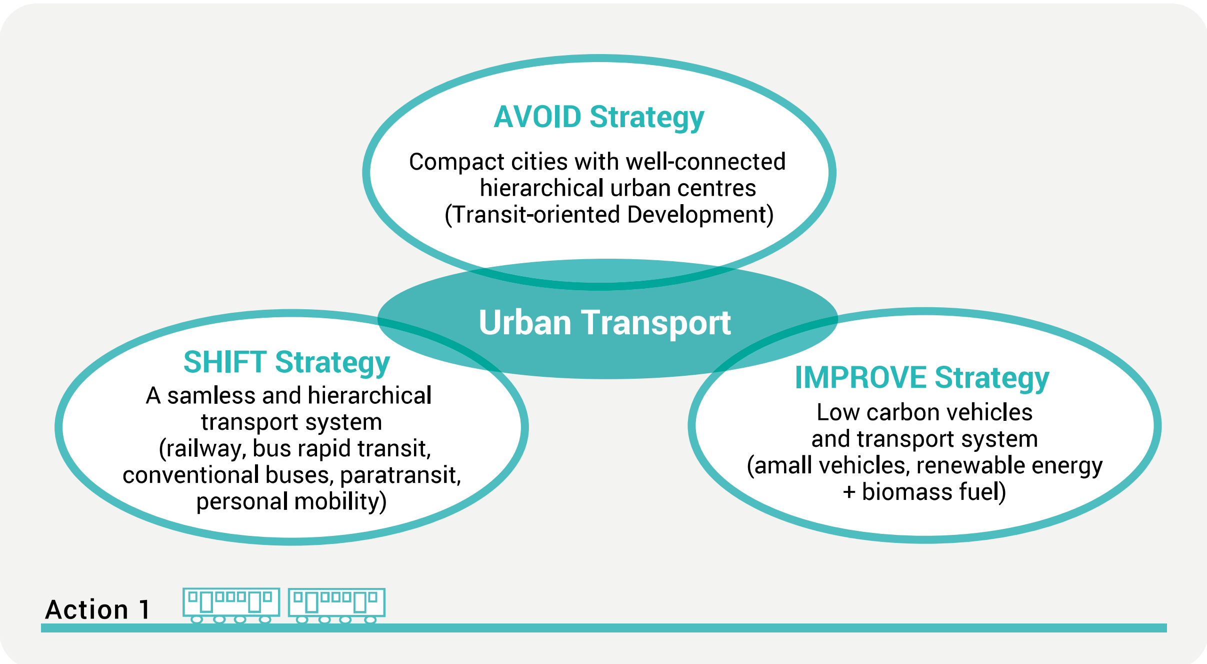

Figure 2.1 Key actions for urban transport.

Action 1.1: Compact cities with well-connected hierarchical urban centers (Avoid)

Many aspects need to be considered when designing compact cities, two key ones being to develop employment cores in urban transit corridors and to exclude private cars from inner city areas.

Although it is difficult to avoid increases in the number of trips, given a growing economy, it is important to develop transport infrastructures to reduce travel volumes. Transit-oriented development (TOD), which integrates industrial and residential development around stations of urban public transport, can bring about more self-contained urban cores, enabling workplaces to be closer to homes. In order to implement TOD to develop suburban industrial cores, transport planning needs to be integrated with urban and regional planning, something not usually considered in unison in developing cities.

Use of value-capture schemes would help exploit the benefit of increased land value from transport development, especially at the early stage of development with low land values. Promoting such schemes in combination with TOD is effective not only in central business districts (CBDs) but also urban fringes and suburbs, particularly in sprawling cities. Car use would also be reduced under TOD, through offering residential tax discounts (or similar incentives) for non-car owners.

Extensive rail and related infrastructure development may not be feasible in developing countries under the constraints of financial budgets and resources, in which case development could be scaled back by excluding car traffic from inner city areas and improving the mobility of public transport. This would free-up road space for slower and eco-friendly modes such as bicycles and walking.

Further, high accessibility for aged and low-income people to meet health and education requirements needs to be secured by providing communal facilities in local areas. This is in sync with development of self-contained urban and sub-urban cores.

Action 1.2: A seamless and hierarchical transport system (SHIFT)

One of the demands in urban transport planning is to shift the increasing demand for car use to low carbon public transport options. Interregional rail development generates new travel demand in cities, such as for commuting, business, and leisure, which means it is important to instill the benefits of public transport use through early development of intensive urban public transport networks.

An efficient public transport system needs an integrated management system encompassing various mass-transit and feeder transport modes. The efficiency of transport management can be improved with an integrated fare system and dynamic service operations, taking advantage of information and communication technology (ICT). Moreover, the management system for individually operated paratransit services needs to be reformed in order to retain community-based feeder transport services under economic growth conditions.

Action 1.3: Low carbon vehicles with efficient road-traffic systems (IMPROVE)

As mass-transit development in smaller cities and rural areas suffers from reduced efficiency and low carbon savings, advances in vehicle technology to increase energy efficiency of road transport will be needed. The present focus is on small-size EVs, including motorcycles, paratransit vehicles and delivery cars, but development is expected to encompass larger low emission vehicles (LEVs) within the next couple of decades.

The development and promotion of alternative green fuels is another effective option. In order to promote EVs, development of smart-grid systems would improve the efficiency of power generation, storage and use.

Efficient traffic management can also contribute to improving the energy efficiency of urban transport. For instance, a system that reduces idling or travel at sub-optimal speeds, reduces travel time, and encourages vehicle sharing or pooling would cut energy use.

Table 2.1 Timeline of actions for urban transport

Stakeholder	Action category	Action	Level of achievement 2030 %	2040 %	2050 %
Government	Action 1.1	Expand slow-mode areas of cars around stations	50	75	99
		Establish multigenerational service facilities around stations	25	50	75
		Transit-oriented development (TOD) by means of “value capture”	50	75	99
		Introduce tax systems to promote TOD	25	50	75
	Actions 1.1 & 1.2	Develop railways and BRT with high quality pedestrian areas around stations in early stage	50	75	75
		Develop radial and orbital public transport networks connecting urban centres	50	75	75
		Control car use in city centres	75	99	99
		Develop polycentric business centers in key transit nodes	75	99	99
		Establish freight distribution systems	75	99	99
	Action 1.2	Implement suburban park & ride	75	99	99
		Separate trunks and feeders of bus/paratransit routes	75	99	99
		Enhance to provide user-friendly circulating local transport services for the aged	50	60	70
		Develop efficient and modern public transport based on information and communication technologies (ICT)	50	60	70
		Cooperative management of a comprehensive region-wide transport system			
Private Sector	Action 1.3	Promote passenger EVs	75	99	99
		Promote freight EVs	50	75	99
		Develop biomass fuel and renewable energy	75	99	99
		Develop energy-efficient smart grid system	75	99	99
Citizens	Action 1.1	Preference for locations near stations	75	99	99
		Preference for short-distance travel	75	99	99
		Popularisation of online shopping and telecommuting	75	99	99
	Action 1.2	Preference for travel by faster and more comfortable public transport	75	99	99
		Preference for low carbon vehicles	75	99	99

International	Action 1.1	Develop model cities for low carbon transport	75	99	99
	Action 1.1 & 1.2	Establish financial schemes and emissions trading to support development of low carbon transport	75	99	99
		Integrate railway-track gauges, technology transfer of railway-track construction, and railway and bus-vehicle maintenance from developed countries	75	99	99
	Action 1.2	Adopt models of urban transport systems by other cities	75	99	99

2.2 Actions for interregional transport (Action 2)

The key concept of interregional transport is mainstreaming rail and water, which considers three actions. They are: formation of industrial corridors using a low carbon transport system (Action 2.1); establishment of an intermodal transport system incorporating rail and water (Action 2.2); and reduction of CO_2 emissions from vehicles and aircraft (Action 2.3) (See Figure 2.2).

Action 2.1 focuses on developing low carbon infrastructure for interregional transport (AVOID), Action 2.2 focuses on an interregional and intermodal traffic system to shift to use of low carbon transport (SHIFT), and Action 2.3 focuses on developing interregional transport technologies to reduce GHG emissions (IMPROVE).

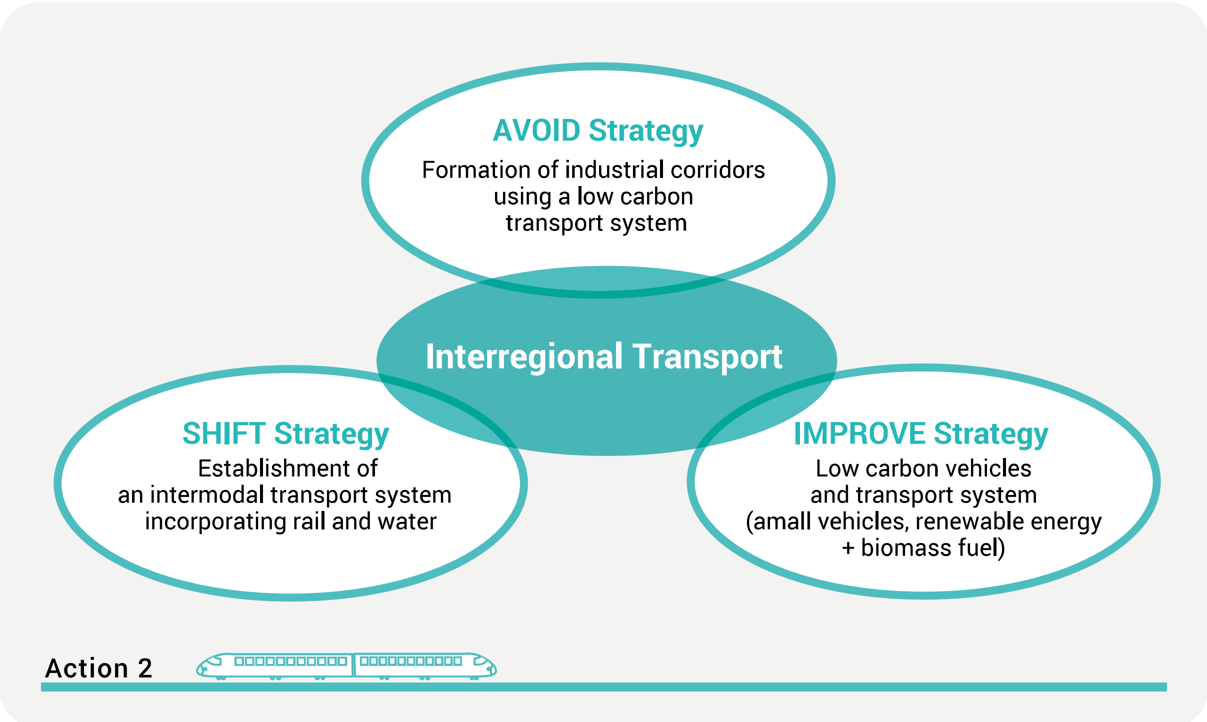

Figure 2.2 Key actions for interregional transport

Action 2.1: Formation of industrial corridors using a low carbon transport system (AVOID)

High-speed rail networks for handling increased demand in international passenger transport need to be established, and this is even more important for freight.

First, a conventional freight rail network for shipping heavy loads needs establishing, by extending existing railways, followed by developing dry ports in highly accessible hub locations linking high-speed freight rail, conventional freight rail and highways. By connecting these rail and road networks to urban transport systems, distribution efficiency and inner city traffic congestion can be improved. Further, fostering industry clusters in the vicinity of dry ports would reduce transport distances in the supply chain.

To realise low carbon manufacturing through restructuring of the supply chain, awareness needs to be changed, not only among manufacturers and suppliers but also consumers, towards products manufactured and consumed locally, which is best achieved through introduction of a carbon tax. Expanding the mandate to estimate the carbon footprint of products and to organise suchinformation will also be of critical importance. To further reduce CO_2 emissions, long-distance business travel for meetings can be reduced by making full use of information and communication technology (ICT) such as video conferencing.

Action 2.2: Establishment of an intermodal transport system (SHIFT)

The use of maritime transport should continue to be promoted for extra-continental freight shipments. It is therefore necessary to establish base ports in key geopolitical locations.

In intra-continental regions, the use of both passenger and freight rail as low carbon transport modes should be promoted by developing high-speed rail systems. For freight shipments in particular, rail usage can be further advanced by linking high-speed rail to conventional rail and highway networks, and by promoting industry clusters and supply chain restructuring. Intermodal logistics needs to become an integral part of industrial supply chains, and for this a network of mode-switching facilities is crucial for its diffusion, as this would enhance the efficiency of supply chains on both operational and energy use indicators.

In addition, skills education and training for efficient operation of freight rail systems to ensure punctuality and reliability are also necessary.

Action 2.3: Reduction of CO_2 emissions from vehicles and aircraft (IMPROVE)

CO_2 emissions can be reduced by technologically tweaking various transport modes, such as reducing weight and improving engine performance of aircraft, switching to hybrid diesel freight vehicles, and developing technologies to power maritime vessels by electricity. Similarly, reductions in CO_2 emissions can be expected in freight distribution at terminals by upgrading automated guided vehicles (AGVs) through technological innovations and encouraging electrification, automation, and logistical streamlining.

Table 2.2 Timeline of actions for interregional transport

Stakeholder	Action category	Action	Level of achievement 2030 %	2040 %	2050 %
Government	Action 2.1	Develop ports and airports as international hubs	20	50	75
		Introduce domestic fuel tax/carbon tax	50	75	75
	Action 2.2	Develop high-speed passenger railways between domestic regions	50	75	75
		Develop freight railways and maritime transport between domestic regions	50	75	99
		End all sales of gasoline and diesel-powered vehicles	0	30	50
		Shift to "local production for local consumption" systems End all sales of gasoline and diesel-powered vehicles	50	75	99
Private Sector	Action 2.1	Replace business travel by online videoconferencing	50	75	75
		Optimise supply chains for low carbon transport	50	75	75
	Action 2.2	Promote modal shift to railways and improve loading capacity	50	75	99
Citizens	Action 2.1	Preference for locations near stations	75	75	75
		Preference for short-distance travel	50	75	75
		Popularisation of online shopping and telecommuting	50	75	75
	Action 2.2	Preference for travel by faster and more comfortable public transport	75	75	99
		Preference for low carbon vehicles	75	99	99
International	Action 2.1	Develop model cities for low carbon transport	99	99	99
	Actions 2.1 & 2.2	Establish financial and emissions trading schemes to support development of low carbon transport	75	99	99
		Coordinate integration of railway-track gauges, technology transfer of railway-track construction, and railway and bus-vehicle maintenance from developed countries	75	99	99
	Action 2.2	Coordinate adaptation of models of urban transport systems from other cities	75	99	99

2.3 Actions for responsible consumption and production (Action 3)

The core concept behind responsible consumption and production is to pursue smart ways to use materials that realise the full potential of resources, in which three actions are considered: production that dramatically reduces the use of resources (Action 3.1); use of products in ways that extend their lifespan (Action 3.2); and development of systems for the reuse of resources (Action 3.3).

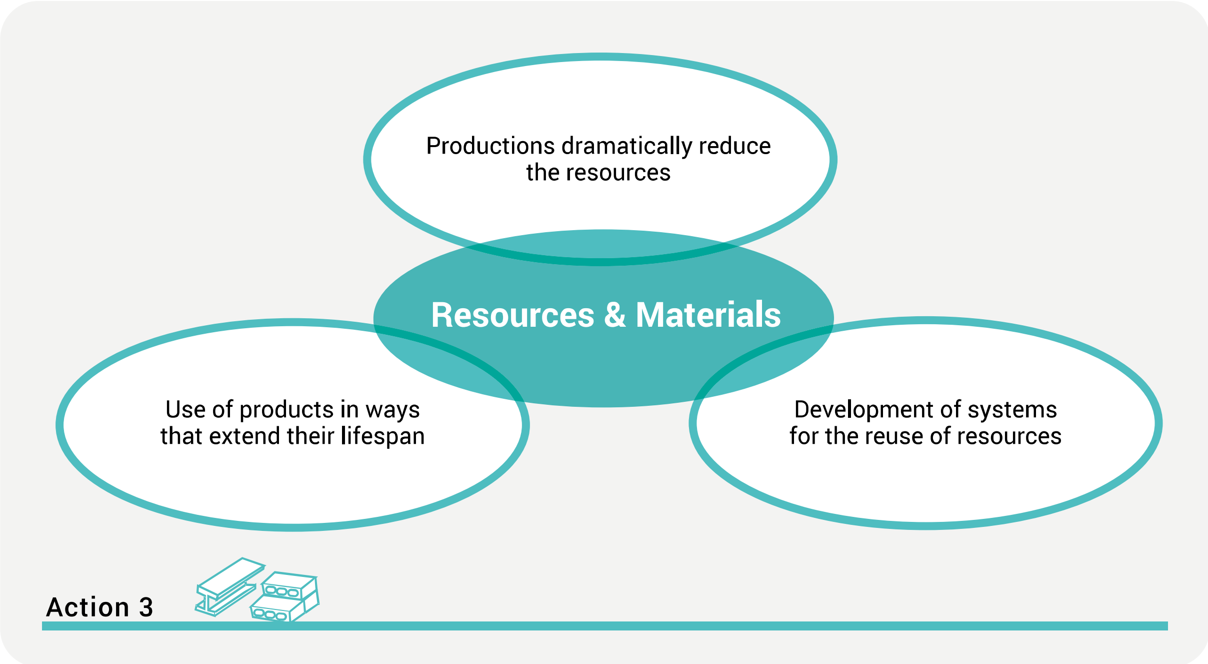

Figure 2.3 Key actions for responsible consumption and production

Action 3.1: Production that dramatically reduces the use of resources

Drastic reduction in resource use is the key to reducing GHG emissions substantially at the point of raw material production. To do so, the amounts of raw materials that are used should be reduced, e.g., through weight reduction, while maintaining the present roles of materials in the products. Alternatively, substitution of raw materials for carrying out the same functions should be explored. However, such technologies require further research, development and diffusion, which will require support through tax reductions, subsidies and involvement of international institutions, for example.

Action 3.2: Use of products in ways that extend their lifespan

After resources are transformed into infrastructure or products, using them for as long as possible is an effective strategy to reduce the usage rate of new resources.

To attain this goal, technologies to extend the lifespan of infrastructure and products for as long as possible and to provide appropriate maintenance during use should be established and diffused widely throughout society. Additional research and development of such technological systems will necessarily have to be undertaken with the joint support of governments and industries. Diffusion of these systems should also be supported through tax reductions and subsidies.

For goods used in daily life, it is important to select products that consume less resources and are long-lasting, recyclable and reusable. Several measures should be pursued to support consumer choice, such as the appropriate disclosure of product information to consumers through product evaluation and comparison systems for use at the time of selection, and incentive systems including green point accumulation when consumers select green products.

Action 3.3: Development of systems for the reuse of resources

In general, the amounts of new resources (primary resources) consumed can be reduced, thereby reducing carbon emissions, if resources already stocked in society in various forms are recycled or reused. Although recycling and reuse technologies already exist for diverse byproducts and wastes, the range of target byproducts and wastes they can handle can be expanded, high-level recycling and reuse can be introduced, and the efficiency of existing technologies can be further raised. Consequently, additional support for research and development of these technologies is necessary. Support for the diffusion of technologies that have already been developed is also indispensable. International institutions and national governments should jointly promote such activities.

Table 2.3 Timeline of actions for resources and materials

Stakeholder	Action category	Action	Level of achievement 2030 %	2040 %	2050 %
Government	Action 3.1	Design low carbon cities and national land that use less materials	50	75	99
		Implement low carbon urban and national design that use less materials	25	50	75
		Support research on technological development related to the effective use of resources	50	75	99
		Establish and operate organisation to evaluate effectiveness of public enterprises	25	50	75
	Action 3.2	Construct long-lasting infrastructure and provide support for such construction	25	50	75
	Action 3.3	Develop and introduce recycling and reuse systems for various products	50	75	99
Private Sector	Action 3.1	Develop and deploy technologies for weight reduction and carbon intensive materials replacement	50	75	99
	Action 3.2	Develop and deploy life-extension technologies and maintenance systems	50	75	99
	Action 3.3	Develop and deploy technological systems for recycling and reuse	50	75	99
Citizens	Action 3.1	Create lifestyles that are less material intensive	50	75	99
	Action 3.2	Choose houses/materials that have long life spans	50	75	99
	Action 3.3	Select recyclable and reusable products that are long-lasting and less resource intensive	50	75	99
International	Action3.1	Cooperate in research on technological development related to effective use of resources	75	99	99
	Actions3.1 & 3.2	Promote and disseminate new technologies internationally	50	99	99
	Actions 3.1, 3.2 & 3.3	Develop environmental load intensity database for new technologies	50	75	99
	Action 3.3	Introduce international environmental labeling system for traded products	50	75	99

2.4 Actions for low carbon buildings (Action 4)

The key concept of low carbon buildings is energy saving spaces utilising sunlight and wind in which three actions are considered: improvement of the energy-efficiency performance of buildings (Action 4.1); Application of high-efficiency equipment to buildings including heating/cooling devices (Action 4.2); and visualisation of energy-saving efforts (Action 4.3).

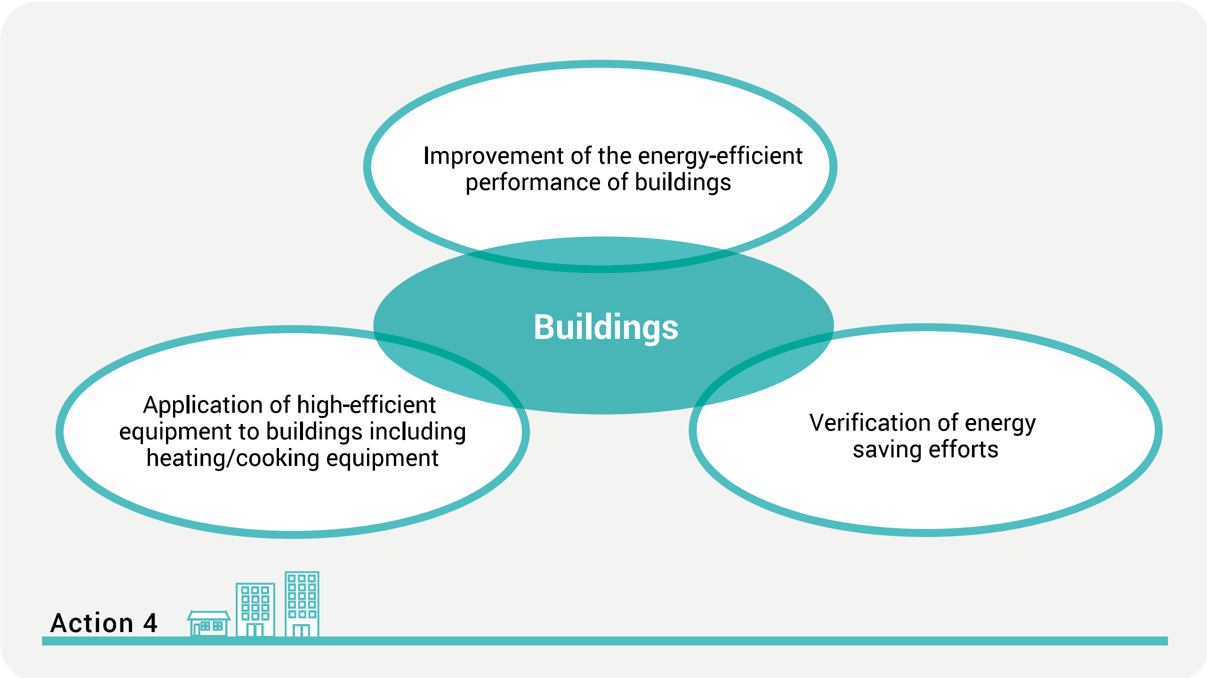

Figure 2.4 Key actions for low carbon buildings

Action 4.1: Improvement of the energy-efficiency performance of buildings

In many regions in the world, energy demand for heating and cooling is dramatically increasing. In order to curb energy demand for buildings it is essential to consider energy efficiency as well as comfort from the design and construction phases by setting standards for energy consumption, heat load, and airtightness. One option is to build energy-efficient buildings that meet the criteria of each country's standards so that people can actually experience the benefits and comfort of such buildings.

To reduce cooling and heating demand, the use of natural ventilation and sunlight is effective, in addition to insulation. The application of renewable energy to buildings from photovoltaics or wind turbine generation systems is also an effective option for reducing fossil fuel consumption, although this does not reduce the cooling or heating demand directly. For this option, a strengthened R&D programme together with application of energy storage systems is important.

The initial investment required for high energy performance buildings is generally high. Financial support such as subsidies or tax reductions can therefore serve as a big incentive for owners.

Action 4.2: Application of high-efficiency equipment to buildings including heating/ cooling equipment

Improvement of the energy efficiency of equipment reduces its energy consumption while maintaining the same energy service level, thus contributing to GHG reductions. In order to successfully achieve this, relevant information must be provided to the consumer in an appropriate manner. By setting energy performance standards and obliging suppliers to follow them, energy-efficient equipment can be further promoted. The standards should be reviewed regularly and updated according to technical developments.

To efficiently implement low carbon measures in buildings, attention should be focused not only on each apparatus but also on the overall system, for example through use of a building energy management system (BEMS), which realises central control of equipment such as air conditioners used by the various tenants of a building through information technology (IT) solutions.

Action 4.3: Visualisation of energy-saving efforts

By visualising energy consumption and the cost to the consumer, wasteful energy consumption can be reduced. The acquisition of appropriate data that reflect the actual efforts being made is essential

Table 2.4 Timeline of actions for buildings

Stakeholder	Action category	Action	Level of achievement 2030 %	2040 %	2050 %
Government	Action 4.1	Set goals by all ministries and related organisations for introduction of low carbon building	50	75	99
		Extract and eliminate regulatory barriers to raise penetration of low carbon buildings	50	75	99
		Create comprehensive policy package and system with periodic reviews of their performance	50	75	99
	Actions 4.1 & 4.2	Introduce system design and various incentives for increasing market penetration	50	75	50
		Gradual removal of various incentives created for penetration	25	50	75
	Action 4.2 & 4.3	Provide support for technology development and establish quality assurance system	50	75	99
	Action 4.3	Introduce energy conservation labeling	50	75	99
		Promote information collection and provision	75	99	99
		Promote education programmes to provide information to stakeholders (e.g., architects, engineers, consumers)	75	99	99
Private Sector	Action 4.2	Promote transfers of energy-efficient technologies	50	75	99
		Invest in energy-efficient technology development	75	99	99
	Action 4.3	Disclose and publicise information for energy-efficient technologies	75	99	99
Citizens	Action 4.2	Select energy efficient equipment and buildings	75	99	99
	Action4.3	Share wisdom and practices for environmentally friendly operation	75	99	99
International	Action 4.2	Technology transfer cooperation	50	75	99
		Global standardisation of best practices	50	75	99
	Action 4.3	International standardisation of criteria for evaluation of building energy-saving performance	50	75	99
		Awareness, integration, and expansion of energy-saving standards	75	99	99

for such visualisation. To accomplish this task, an energy auditing system should be developed and adopted and the accuracy of the published data should be reconfirmed. Until now, separate energy-efficiency codes have been developed and introduced by each country, however, unifying them into an international standard would enable easier evaluation of technologies.

If energy-saving efforts can be visualised, the efforts of industries or citizens can be compared, and these efforts can be further accelerated by providing related grants or tax incentives. A system that allows users to browse a list of energy-efficient technologies should also be developed and managed in order to improve access to relevant information.

2.5 Actions for biomass energy (Action 5)

The key concept of biomass energy is local production and local consumption of biomass, in which three actions are considered: sustainable co-production of biomass energy and food (Action 5.1); low carbon energy systems using local biomass resources in rural areas (Action 5.2); and improvement of living environments with intensive biomass utilisation (Action 5.3).

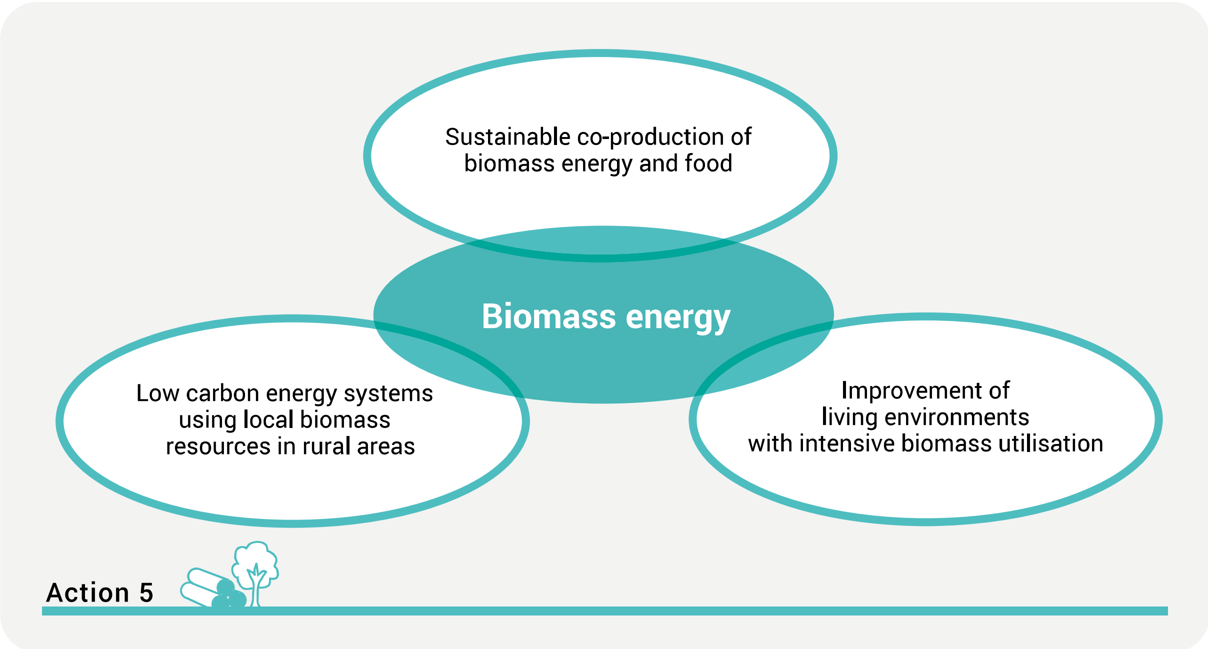

Figure 2.5 Key actions for biomass energy

Action 5.1: Sustainable co-production of biomass energy and food

Biomass is a renewable energy, but if it is used up quickly, its rate of usage outpaces that of renewal, resulting in a negative impact on the environment. Competition with food crop production is another problem. It is therefore crucial to establish systems that can produce and utilise biomass resources sustainably.

To establish a sustainable biomass production system balanced with food production and forest conservation, it is necessary to improve the efficiency of biomass production technologies, as well as to achieve sustainable biomass production by adjusting land use. Technologies need to be developed and disseminated for effective utilisation of both already exploited and currently unused biomass resources. Moreover, since excessive reliance on biomass may lead to shortages of biomass resources to meet future demand, a business management model should be formulated and implemented based on sustainability objectives at an early stage.

Since biomass is a carbon-neutral resource, the CO_2 emitted by its use is not counted as an emission. If a carbon capture and storage (CCS) system is coupled with biomass, this can contribute to reduced atmospheric CO_2 emissions.

Action 5.2: Low carbon energy systems using local biomass resources in rural areas

In order to promote independent energy supply systems using local biomass resources in rural areas, it is necessary to design and implement such systems for biomass energy. It is equally important to propagate the advantages of implementing such systems so that people in rural areas understand the benefits beyond reduced carbon emissions.

In the implementation phase, investment by governments and international organisations is important, but to achieve widespread adoption of the systems, it is desirable for agricultural communities to procure funds at local levels. In order to facilitate this, mechanisms for providing direct access of communities to funds through local branches of banks must be set up. In the operating phase, appropriate incentives for energy conservation and energy utilisation can be provided. It is also important to remove subsidies for fossil fuels and fossil fuel-based electricity, in order to improve the competitiveness of biomass resources.

Action 5.3: Improvement of living environments with intensive biomass utilisation

The widespread adoption of new technologies is an effective means of improving living environments as well as reducing the carbon intensity of energy systems. New biomass technologies are presently used in a few countries and regions. It is therefore necessary to promote technology transfers and institutional support for the adoption of these technologies internationally. Even if advanced biomass energy technologies are too expensive to be introduced in each home, they can be implemented at the community level as joint-use systems, thereby reducing costs and accelerating adoption. Local governmental and administrative agencies could play an important role in facilitating this process.

Table 2.5 Timeline of actions for biomass energy

Stakeholder	Action category	Action	Level of achievement 2030 %	2040 %	2050 %
Government	Action 5.1	Formulate and implement policies of land use and food production to avoid conflicts with biomass production	75	99	99
		Institutional and policy support to the sustainable management of forests and farmland	75	99	99
	Action 5.2	Support dissemination of energy-efficient furnaces	50	75	99
		Policy support for technology transfers and establishment of advance biomass technologies	50	75	99
		Phasing out fossil fuel subsidies	75	99	99
	Action 5.3	Education on the transition from traditional to modern use of biomass	75	99	99
Private Sector	Action 5.1	Commercialise biomass products that does not compete with food production	75	99	99
	Action 5.2	Improve and disseminate energy-efficient furnaces	75	99	99
		Promote research and development of next-generation biomass energy	75	99	99
		Technology development for biomass CCS technologies	10	20	30
		Implement biomass CCS technologies	3	5	10

Citizens	Action 5.1	Understand sustainable forest and agricultural area management and biomass production	75	99	99
	Actions 5.2 & 5.3	Introduce advanced biomass utilisation technologies for communities	50	75	99
	Action 5.3	Knowledge sharing for advanced use of stoves	75	99	99
International	Action 5.2	Establish financial scheme to support development and diffusion of technologies	50	75	99
		Accumulate global wisdom concerning technology transfer programs	75	99	99
	Action 5.3	Share and disseminate knowledge obtained	75	99	99

2.6 Actions for energy systems (Action 6)

The key concepts of energy systems are low carbon and use of local resources, in which three actions are considered: promotion of sustainable local energy systems with renewables (Action 6.1); creation of smart energy supply and demand systems (Action 6.2); and enhancement of energy security by integrating low carbon energy sources into existing energy systems (Action 6.3).

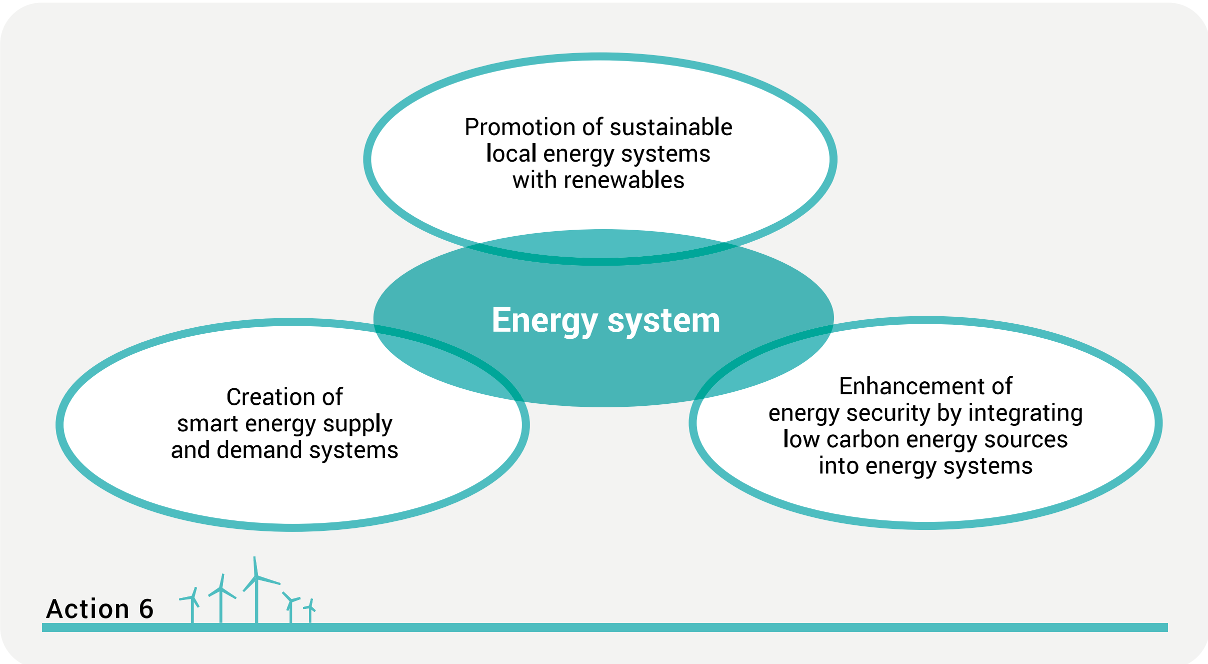

Figure 2.6 Key actions for energy systems

Action 6.1: Promotion of sustainable local energy systems with renewables

Solar and wind power are promising sources of renewable energy for low carbon development. As renewables are intermittent energy resources whose output fluctuates according to natural conditions, energy output needs to be equalised and balanced with energy demand not only by introducing energy storage systems, but also by coordinating the operation of renewable energy systems in multiple locations. Such technologies should be developed to maximise the use of power generated from renewables.

Compared with conventional systems, the cost of renewable electricity is still high. Incentives to support introduction should therefore be provided, including subsidies and low-interest loans. Incentives to encourage use should also be provided, including discounts of electric charges in accordance with the quantity of power generated, and reductions in property taxes. In addition, exchanges for electric power transactions should be established to facilitate profits from the sale of generated power.

Action 6.2: Creation of smart energy supply and demand systems

To expand the renewable and other low carbon energy sources, it will be essential to establish systems that make it possible to solve the problems caused by the mismatch between demand and supply. Such systems are known as smart energy systems. Some of the component technologies such as smart meters have already entered the market, but further research and development is required in order to realise key smart energy system technologies. Energy storage systems will also be key technical components.

Developing and implementing real-time monitoring systems that provide information of energy supply and demand is important to realising a low carbon energy system. As information must be closely coordinated with the status of industrial activities, people's lifestyles, and so on, there is a need to ensure adequate security to prevent unauthorised third-party access. Moreover, as these systems will operate 24 hours a day, 365 days a year, self-diagnostic systems that constantly monitor the system will need to ensure immediate detection and restoration in the event of a security breach.

Action 6.3: Enhanced energy security by integrating low carbon energy sources into existing energy systems

There is considerable variation among countries in terms of possible locations for renewable energy and fossil fuel reserves. Constructing a system network will make it possible to introduce renewables on a large scale in places with good conditions for generating energy, and to export the surplus power to other countries and regions.

CCS is a technology for capturing generated CO_2 to prevent it being emitted into the atmosphere, and then injecting, isolating and storing it underground or in other locations. Further R&D is needed before CCS technology can be made viable and implementable on the ground.

Table 2.6 Timeline of actions for energy systems

Stakeholder	Action category	Action	Level of achievement 2030 %	2040 %	2050 %
Government	Action 6.1	Expand electrified areas	75	99	99
		Assess potential for renewable energy	75	99	99
		Develop a medium- to long-term low carbon energy plan	75	99	99
		Introduce measures to stimulate positive attitude toward renewable energy and disseminate renewables	75	99	99
	Actions 6.1 & 6.2	Establish relevant regulations	75	99	99
Government	Action 6.2	Implement pilot project for smart grid	75	99	99
		Establish demand response technologies and consensus building among utility customers	50	75	99
		Ensure access to energy for all	75	75	99
	Action 6.3	Consider land for CCS	10	20	30
		Establish CCS facilities for thermal power generation	3	5	10
Private Sector	Actions 6.1, 6.2 & 6.3	Research on high-efficiency power generation technologies	75	99	99
	Action 6.2	Develop control methods and smart grid systems for making use of wide variety of energy sources and technologies	50	75	99
		Establish demand response technologies	75	75	99
		Establish consensus building for utilising demand response technologies among utility customers	75	75	99
	Action 6.3	Develop and implement hydrogen utilisation technologies	25	50	50
		Deal with cyber security problem	75	75	75
Citizens	Action6.3	Preference for low carbon electricity sources available (e.g., purchase of green electricity)	50	75	99
		Cooperation with demand management initiatives such as peak shifting	75	99	99
International	Action6.1	Unify electric power standards at international level	75	99	99
		Develop concept for energy system network for developing countries	75	99	99
		Joint development and knowledge sharing of technologies and tools for weather information and forecasting	75	99	99
	Action 6.2	Support energy system network in developing countries	75	99	99

2.7 Actions for agriculture and livestock (Action 7)

The key concept of agriculture and livestock is low emission agricultural technologies in which three actions are considered: efficient use of technologies (Action 7.1); highly efficient fertiliser application and residue management (Action 7.2); and recovery and use of methane gas from livestock manure (Action 7.3).

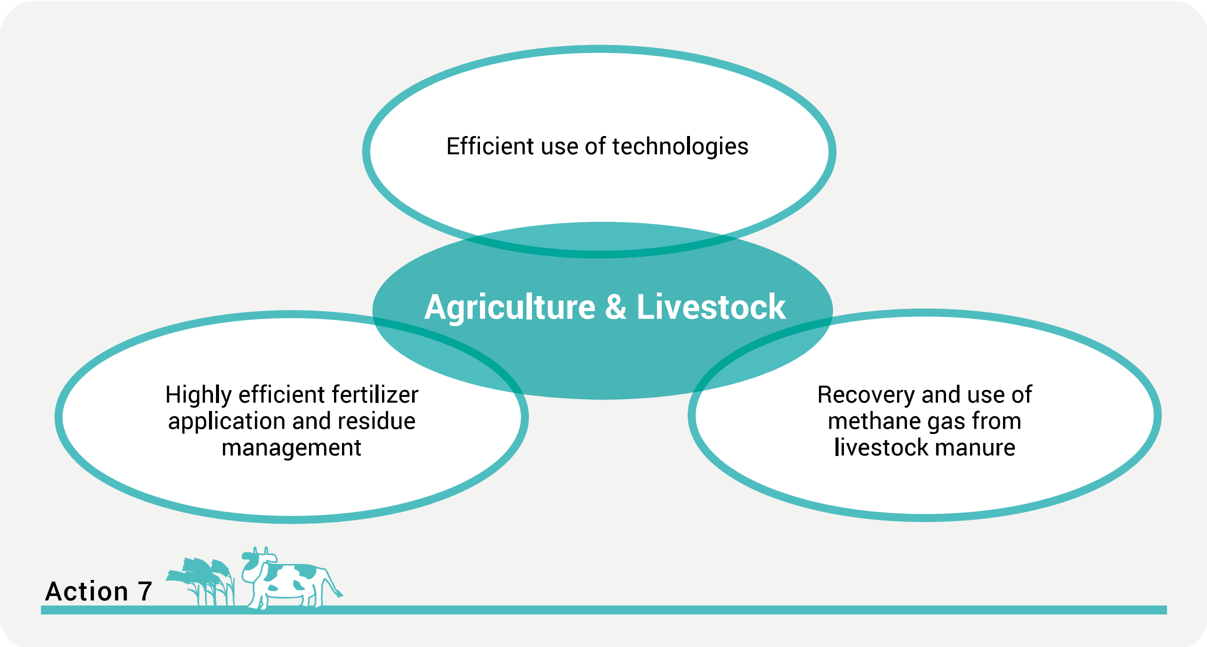

Figure 2.7 Key actions for agriculture and livestock

Action 7.1: Efficient use of technologies

Many new technology applications are emerging for improving the management of not only farming but also marketing and selling agricultural products. Such technologies have the potential to enhance efficiency, mitigate GHG emissions, support sustainable practices, and simultaneously improve the economics of farming as well as farmers.

For instance, best practice knowledge and techniques can be applied to improve the efficiency of water resource usage. Rice paddy fields that are continuously flooded during the entire cultivation period produce more CH_4 emissions than fields that are not flooded the whole time. Such "midseason drainage" involves the removal of surface water from the field during the cultivation period. This is a longstanding custom to prevent root decay and increase crop yield in Japan. Moreover, alternating flooding and drainage is also applied to manage crop growth and avoid waterlogging. To implement a system that allows midseason drainage and alternating flooding and drainage, appropriate infrastructure is necessary. In addition, a high water storage capacity is needed to provide sufficient water for rice paddies in rain-fed areas. For these reasons, irrigation facilities and reservoirs need to be installed as required. These techniques can contribute to emissions mitigation and also a reliable water supply for food production.

IT technologies contribute to both efficient agricultural production and marketing and distribution. Weather forecasts provide useful information for selecting suitable seeds and optimal planting times. The value of such information continues to rise as the effects of climate change increase. Greater fluctuations and uncertainties in weather patterns make farmers more vulnerable, therefore the role of IT for accessing reliable information will acquire greater importance. At present, good models of sustainable and low carbon farming (for example, organic farming) are confined to selected local experiments by individuals and small communities in certain parts of the world.

IT can play a useful role in connecting such individuals and communities and spreading information about best practices of sustainable agriculture.

IT can also help small farmers overcome the barriers of location and scale. Most small farmers do not have the capacity to reach out to the right customers and market their produce. With the help of IT technologies such as the Internet, farmers have begun selling their products directly to customers by highlighting special values such as health benefits, environment friendliness and low carbon. Health and environmentally conscious customers often face the barrier of lack of reliable information about sources of supply, thus IT helps connect such farmers and customers, thereby increasing the markets for sustainable agriculture. Small farmers in developing countries face higher barriers due to imperfect markets, dependence on local rent-seeking agents, and poor access to information and finance. If they are trained in the use of IT and the appropriate IT infrastructure is set up in rural areas, they can gain access to weather forecasts, bank loans, and markets, which will all help. Further, they will secure better prices for their produce by virtue of being able to access markets over a larger geographical radius than that without IT support.

Action 7.2: Highly efficient fertiliser application and residue management

In the soil, N_2O is generated from the biological reaction between microbes and nitrogen fertiliser applied to croplands. Avoiding excessive use of nitrogen fertiliser and increasing the efficiency of nitrogen use will contribute to reduced N_2O emissions from croplands.

Several effective technologies to reduce fertiliser use are available, such as spreader machines, "split fertilisation" machines, and slow release fertiliser machines. Knowledge of these techniques needs to be shared so that they can be put into wider practice.

The tillage of cropland can cause soil disturbance and reduce the carbon stock in the soil. Carbon is contained in crop residues and is emitted into the atmosphere through burning and decomposition. Zero tillage and low tillage are known as methods to avoid soil disturbance and increase the carbon stock in the soil. Stopping the practice of burning residues will also contribute to reductions in emissions. Such useful methods of tillage and residue management also need to be shared.

Action 7.3: Recovery and use of methane gas from livestock manure

Untreated manure releases CH_4 into the atmosphere due to anaerobic decomposition. Therefore, the use of CH_4 derived from manure as energy contributes to both GHG emissions reduction and clean energy supply.

There are various types of manure plants. In an anaerobic decomposition plant, manure is decomposed by bacteria and biogas is generated and used in farms or homes for cooking and lighting. Since large plants are still expensive, farmers can start by installing farm-scale plants or simple, low-cost plants. It is reported that unheated-type decomposition plants using the same mechanism have already been installed in some Asian countries, including China and India.

At the same time, introducing regulations on manure management as well as providing financial support for the installation of manure management systems are expected to promote implementation of these infrastructures.

Table 2.7 Timeline of actions for biomass energy

Stakeholder	Action category	Action	Level of achievement 2030 %	2040 %	2050 %
Government	Action 7.1	Technology transfer for water management in rice paddies	75	99	99
		Set up IT infrastructure in rural areas to facilitate access of farmers to information about weather forecasts and best practices, and to finance and markets	75	99	99
	Actions 7.1 & 7.2	Social infrastructure for agricultural technology diffusion (e.g., irrigation, manure management systems)	75	99	99
		Research and development of technologies that account for specific regional conditions	75	99	99
	Action 7.2	Introduce regulations and obligations (e.g., regulations on managements of crop residue and livestock manure, cessation of excessive reliance on fertilisers)	75	99	99
		Disseminate technology and information on highly efficient fertiliser application	75	99	99
		Develop slow-release fertilisers and reduce their costs	75	99	99
		Diffuse concentrated feed system	75	99	99
Private Sector	Action 7.1	Water management in rice paddies and fertiliser management in croplands	75	99	99
		Provide information for better agricultural production including weather forecast	50	75	99
		Use of IT to connect farmers engaged in sustainable and low carbon practices with each other and with customers, thereby spreading best practices and markets for sustainable agriculture	50	75	99
	Actions 7.1, 7.2 & 7.3	Active participation technical training	75	99	99
	Action 7.2	Replace roughage with concentrate feed	75	99	99
	Action 7.3	Utilise methane from livestock manure	75	99	99
Citizens	Action 7.1	Preference for agricultural products produced by low carbon farming methods	75	99	99
		Networks of customers of sustainable and low carbon agricultural products that help spread awareness and connect with farmers	50	75	99
	Action 7.3	Self-consumption of methane from manure management	75	99	99
International	Actions 7.1, 7.2 & 7.3	Technology transfer and joint research	75	99	99
		Promote preference for low carbon agricultural products	75	99	99

2.8 Actions for land use and forestry (Action 8)

The key concept of forestry and land use is sustainable forestry management in which three actions are considered: forest protection and effective plantation (Action 8.1); sustainable peatland management (Action 8.2); and monitoring and management of forest fires (Action 8.3).

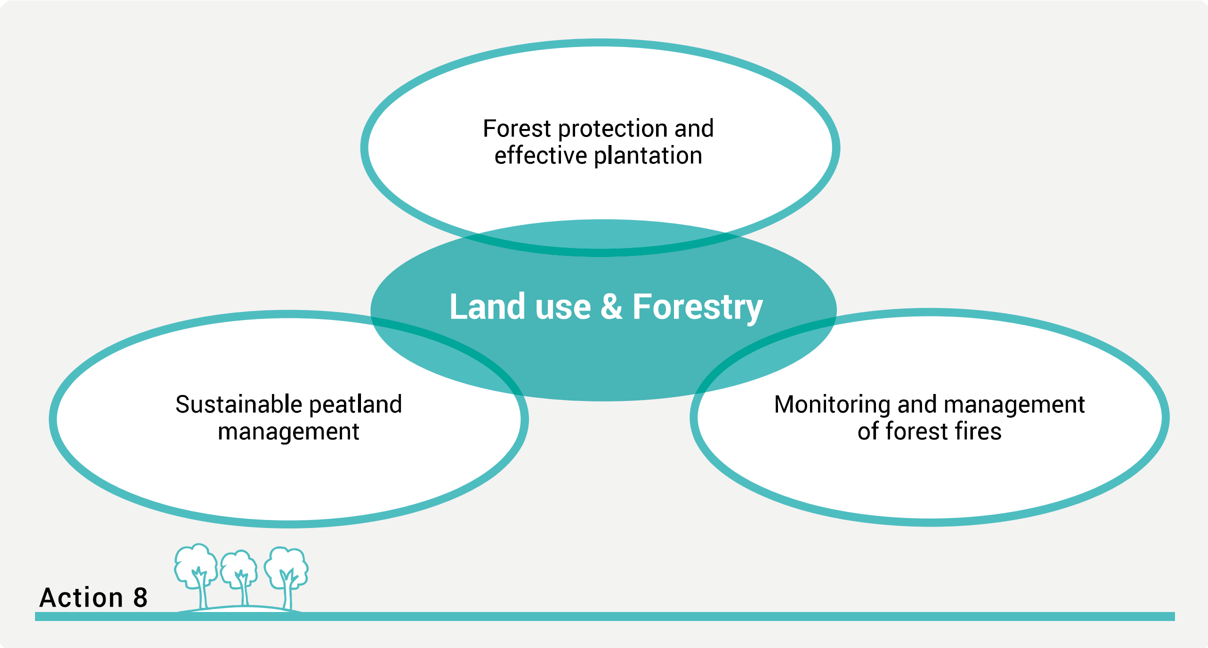

Figure 2.8 Key actions for land use and forestry

Action 8.1: Forest protection and effective plantation

The following four measures can contribute to the reduction of unplanned deforestation. First is reduction of shifting cultivation, which refers to a cycle in which cultivation of crops is carried out in such a way that results in soil degradation and drop in crop productivity, meaning farmers create new areas for cultivation by clearing forested land. The dissemination of skills and technologies to allow farmers to continue cultivation on the same land will promote the resettlement of forest squatters and reduction of unplanned deforestation. The second measure is the provision of financial support and basic education to people whose lives depend on illegal logging. Illegal logging can be reduced by tree planting and forest management activities aimed at generating alternative employment and financial support for these people. The third measure is the establishment of forest management units (FMUs). This involves the classification of forests into several units, and establishing an FMU for each unit. The FMUs enforce strict regulations on unplanned deforestation and illegal logging and protect the overall forest from unplanned deforestation. The final measure is involvement of the community in forest management. Local governments should establish community forests and forest boundaries with community participation, and improve forest extension services in high-risk areas. Such community participation will serve as an incentive to promote forest management among local communities and encourage them to gain knowledge and management skills.

Reduction of planned deforestation will also contribute to sustainable forest management through regulations, strict management of land use permits and mandating certifications for deforestation.

Enlargement of the carbon stock on remaining forestland is also important. Enhancing natural regeneration and reforestation of critical, degraded, or unproductive forest areas will increase the carbon stock of forests, and the private sector can also contribute here by establishing private forests. This will require dissemination of planting techniques and measures for easy access to forestland. Social and financial support will also promote the entry of private participants.

Action 8.2: Sustainable peatland management

Improving peatland management practices is important as this will reduce peatland exploitation and prevent forest fires. Governments should enforce strict compliance with regulations on the cultivation of peatland, allowing cultivation only on land with a peat depth of less than 3 m and prohibiting it on land with a greater peat depth. These management practices can be flexibly tailored according to the demand for land for crops and plantations.

In addition, towards the goal of zero burning, the lighting of fires for the clearing of peatland must be strictly controlled, as should the management of water resources. Peatland rehabilitation is achieved by preventing uncontrolled fires and improving water quality. Effective measures for the improvement of water quality include blocking off water channels and establishing regulations on water quality. Reforestation of degraded peatland also contributes to its rehabilitation.

Action 8.3: Monitoring and management of forest fires

Since forest fires are a major source of GHG emissions, fire management is important.

The practice of burning for land clearance can cause uncontrolled fires, so it is necessary to prevent the lighting of such fires. Incentive mechanisms to promote zero burning as well as rental of tractors and machinery can be effective measures here.

At the same time, uncontrolled fires themselves need to be prevented. The development of an early warning system for fires, establishment of a fire-extinguishing system and deployment of rangers are important measures for this purpose. Members of local communities should also be encouraged to participate in firefighting at the local level.

Table 2.8 Timeline of actions for forest and land use

Stakeholder	Action category	Action	Level of achievement 2030 %	2040 %	2050 %
Government	Action 8.1	Introduce classification of protected forest area	75	99	99
		Stop unplanned cropland expansion	75	99	99
		Enhance control of illegal logging	75	99	99
		Prohibit exportation of illegally logged timber and wood products	75	99	99
		Issue certificates for sustainable oil palm and wood products	75	99	99
		Technology transfers and information support for forest management	75	99	99
		Education and social support to those who depend on illegal logging	75	99	99
		Strengthen economic activities other than primary sector industry	50	75	99
	Actions 8.1, & 8.2	Establish land use plan	75	99	99
		Formulate and strengthen rules for land use	75	99	99
		Introduce licenses for usage in forestland and peatlands	75	99	99
	Action 8.2	Peatland management (e.g., peatland drainage, development of thick peat)	75	99	99
	Action 8.3	Enhance fire management	75	99	99
Private Sector	Action 8.1	Eliminate wood products made from illegally logged timber and use certificated products	75	99	99
		Allow logging, plantation and land clearance only by licensed persons	75	99	99
		Learn forest management skills for appropriate logging and forestation	75	99	99
Citizens	Action 8.1	Strengthen community activities to be independent of illegal logging	75	99	99
International	Action 8.1	Prohibit import of illegally logged wood	75	99	99
		Introduce international certificate of oil palm and wood products	75	99	99
		Enhance international cooperation for afforestation and education	75	99	99
		Share monitoring facilities such as satellites	50	99	99

2.9 Actions for technologies and finance (Action 9)

The key concept of technologies and finance is the provision thereof for low carbon society in which three actions are considered: promotion of private-sector R&D for LCS (Action 9.1); establishment of adequate funding to support R&D and technology diffusion (Action 9.2); and fostering environmentally conscious consumers who choose low carbon products (Action 9.3).

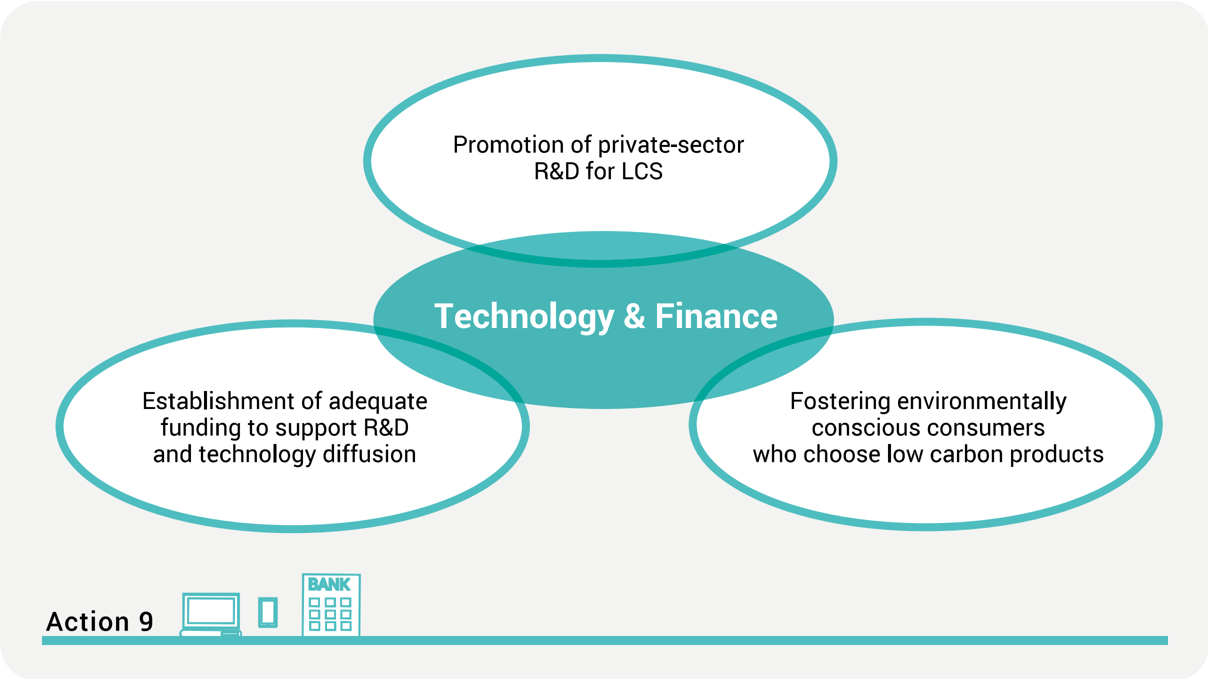

Figure 2.9 Key actions for technologies and finance

Action 9.1: Promote private-sector R&D for LCS

The first measure involves the sharing of knowledge and technologies related to LCS. Particularly at the technology development stage, it is important to establish programs for achieving green technologies within science and technology policies, to strengthen R&D networks between research institutes, and to build technology-demonstration partnerships.

The second measure is to strengthen institutional arrangements to promote technology diffusion. It is important to strengthen technical capabilities and capacity-building to train specialists, to strengthen knowledge of intellectual property rights (including patent systems), and to implement industry-by-industry technical cooperation programmes.

The third measure involves the implementation of economic incentives to stimulate private-sector investment. Examples include carbon credit systems, electricity-purchasing programs, subsidies, taxes. It is not enough merely to implement incentives; measures to facilitate the flow of private-sector funds, such as matching overseas investors with in-country project proponents and formulating policies to mitigate investment risk need introducing.

For example, in order to significantly advance the deployment of renewable energy systems, international R&D support for such systems should be linked with institutional cooperation to attract foreign investment and boost technology deployment, promotion of technology transfers, and tax system/institutional support to establish technologies in recipient countries.

Action 9.2: Establish adequate funding to support R&D and technology diffusion

The task of creating conditions needed for the R&D

and diffusion of low carbon technologies spans many sectors, so it is essential to consider the appropriate distribution of public and private funds, including international environmental funds and sector-based funds, depending on the purpose.

The Green Climate Fund (GCF) provides resources for capacity-building and technology transfer. UNFCCC reaffirmed the importance of financial resources at all stages of the technology cycle, including at the early stages, in order to enable Parties to enhance their mitigation and adaptation actions (UNFCCC, 2017).

Numerous renewable energy and energy-efficiency projects have been implemented in developing countries, funded by official development assistance (ODA) and international institutions, for basic infrastructure improvements and to boost economic development.

Equally important is the use of public funds to encourage greater investment from the private sector. Estimates of amounts of funds supplied to date for climate change mitigation show that the private-sector outweighs the public sector by a factor of from several ten to several hundred. These findings remind us of the importance of private-sector funds as a part of the total stream of financial flows.

Judged from a long-term economic viewpoint, investment in LCS would be the rational choice. Generally speaking, however, high initial investment costs are a major obstacle to private-sector companies in developing countries investing in low carbon technologies and using those that have already been commercialised. The speed with which private-sector companies can take action (e.g., to boost energy efficiency, carry out R&D to expand the use of renewable energy, manufacture energy-efficient products and sell them) holds the key to success in achieving a country's greenhouse gas emission reduction targets. Governments could therefore help private-sector companies overcome their financial and economic barriers by offering financial support so that the country's industrial centers can invest safely in innovative R&D—for example, through programmes to assist private-sector R&D, support to cover initial investment costs and risks, and measures to support the commercialisation of newly developed low carbon technologies.

Action 9.3: Foster environmentally conscious consumers who choose low carbon products

It is important that citizens are able to choose locally produced agricultural and other products that are certified as produced and supplied through sustainable and low carbon processes. When it comes to biomass resources, the promotion of "local production for local consumption" has important implications for the deployment of low emission agricultural technologies, and sustainable forest and land use management.

Citizens can also choose low carbon energy sources through their actions such as by installing photovoltaic equipment during new house construction, and purchasing green electricity. A widespread programme of education and awareness generation among citizens of various strata about comparative costs and benefits of low carbon devices and products vis-à-vis conventional ones could go a long way to enhancing acceptance of the former.

Table 2.9 Timeline of actions for technologies and finance

Stakeholder	Action category	Action	Level of achievement 2030 %	2040 %	2050 %
Government	Action 9.1	Establish programs for achieving green technology within science and technology policies	75	99	99
		Standardise energy efficiency of products	75	99	99
		Establish regulations to support developing innovative technologies	75	99	99
		Establish regulations to support commercialisation of innovative technologies	50	75	99
		End all scales of gasoline and diesel-powered vehicles	0	25	50
		Establish incentives for extending payback periods of innovative technologies	50	75	99
	Action 9.2	Implement economic incentives to develop innovative technologies	50	50	50
		Financial support for price reduction of low carbon products	50	25	25
		Subsidise prompt diffusion of existing low carbon products	50	25	25
		Support for large-scale projects such as CCS	50	50	25
		Establishment of low carbon technology funds	50	75	75
	Action 9.3	Provide information for the public to select low carbon appliances	75	75	99
Private Sector	Action 9.1	Develop low carbon technologies	75	75	99
		Exchange views with government on institutional barriers to technology diffusion	75	75	99
	Action 9.2	Increase investment of technology R&D with government support	75	75	99
	Action 9.3	Publicise strategies to inform consumers of low carbon products	75	75	99
Citizens	Action9.3	Smart consumers that select low carbon products	75	75	99
		Appropriate use of low carbon products without unnecessary uses	75	75	99
International	Action 9.1	Regional ownership of innovative technologies	50	75	99
	Actions 9.1 & 9.3	Capacity building toward recognition of Intellectual Property Right (IPR)	50	75	99
	Action 9.2	Establish strategies of funding mechanism for technologies in developing countries	50	75	99
	Actions 9.2& 9.3	Establish technology information centers in developing countries	50	75	99

2.10 Actions for governance (Action 10)

The key concept of governance is transparency and fairness, in which three actions are considered: create an efficient administrative management framework (Action 10.1); establish fair and transparent business practices (Action 10.2); improve literacy with respect to environmental policies and technologies (Action 10.3).

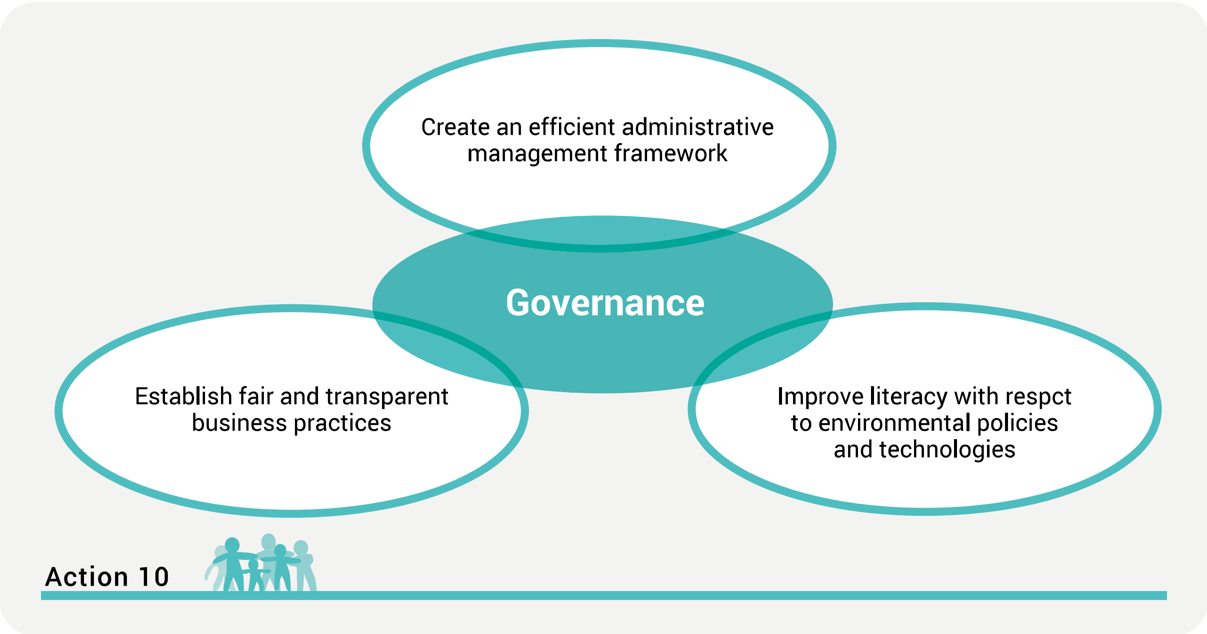

Figure 2.10 Key actions for governance

Action 10.1: Create an efficient administrative management framework

Due to the complex nature of climate change, its policies reside not only with the UNFCCC but also with forums outside of the United Nations system, including many international institutions at bilateral, regional, and multilateral levels. Thus, to resolve climate change issues we need to draw more implications from "fragmented governance," where the focus is not only on policy agreed under the UNFCCC, but also on the functions of various international institutions.

To make low carbon Asia a reality, it will be important to expand and spread norms to promote climate change policies into various policy areas, through fragmented international climate institutions. To achieve this, it will be necessary to create and strengthen efficient administrative management frameworks.

To strengthen the international system, it is necessary to strengthen governance at different levels: local, regional, national and global. Measures at the local level are important when it comes to adoption of measures such as local production of biomass resources for local consumption, use of low emission agricultural technologies, and decentralised renewable energy systems like rooftop solar photovoltaics (PV). It will be important in the future to encourage voluntary emission reduction efforts by developing countries through their use of combinations of various GHG reduction strategies.

It is also necessary to make institutional changes such as revisions to tax systems and land use plans. For this to happen, there is a need for countries to enhance policy coordination and technology transfers. For example, by sharing knowledge about the creation of smart energy systems, national governments can develop medium-term and long-term policies that incorporate the aims of LCS and are able to demonstrate domestically and abroad that they are working towards LCS.

Action 10.2: Establish fair and transparent business practices

Since companies are typically the actors that own low carbon technologies and carry out economic activities with them, their involvement is essential in the creation of effective management frameworks. To this end, there is a need for corporate activities to be conducted based on fair market principles, by encouraging public-private partnerships in cooperation with industry and by creating standardisation and certification systems.

When it comes to the deployment and transfer of low carbon technologies, it is beneficial to share information about best practices related to technology standardisation and codes, as well as labeling schemes. As regards product environmental labeling systems, product rating systems can be developed through cooperative international research on the efficient use of resources in technology development. Since emerging economies may not have well-established law enforcement systems, and may be dealing with many administrative issues, being able to effectively make use of existing label international certification systems could be valuable for them. Examples include support for the establishment of building codes suited to certain climate zones and energy-efficiency standards for industrial equipment.

It is also possible to obtain objective, expert evaluations of low carbon technologies by creating product evaluation systems through industry-government collaboration and operating independent evaluation systems. Such independent evaluation systems can contribute to smart ways of using materials that realise the full potential of resources. It is also important to link these certification systems with the institutional frameworks of existing certification systems.

Action 10.3: Improve literacy with respect to environmental policies and technologies

Equally important for strengthening the framework of administrative management and promoting business activities based on fair market principles is the promotion of environmental education, to achieve a transformation in citizens' lifestyles towards low carbon living. Policy reviews are also essential for raising the environmental awareness of developing-country governments and motivating them to bolster their voluntary GHG emission reduction activities.

Stronger environmental education can be expected to transform awareness, possibly leading to the proactive choice of public transport means such as rail and water transport, renewable energy options, and products with low carbon footprint.

The same can be applied to smart ways of using materials that realise the full potential of resources. By being exposed to demonstrations showing the superiority of lifestyles with low material consumption and raising consumer awareness of environmental consideration and energy efficiency, citizens would be imbued with higher awareness and motivation to engage in sustainable consumption patterns, such as purchasing low carbon products and recyclable/reusable products.

Table 2.10 Timeline of actions for governance

Stakeholder	Action category	Action	Level of achievement 2030 %	2040 %	2050 %
Government	Action 10.1	Establish short-, medium- and long-term LCS visions	50	75	99
		Strengthen capacities in relevant agencies to design/implement low carbon policies	50	75	99
		Establish interagency coordination mechanism to align low carbon policies with other development priorities	50	75	99
		Develop multi-stakeholder engagement to bring diverse interests into policymaking process	50	75	99
		Strengthen multi-level governance to encourage and scale up local innovation	50	75	99
		Implement legal and institutional requirements for LCS	50	75	99
		Establish transparency framework to enhance accountability and reduce corruption	50	75	99
		Establish and implement legal and institutional arrangements for fair and equal resource allocation	50	75	99
	Action 10.3	Provide literacy education for environmental policy and technology	50	75	99
Private Sector	Action 10.2	Establish fair and transparent business practices	50	75	99
		Improvement of compliance with internationally agreed business and market principles	50	75	99
Citizens	Action 10.1	Enhance public-private and private partnerships	25	50	75
	Action10.3	Advocate policy recommendations and monitoring for administrative transparency	50	75	99
		Behavioral changes for environmentally desirable consumption patterns	50	70	75
International	Action 10.1	Create LCS governance indicators (e.g., NDC, SDG)	75	99	99
		Support management framework for improved government administration	50	75	75
		Establish framework for sharing good practices and lessons learned	50	75	75
		Support global partnership that distributes financial and other resources to implement low carbon policy	50	75	75
	Actions10.1 & 10.2	Establish framework for technology transfers	50	75	75
	Action 10.3	Capacity building for technology, policy, and administrative efficiency	75	99	99

Chapter 03

Interactions between climate actions and SDG targets

There are many interactions between climate actions and other SDGs (International Council for Science, 2017; Pahuja and Raj, 2017; Northrop et al., 2016; UNEP, 2016). Here we look at those of the 10 low carbon actions described in chapter 2 with other SDGs targets. Some are direct interactions, while others are indirect; some are positive, and some are negative.

Figure 3.1 illustrates the relation between the 10 actions and SDGs. Governance is essential for effective planning and implementation of policies and measures concerning all SDGs. The action for technologies and funding is also fundamental to implementation of all SDGs.

Further, it is evident that all 10 actions are closely related to SDG 13 (climate action), thus here we discuss the interactions of the ten actions with the SDGs other than SGD 13 in order to highlight the synergies between them and also trade-offs that would have to be avoided when designing policy interventions.

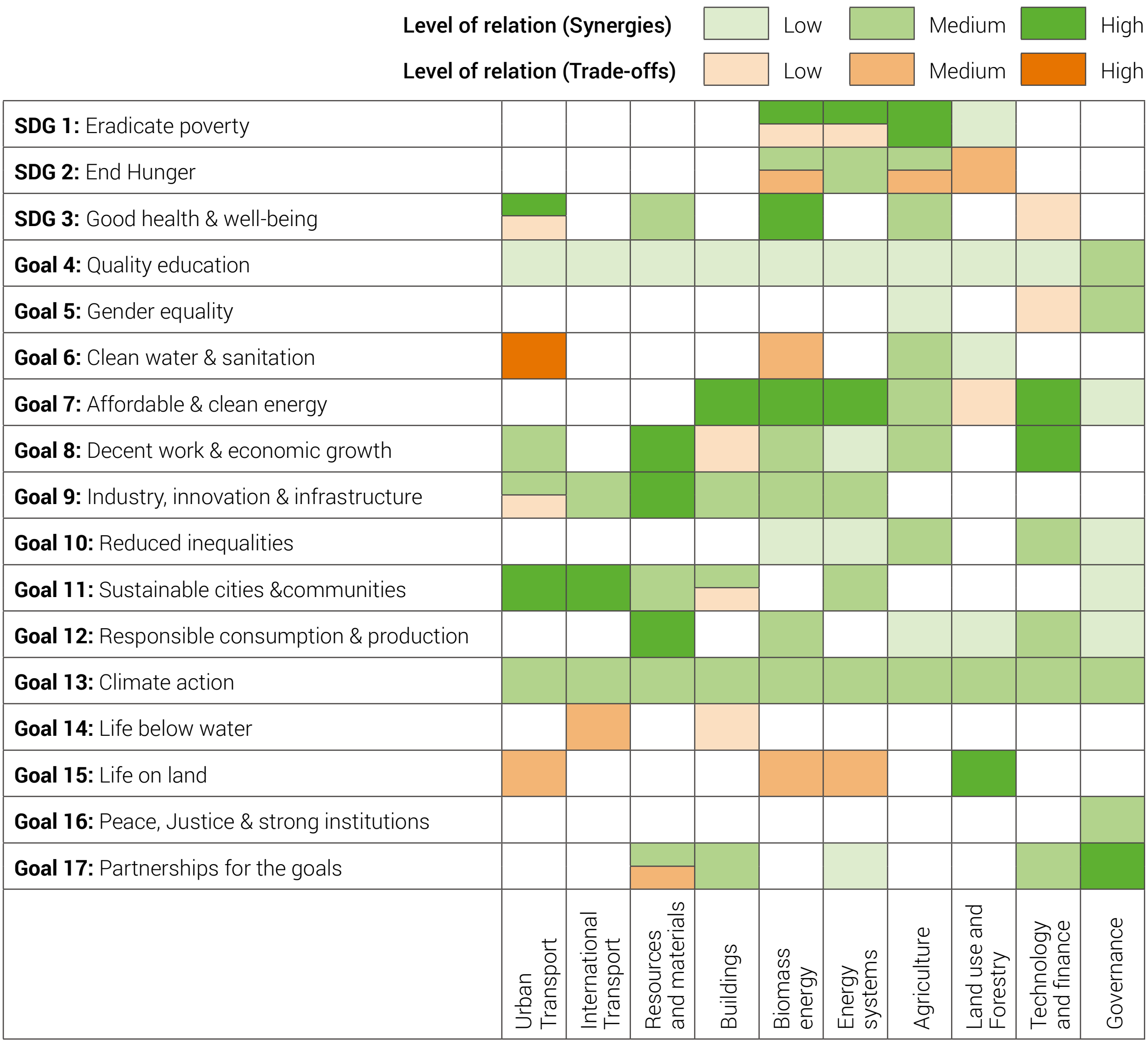

Figure 3.1 Level of relation between the 10 climate actions and other SDGs

The interactions between the climate actions and the SDGs are illustrated in Table 3.1 These actions are mainly referred to as the '10 actions'.

Table 3.1 Key interactions between the 10 actions and SDGs

SDG	Synergies	Trade-offs
Goal 1: No poverty	Low carbon energy systems using local biomass resources can create jobs (Action 5.2) Promotion of decentralised energy systems with renewables can create jobs (Action 6.1) Enhanced food productivity can reduce poverty (Action 7.1) Climate actions can reduce the adverse impact on economic well-being (resulting in increase in the number of poor people) caused by climate change (e.g., flood, sea level rise)	If the rural poor are not involved in the development of biomass energy, existing economic inequality and poverty might continue (Actions 5.1& 6.1)
Goal 2: End hunger	Sustainable co-production of biomass and food can contribute to reduce hunger (Action 5.1) Promoting renewable energy can increase the income for local people, thus reduce hunger (Action 6) Increased food productivity can reduce hunger (Action 7.1) Climate actions can prevent or mitigate the decline in food production caused by climate change (e.g., temperature increase, change of precipitation patterns)	Biomass energy production can reduce the areas for food production (Action 5.1)
Goal 3: Good health & well-being	Shifts to public transport can reduce the number of deaths and injuries from road traffic accident (Action 1.1) Development of environment friendly production and consumption can increase well-being (Action 3) Zero emission buildings can reduce instances of apoplectic stroke (Action 4.1) Use of efficient and modern cook stoves will reduce exposure to indoor air pollution (Action 5.3) Promoting efficient and organic use of fertilisers will avoid adverse impacts of chemicals (Action 7.2) Climate actions can avoid excessive increase in temperature, which causes rise in hyperthermia and epidemics	Fertiliser use, even if efficient, can add to adverse impacts on soil pollution (Action 7.2) Excessive pursuit of economic productivity has the potential to increase pollution (Action 9.2)
Goal 4: Quality education	Education contributes to all climate actions Climate actions can enhance awareness and opportunities for education	
Goal 5: Gender equality	Promoting gender equality could foster environmentally conscious consumers (Action 9.3)	Excessive pursuit of economic productivity has the potential to underestimate unpaid care (Action 9.1)
Goal 6: Clean water & sanitation	Sustainable use of fertiliser contributes to improvement and maintenance of water quality (Action 8.2) Climate actions can prevent water-related damage from worsening (e.g., desertification, floods).	Developing urban areas can be associated with negligence of rural areas where forests are not maintained properly, which causes damage to water bodies (Action 1.1) Co-production of biomass energy and food can interfere with local water related ecosystems (Action 5.1)

Goal 7: Affordable & clean energy	Increase in the share of renewables contributes to the increase in clean energy (Actions 5 & 6)	Increase in biomass farms may conflict with forest preservation objectives (Action 8.1)
Goal 8: Decent work & economic growth	Technological upgrading contributes to achieving higher economic activity (Actions 9.1 & 9.2)	Pursuit of increasing GDP might damage natural resources (Action 3.1)
Goal 9: Industry, innovation & infrastructure	Development of international transport can contribute to sustainable infrastructure and industry (Action 2.1)	Developing urban areas can be associated with negligence of rural areas, which may not be a sustainable development trend from the viewpoint of a country (Action 1.1)
Goal 10: Reduced inequalities	Technology transfer can contribute to reduction of inequalities (Action 9.2)	
Goal 11: Sustainable cities and communities	Development of compact cities contributes to the development of sustainable cities (Action 1.1)	Promoting low carbon building can conflict with the objective of protecting heritage (Action 4.1)
Goal 12: Responsible consumption & production	Efficient use of materials and resources compliments responsible consumption and production (Action 3)	
Goal 13: Climate action	All 10 actions are included	–
Goal 14: Life below water	Actions for forest preservation can also preserve marine and coastal ecosystems (Action 8.1)	Increase in water transport can increase marine pollution (Action 2.1)
Goal 15: Life on land	Actions for forest preservation can also preserve ecosystems on land (Action 8.1)	Developing urban areas can be associated with negligence and damage of ecosystems in rural areas (Action 1.1) Biofarms can damage ecosystems on land (Action 5.1)
Goal 16: Peace, justice & strong institutions	Creating an efficient administrative management framework can contribute to justice (Action 10.1)	
Goal 17: Partnerships for the goals	Establishment of fair and transparent business partnerships can promote sustainable development goals (Action 10.2)	The target of increasing the share of global exports may damage natural resources (Action 3.1)

3.1 Interactions between climate actions of urban transport and other SDGs

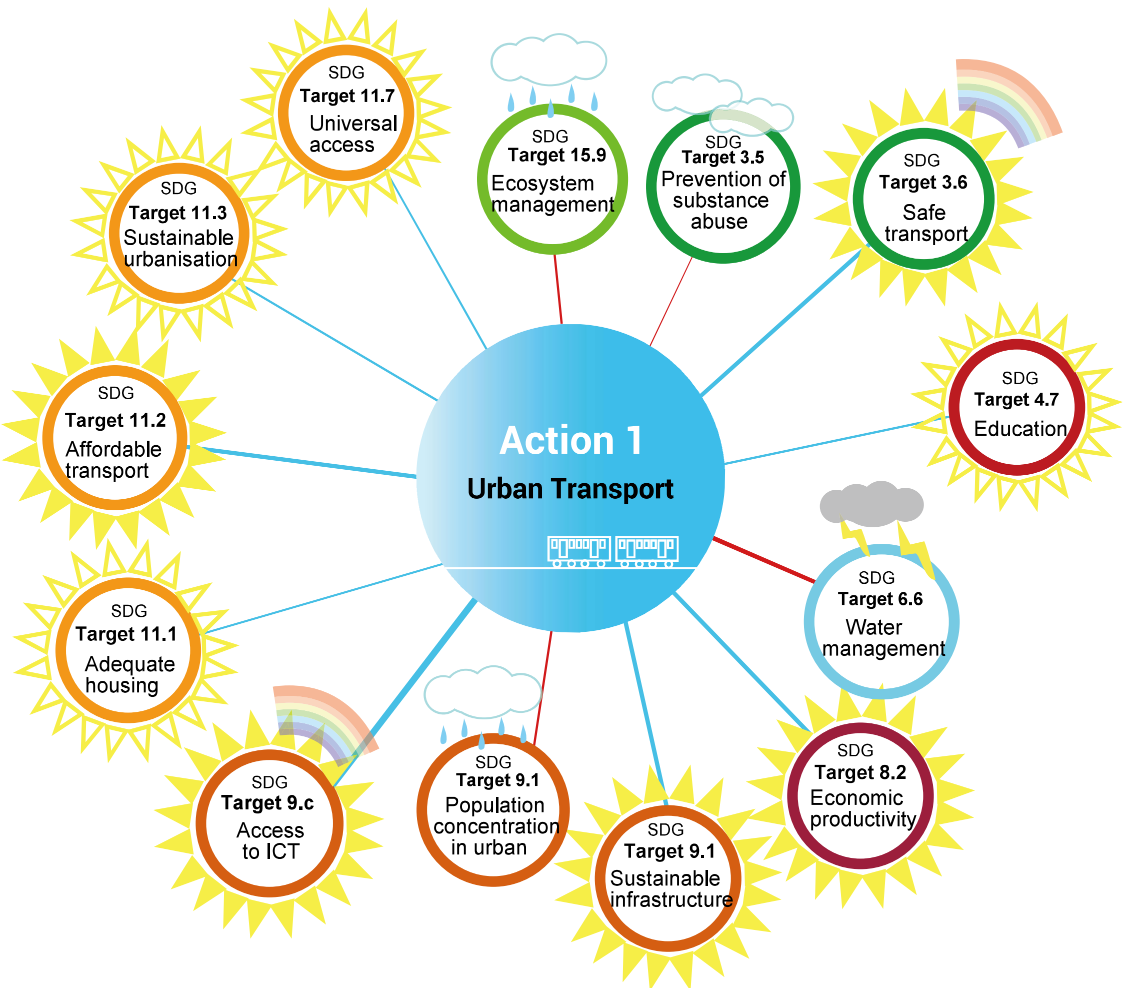

Figure 3.2 Key interactions between actions of urban transport and other SDG targets

Table 3.2 Synergies of climate action 1: "urban transport" with SDG targets

Theme	Targets having synergies with Action 1	Synergies
Safe transport	**Target 3.6:** Halve the number of global deaths and injuries from road traffic accidents	Well-designed pedestrian and bike roads as well as traffic control systems contribute to reducing traffic accidents (+++).
Education	**Target 4.7:** Ensure all learners acquire the knowledge for sustainable development	Knowledge and skills can promote sustainable urban design (+).
Economic productivity	**Target 8.2:** Achieve higher levels of economic productivity	Enhancing technological levels and innovation can contribute to increase in low carbon vehicles (++).
Sustainable infrastructure	**Target 9.1:** Develop quality, reliable, sustainable and resilient infrastructure	Development of infrastructure for efficient urban public road network can facilitate the shift to public transport as well as reduction of commuting distance (++).

Access to ICT	**Target 9.c:** Increase access to information and communication technology	Increase of access to ICT can facilitate telecommuting which contributes to reduction of traffic volume (+++).
Adequate housing	**Target 11.1:** Ensure access for all to adequate, safe and affordable housing	Developing infrastructure of compact cities can contribute to secure access for all to adequate, safe and affordable housing (+).
Affordable transport	**Target 11.2:** Ensure access for all to adequate, safe and affordable transport system	Providing access to safe, affordable, accessible and sustainable transport systems can facilitate the shift to public transport (++).
Sustainable urbanisation	**Target 11.3:** Enhance inclusive and sustainable urbanisation	Designing compact cities goes with inclusive and sustainable urbanisation (+).
Universal access to safe, green and public spaces	**Target 11.7:** Provide universal access to safe, inclusive and accessible, green and public spaces	Urban planning includes universal access to safe, inclusive and accessible, green and public spaces (+).

Table 3.3 Trade-offs of climate action 1: "urban transport" with SDG targets

Theme	Targets having trade-offs with Action 1	Trade-offs
Prevention of substance abuse	**Target 3.5:** Strengthen the prevention and treatment of substance abuse	In the process of urbanisation, disorganisation can create slum areas, with problems of unemployment/under-employment and drugs addiction. Therefore, proper governance and management of cities including provision of economic opportunities and essential social security is important (-).
Water resource management	**Target 6.6:** Protect and restore water-related ecosystems	Developing urban areas could further increase rural-to-urban migration and reduce population in rural areas, which may affect the management of forest and arable lands. This can also influence the quality of water and aquatic life (---).
Infrastructure	**Target 9.1:** Develop quality, reliable, sustainable and resilient infrastructure	Development of compact cities may increase urban population and reduce rural population, which may not be a sustainable trend from a country's viewpoint (--). To develop road networks so as to provide accessibility to roads within 2 km for all people could cost a lot and promote motorisation. There may be an option to develop special low carbon cars suitable for driving in rural and rough terrains, and share them within communities(-).
Ecosystem management	**Target 15.9:** Increase ecosystem and biodiversity values	Urbanisation can shift populations from rural to urban areas which may affect land use and forest management (--).

Box: Integration of SLCPs/air pollution into NDCs

Short-lived climate pollutants (SLCPs) are species of air pollutants such as black carbon, methane, tropospheric ozone, and hydroflourocarbons (HFCs) that contribute to significant near-term climate warming over relatively short atmospheric lifetimes (weeks to a decade) while also having adverse impacts on air quality, public health, and/or other immediate development concerns (i.e. saving energy). Mitigating SLCPs can help achieve Paris Agreement goals as well make progress on climate change, air quality, public health, sustainable cities, sustainable consumption and production and energy-savings targets under the sustainable development goals (SDGs). As such, some countries have begun to integrate SLCPs or related terms and actions into their nationally determined contributions (NDCs). This is particularly important in Asia where the SLCP emissions and multiple benefits from their mitigation are the greatest.

Table Box.1 below highlights the results of an analysis of countries in Asia that have integrated SLCPs (or related terms and actions) into their nationally determined contributions (NDCs). Most remarkably, it shows that India, Sri Lanka and Laos PDR focus on achieving black carbon reductions in the transport sector through measures targeting diesel emission reductions. As for methane, Bangladesh, Cambodia, China, Indonesia, Japan, Malaysia, Nepal, South Korea, Sri Lanka, Thailand, and Viet Nam outline plans to reduce methane in their NDCs in the waste, agriculture, and energy sectors. In the waste sector, Bangladesh has set clear targets for landfill gas to be captured and used for electricity generation. Meanwhile, Bangladesh, China, Japan, South Korea, Thailand and Viet Nam expressed their intent to reduce HFCs, while Japan is introducing refrigerant control technology and some other measures to control emissions of fluorinated gases.

Table Box.1 SLCP reduction mentioned in NDCs in Asian Countries

Country	BC	Methane	HFC
Bangladesh		●	●
Cambodia		●	
China		●	●
India	●		
Indonesia		●	
Japan		●	●
Lao	●		
Malaysia		●	
Nepal		●	
South Korea		●	
Sri Lanka	●	●	
Thailand		●	
Viet Nam		●	

(Kaoru Akahoshi and Eric Zusman)

3.2 Interactions between climate actions of interregional transport and other SDG targets

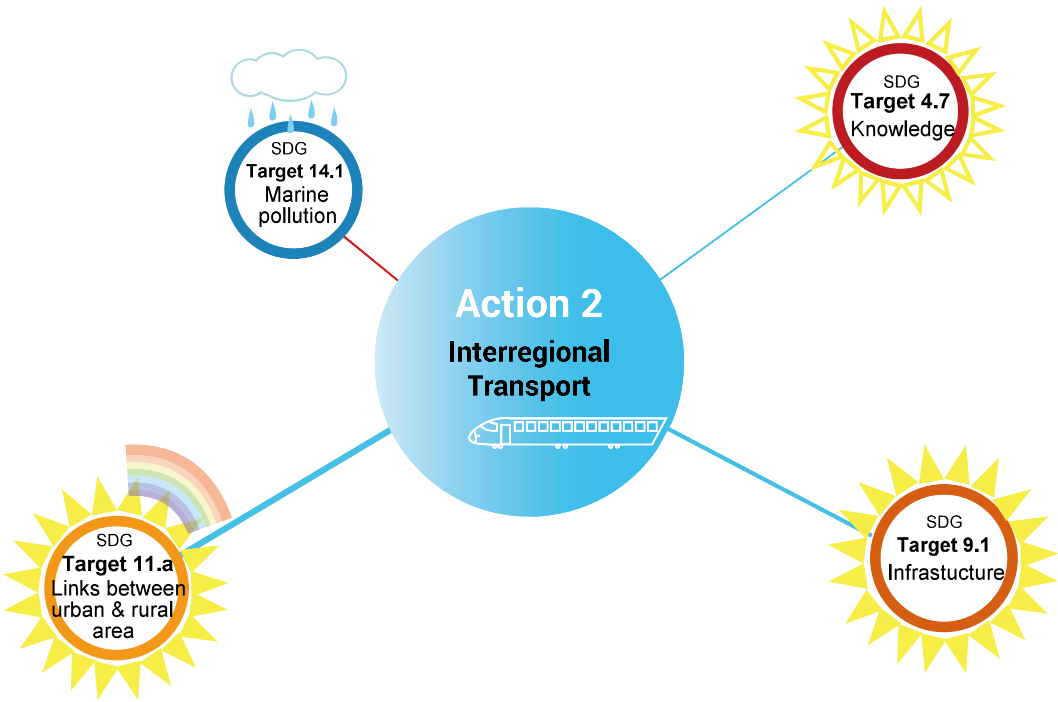

Figure 3.3 Key interactions between actions of interregional transport and other SDG targets

Table 3.4 Synergies of climate action 2: "interregional transport" with SDG targets

Theme	Targets having synergies with Action 2	Synergies
Knowledge	**Target 4.7:** Ensure that all learners acquire the knowledge and skills to promote sustainable development	Acquiring knowledge promotes awareness about sustainable interregional transport (+).
Infrastructure	**Target 9.1:** Develop quality, reliable, sustainable and resilient infrastructure	Achieving targets to improve infrastructure quality is likely to contribute to development of sustainable interregional transport, and vice versa (++).
Links between urban and rural areas	**Target 11.a:** Support positive economic, social and environmental links between urban, semi-urban and rural areas by strengthening national and regional development planning	Developing sustainable interregional transport contributes to enhancing urban and rural links (+++).

Table 3.5 Trade-offs of climate action 2: "interregional transport" with SDG targets

Theme	Targets having trade-offs with Action 2	Trade-offs
Marine pollution	**Target 14.1:** Prevent and significantly reduce marine pollution of all kinds	Mainstreaming water transport can increase marine pollution if it is not properly managed (--).

3.3 Interactions between climate actions of resources and materials and other SDG targets

Figure 3.4 Key interactions between actions of resources & materials and other SDG targets

Table 3.6 Synergies of climate action 3: "resources and materials" with SDG targets

Theme	Targets having synergies with Action 3	Synergies
Reduction of pollution	**Target 3.9:** Reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	Development and deployment of environment friendly products as well as the reduction of production has synergies with decrease in air and water pollution. (++).
Skills to promote SCP (Sustainable Consumption & Production)	**Targets 4.2, 4.3, 4.7:** Ensure that all learners acquire the knowledge and skills needed to promote sustainable development	Sufficient knowledge and skills are essential to promote sustainable consumption patterns. Also, since primary education can help in developing a fundamental mindset of sustainable use of products, education should be accessible for all children equally throughout the world (+).

Economic productivity	**Target 8.2:** Achieve higher levels of economic productivity through diversification, technological upgrading and innovation	Improvement of productivity through upgrading technologies and innovation can realise efficient use of resources (++).
Resource efficiency in consumption & production	**Target 8.4:** Improve progressively global resource efficiency in consumption and production, and endeavor to decouple economic growth from environmental degradation	The framework of sustainable consumption and production can help decouple global resource efficiency with economic growth (+++).
Resource efficiency in infrastructure	**Target 9.4:** Upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency	Upgrading infrastructure and retrofitting industries with greater adoption of clean and environmentally sound technologies and industrial processes can increase resource use efficiency (+++).
Protection of heritage	**Target 11.4:** Protect the cultural and natural heritage	Enhanced respect for natural resources and local heritage leads to extension of their life span (++).
Integrated policies	**Targets 11.6:** Reduce the adverse per capita environmental impact of cities **Target 11.b:** Increase the number of cities to adopt integrated policies	Increase in the number of cities and human settlements that adopt and implement integrated policies and plans can also contribute to increased resource efficiency (++).
Programmes on SCP (Sustainable Consumption & Production)	**Targets 12.1:** Implement the 10-Year Framework of Programmes on SCP **Target 12.a:** Support developing countries to move towards more SCP **Target 12.c:** Rationalise inefficient fossil-fuel subsidies	Implementation of 10-year framework of Programmes on Sustainable Consumption and Production can significantly support to achieve the target of resource efficiency in both developed and developing countries (+++). Supporting developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production will help increase resource efficiency (+++).
Efficient use of natural resources	**Target 12.2:** Achieve sustainable management and efficient use of natural resources	Adopting the metrics of material footprint per capita and per GDP can help achieve sustainable management and efficient use of natural resources. (++).
Waste reduction	**Target 12.5:** Substantially reduce waste generation	Realising full potential of resources contributes to waste reduction (++).
Sustainable practices	**Target 12.6:** Promote companies to adopt sustainable practices	Adoption of sustainable practices by companies is likely to contribute to efficiency of resources and materials (++).
Public procurement	**Target 12.7:** Promote public procurement practices	Sustainable public procurement policies promote efficient use of materials (++).
Technology diffusion	**Target 17.7:** Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries	Promotion of the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries is significantly correlated with overall enhancement of efficiency and sustainability of resource and material cycles (++).

Table 3.7 Trade-offs of climate action 3: "resources and materials" with SDG targets

Theme	Targets having trade-offs with Action 3	Trade-offs
GDP growth	**Target 8.1:** Annual growth rate of real GDP per capita	Targets of increasing GDP might damage resources as has been already experienced by developed countries (--).
Development-oriented policies	**Target 8.3:** Promote development oriented policies	Development-oriented policies should be carefully organised since encouraging economic growth unilaterally causes social problems and damages bio-diversity and well-balanced environmental conditions (-).
Industrialisation	**Target 9.2:** Promote inclusive and sustainable industrialisation	Raising industry's share of employment and GDP without effective policies for clean and green growth may increase carbon emissions (-).
Increase exports	**Target 17.11:** Significantly increase the exports of developing countries	Targets of increasing the share of global exports may cause negative impact on the environment through logistics and production processes, and also increase waste and pollution (--).

3.4 Interactions between climate actions of buildings and other SDG targets

Figure 3.4 Key interactions between actions of low carbon buildings and other SDG targets

Table 3.8 Synergies of climate action 4: "buildings" with SDG targets

Theme	Targets having synergies with Action 4	Synergies
Capacity building	**Target 4.b:** Expand the number of scholarships in developing countries Target 4.c: Increase the supply of qualified teachers in developing countries	Fundamental capacity building in higher education contributes to expanded awareness of energy efficient buildings (+).
Energy efficiency	**Target 7.1:** Ensure universal access to affordable, reliable and modern energy services **Target 7.2:** Increase the share of renewables **Target 7.3:** Double the global rate of improvement in energy efficiency	Increase in access to modern energy and share of renewables, and improvement in energy efficiency can support the dissemination of energy-efficient buildings. (+++).
Support for modern energy	**Target 7.a:** Enhance international cooperation to facilitate access to clean energy research and technology **Target 7.b:** Expand the supply of modern and sustainable energy services	International support to expand modern energy services contributes to development of low carbon buildings (+++).
Infrastructure	**Target 9.1:** Develop quality, reliable and resilient infrastructure **Target 9.2:** Promote inclusive and sustainable infrastructure **Target 9.4:** Upgrade infrastructure and retrofit industries	Promoting sustainable industrialisation also promotes low carbon buildings (+).
Economic activity	**Target 9.3:** Increase access of small-scale enterprises	Increase of economic activities in developing countries can enhance deployment of low carbon buildings (++).
Education	**Target 9.5:** Enhance scientific research **Target 13.3:** Improve education, awareness-raising and human and institutional capacity	Improvement in scientific research and education system can help to increase awareness about low carbon buildings (+).
ICT technology	**Target 9.c:** Significantly increase access to information and communications technology	Internet technologies and other information technologies can help to spread awareness about low carbon buildings (++).
Financial and technological support	**Target 9.a:** Facilitate sustainable and resilient infrastructure in developing countries **Target 9.b:** Support domestic technology development in developing countries	Financial and technological support for infrastructure can also contribute to low carbon buildings (++).
Human settlement	**Target 11.1:** Ensure access to adequate, safe and affordable housing **Target 11.3:** Enhance sustainable human settlement planning and management	Ensuring access to adequate, safe and affordable housing contributes to development of low carbon buildings (++).
Technology transfer	**Target 17.7:** Promote the development, transfer, dissemination and diffusion of environmentally sound technologies	Dissemination and diffusion of environmentally sound technologies promotes energy efficient and low carbon buildings and equipment (++).
Global partnership	**Target 17.16:** Enhance global partnership for Sustainable Development	Global partnership for sustainable development can contribute to deployment of energy efficient buildings and equipment (++).
Public and private partnership	**Target 17.17:** Encourage and promote effective public-private and civil society partnerships	Partnerships can contribute to dissemination and diffusion of environmentally sound technologies (++).

Table 3.9 Trade-offs of climate action 4: "low carbon buildings" with SDG targets

Theme	Targets having trade-offs with Action 4	Trade-offs
Tourism	**Target 8.9:** Promote sustainable tourism	Tourism requires preservation of local heritages and cultures that are sometimes barriers to renovation for energy efficiency. However, recent technology developments can resolve this situation without high-costs (-).
Heritage	**Target 11.4:** Protecting cultural and natural heritage	Protecting cultural and natural heritage should be encouraged; however, it may be difficult to preserve and reform such with high efficiency because of high costs. Therefore, a mechanism for funding such efficiency enhancement efforts is required. Otherwise, there is a risk of scrapping of heritage buildings instead of conservation (-). Modern high-efficiency equipment does not necessarily suit the ambiance of historical buildings, thus owners are sometimes reluctant to apply these new technologies (-).

3.5 Interactions between climate actions of biomass energy and other SDG targets

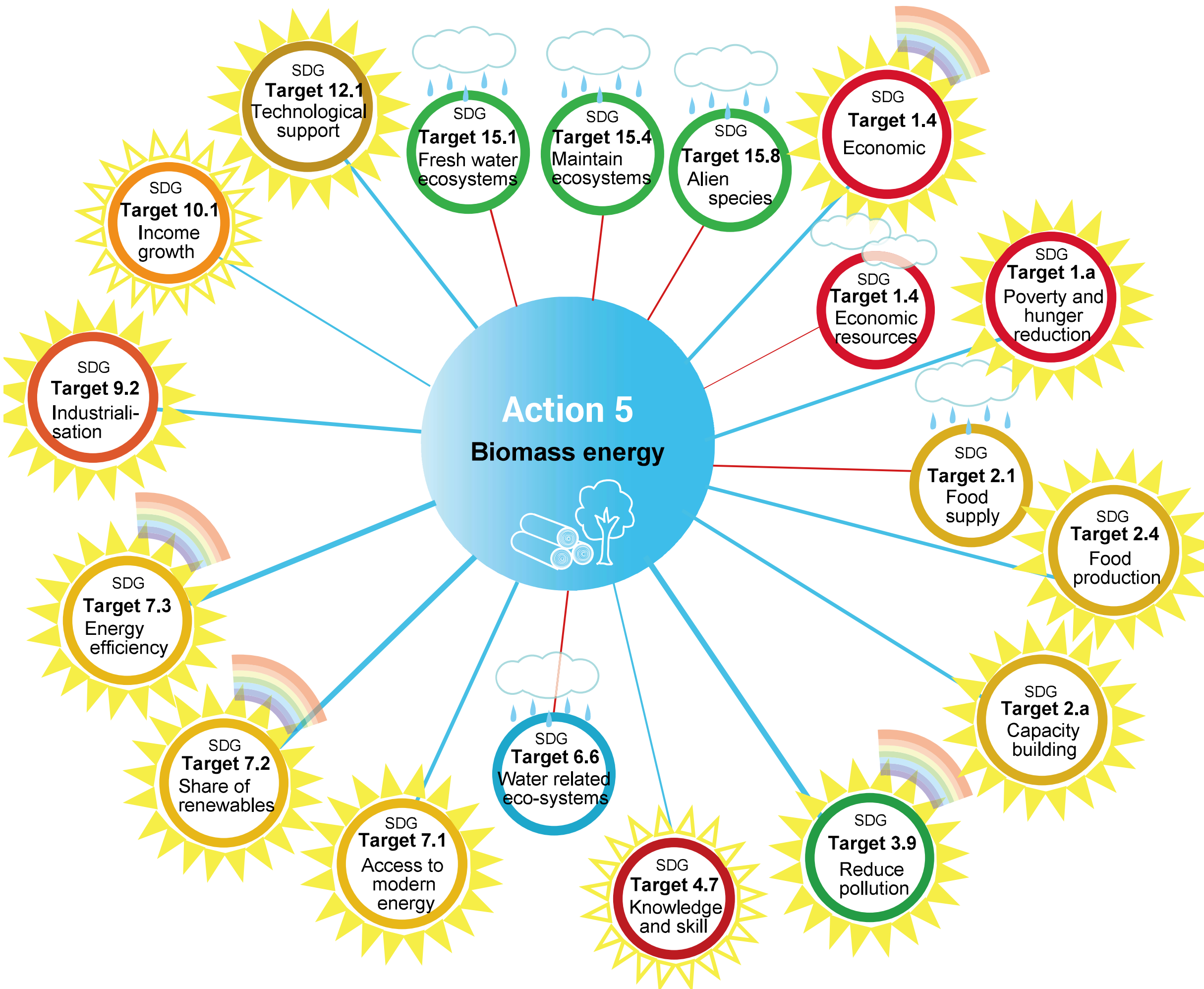

Figure 3.5 Key interactions between actions of biomass energies and other SDG targets

Table 3.10 Synergies of climate action 5: "biomass energy" with SDG targets

Theme	Targets having synergies with Action 5	Synergies
Economic resources	**Target 1.4:** Ensure all have equal rights to economic resources **Target 1.5:** Build the resilience of the poor and reduce their exposure and vulnerability to climate-related extreme events **Target 4.4:** Increase the number of people who have relevant skills **Target 8.3:** Promote development oriented policies that support productive activities **Target 8.5:** Achieve employment for all **Target 8.6:** Reduce the proportion of youth not in employment, education or training **Target 10.1:** Achieve and sustain income growth	Poor families in rural areas of developing countries can be involved in new business models centered around co-production of biomass energy and food. As part of this they can be provided tenure rights to land and access to microfinance and other basic services. These poor families can be engaged as part of cooperatives, micro-enterprises or as regular entrepreneurs, depending on whatever is effective to implement in a particular country. Training of youth in skills related to modern and sustainable co-production of biomass energy and food can be included as part of skills development, employment, entrepreneurship and income generation programmes. Granting rights over assets such as land and biomass resources will enhance the economic status of poor families, thereby building their resilience against climate-related/extreme events and disasters (+++).
Poverty and hunger reduction	**Target 1.a:** Ensure mobilisation of resources **Target 1.b:** Create policy framework to support investment in poverty eradication actions **Target 2.1:** End hunger and ensure access to sufficient food **Target 2.2:** End all forms of malnutrition	Biomass based local economic activities can be included within poverty, hunger and malnutrition reduction programmes, and governments in low income countries can set targets of resource allocation to the same (++).
Food production	**Target 2.4:** Ensure sustainable food production systems	Promoting sustainable co-production of biomass energy and food can increase areas under sustainable local food production systems (++).
Capacity building	**Target 2.a:** Increase investment to enhance agricultural productive capacity in developing countries	Improving efficient biomass utilisation practices can be included in the ambit of agricultural research and technology development in low income countries through government investment and international cooperation (++).
Reduce pollution	**Target 3.9:** Reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	Use of efficient and modern cookstoves/furnaces in rural households will reduce exposure to indoor air pollution (+++).
Knowledge and skills	**Target 4.7:** Ensure all to acquire the knowledge and skills to promote sustainable development	Integrating sustainable practices of co-production of biomass energy and food within education programme on sustainable development will raise awareness and skills of such practices (+).
Access to modern energy	**Target 7.1:** Ensure access to modern energy services	Enhancing local production and local consumption of modern biomass energy contributes to access to modern energy services (++).
Share of renewables	**Target 7.2:** Increase the share of renewable energy	Enhancing biomass energy contributes to increasing the share of renewable energy (+++).
Energy efficiency	**Target 7.3:** Improve energy efficiency **Target 8.4:** Improve resource efficiency **Target 12.2:** Achieve efficient use of natural resources	Efficient use of biomass energy contributes to global rate of improvement of energy efficiency and material (resource) efficiency (+++).

Industrialisation	**Target 9.2:** Promote industrialisation **Target 9.3:** Increase the access of small-scale industries **Target 9.4:** Upgrade infrastructure **Target 9.5:** Enhance scientific research **Target 9.b:** Support domestic technology development	Programmes for promotion of biomass energy can include promotion of small and medium-sized industries engaged in research, development, manufacturing and services related to biomass energy and food production technologies (including biomass CCS), and facilitating their access to financial services (++).
Income growth	**Target 10.1:** Achieve and sustain income growth	Biomass production can increase incomes of rural people (+).
Technological support	**Target 12.1:** Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production **Target 12.a:** Support developing countries to strengthen their scientific and technological capacity	Sustainable patterns of local production and consumption of biomass can be promoted within the agenda of international technological support to developing countries (++).

Table 3.11 Trade-offs of climate action 5: "biomass energy" with SDG targets

Theme	Targets having trade-offs with Action 5	Trade-offs
Economic resources	**Target 1.4:** Ensure all to have equal rights to economic resources **Target 1.5:** Build resilience to climate-related extremes **Target 2.3:** Double the agricultural productivity and incomes of small-scale food producers	If the rural poor (landless and small farmers) are not involved as participants in the new economic activities based on biomass energy and food production, then existing dominant communities who already own large land areas and other resources may exert control over them, meaning existing economic inequality and poverty conditions remain unchanged (-).
Food supply	**Target 2.1:** End hunger and ensure access to food **Target 2.2:** End all forms of malnutrition	If local biomass energy systems are promoted without consideration of sustainable food supply, it could hamper food security, especially for the poor (--).
Water-related ecosystems	**Target 6.6:** Protect and restore water-related ecosystems	Co-production of biomass energy and food practices could interfere with local water related ecosystems if they are not managed in a sustainable manner (--).
Fresh water ecosystems	**Target 15.1:** Ensure conservation of freshwater ecosystems **Target 15.2:** Promote the implementation of sustainable management of forests	Increase in land area for production of biomass for energy and food could come in conflict with sustainable management and conservation of forests (--).
Mountain ecosystems	**Target 15.4:** Ensure conservation of mountain ecosystems	Increase in biomass energy could come in conflict with mountain ecosystems (--).
Alien species	**Target 15.8:** Reduce the impact of invasive alien species **Target 15.9:** Integrate ecosystem and biodiversity values	Promotion of biomass for energy and food could increase import of alien species and compromise indigenous biodiversity (--).

3.6 Interactions between climate actions of energy systems and other SDG targets

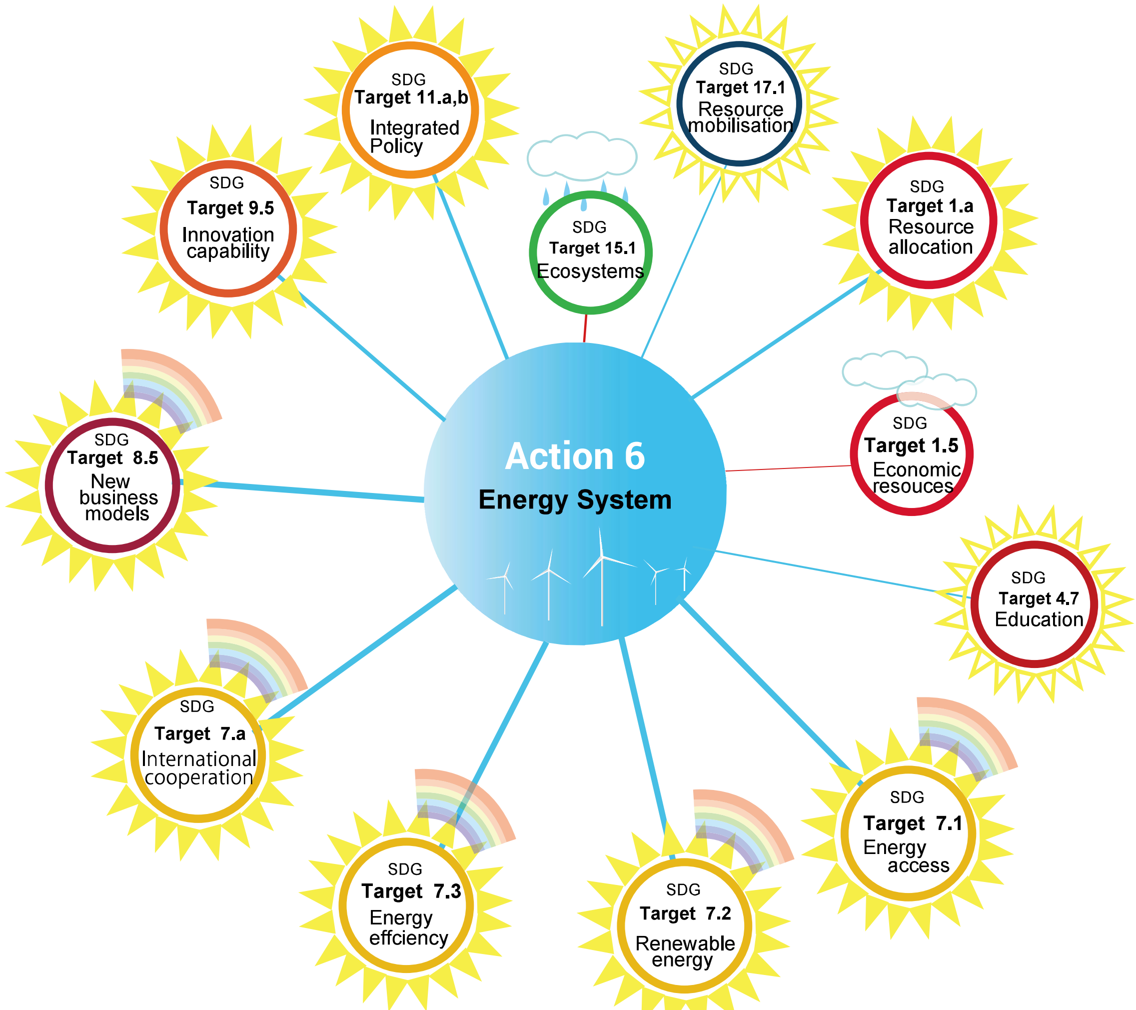

Figure 3.6 Key interactions between actions of energy systems and other SDG targets

Table 3.12 Synergies of climate action 6: "energy systems" with SDG targets

Theme	Targets having synergies with Action 6	Synergies
New business models and economic resources	**Target 1.4:** Ensure all have equal rights to economic resources as well as access to basic services **Target 4.4:** Substantially increase the number of youth and adults who have relevant skills **Target 8.3:** Promote development oriented policies **Target 8.5:** Achieve full and productive employment and decent work **Target 8.6:** Substantially reduce the proportion of youth not in employment, education or training **Target 10.1:** Progressively achieve and sustain income growth	Poor families in rural areas of developing countries can be involved in new business models centered around services based on local renewable energy systems. As part of this they can be provided access to microfinance and other basic services. Poor families can be engaged as part of cooperatives, micro-enterprises or as regular entrepreneurs, depending on whatever is effective to implement in a particular country. Training of youth in manufacturing, operation, maintenance and other service skills related to modern and sustainable energy systems can be included as part of skills development, employment, entrepreneurship programmes (+++).

Resource allocation	**Target 1.a:** Ensure mobilisation of resources to developing countries to end poverty **Target 1.b:** Sound policy framework to support investment in poverty eradication actions **Target 2.1:** Ensure access to safe, nutritious and sufficient food **Target 2.2:** End all forms of malnutrition	Renewable energy based local economic activities can be included within poverty, hunger and malnutrition reduction programmes, and governments in low income countries can set targets of resource allocation to the same (++).
Education	**Target 4.7:** Ensure all learners acquire knowledge and skills	Integrating sustainable practices of local renewable energy systems within education programmes on sustainable development will help build awareness and skills related to such systems (+).
Energy access	**Target 7.1:** Ensure universal access to affordable, reliable and modern energy services	Both centralised and decentralised renewable energy systems can contribute to enhancing access to energy for all (+++).
Renewable energy	**Target 7.2:** Increase substantially the share of renewable energy	Promoting sustainable local energy systems with renewables will directly increase their share (+++).
Energy efficiency	**Target 7.3:** Double the global rate of improvement in energy efficiency	Renewable energy systems can contribute to global rate of improvement of energy efficiency (+++).
International cooperation and access to clean energy	**Target 7.a:** Enhance international cooperation to facilitate access to clean energy research and technology **Target 12.1:** Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns **Target 12.a:** Support developing countries to strengthen their scientific and technological capacity	Development, manufacture and diffusion of local, distributed, modern renewable energy systems and related technologies can be a part of international energy cooperation programmes. International technological support to developing countries should include sustainable and renewable energy systems (+++).
Innovation capability and small & medium industries	**Target 9.2:** Promote industrialisation **Target 9.3:** Increase the access of small-scale industries **Target 9.4:** Upgrade infrastructure and retrofit industries **Target 9.5:** Enhance scientific research and upgrade technological capabilities **Target 9.b:** Support domestic technology development, research and innovation in developing countries	Promotion of small and medium-sized industries engaged in research, development, manufacturing and services related to renewable energy systems and technologies, and facilitating their access to financial services will contribute to industrialisation, innovation capability and renewable energy (++).
Integrated policies	**Target 11.a:** Support positive economic, social and environmental links **Target 11.b:** Adopt Integrated policies and plans	Sustainable, local renewable energy systems should be an integral part of urban, rural, regional and national development plans and integrated policies that include resource efficiency, GHG mitigation and risk management objectives (++).
	Target 17.1: Strengthen domestic resource mobilisation, including international support	Resource mobilisation contributes to promoting renewable energy (+).

Table 3.13 Trade-offs of climate action 6: "energy systems" with SDG targets

Theme	Targets having trade-offs with Action 6	Trade-offs
Economic resources	**Target 1.4:** Ensure all have equal rights to economic resources and access to basic services **Target 1.5:** Build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate related extreme events	If the rural poor (landless and small farmers) are not involved as participants in the new economic activities based on local renewable energy systems, then existing dominant communities who already own large land areas and other resources may exert control over them, meaning existing economic inequality and poverty conditions remain unchanged (-).
Ecosystems	**Target 15.1:** Ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems **Target 15.2:** Promote the implementation of sustainable management of forests **Target 15.4:** Ensure the conservation of mountain ecosystems	Dedicating land area for renewable energy systems can come in conflict with sustainable management and conservation of forests and mountain ecosystems (--).

3.7 Interactions between climate actions of agriculture and livestock, and other SDG targets

Figure 3.7 Key interactions between actions of agriculture and livestock, and other SDG targets

Table 3.14 Synergies of climate action 7: "agriculture and livestock" with SDG targets

Theme	Targets having synergies with Action 7	Synergies
Economic resources	**Target 1.4:** Ensure all have equal rights to economic resources as well as basic services **Target 8.3:** Promote development oriented policies that support productive activities	Poor families in rural areas of developing countries can be involved in new business models offering services of efficient water management to farmers. As part of this they can be provided access to microfinance and other basic services. Such poor families can be engaged as part of cooperatives, micro-enterprises or as regular entrepreneurs, depending on whatever is effective to implement in a particular country (+++).
Food production	**Target 2.3:** Double the agricultural productivity **Target 2.4:** Ensure sustainable food production systems and implement resilient agricultural practices	Programmes of technology transfer of food production can support sustainable food production systems (++). Sustainable food production systems and resilient agricultural practices that increase productivity help to maintain ecosystems that strengthen capacity for adaptation to climate change(++).
Pollution	**Target 3.9:** Reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination **Target 6.3:** Improve water quality by reducing pollution	Promoting use of organic fertilisers and sustainable agricultural practices will contribute to reduce soil pollution, improve ground water quality, and reduce adverse health impacts of chemicals on both the farmers and consumers of food (++).
Knowledge	**Target 4.7:** Ensure all learners acquire the knowledge and skills needed to promote sustainable development	Integrating sustainable practices of water management and organic fertilisers within education programmes on sustainable development can improve awareness and skills related to sustainable food production (+).
Water-use efficiency	**Target 6.4:** Sustainably increase water-use efficiency across all sectors	Efficient water management practices in rice paddy cultivation can contribute to reducing water scarcity and stress (++).
International cooperation	**Target 6.a:** Expand international cooperation in water-related activities	Efficient water management techniques can be included as part of the agenda of international cooperation and capacity building activities in developing countries towards water efficiency and conservation (++).
Local community	**Target 6.b:** Support local communities in improving water management	Local community participation can be built within the design of improved water management programmes in rice paddy cultivation (++).
Energy efficiency	**Target 7.3:** Double the global rate of energy efficiency **Target 8.4:** Improve global resource efficiency **Target 12.2:** Achieve sustainable management and efficient use of natural resources	Efficient and organic fertiliser and residue management can contribute to improved global rate of energy efficiency as well as material (resource) efficiency (++). Recovery and use of methane can also raise global rate of energy efficiency (++).
Income growth	**Target 10.1:** Achieve income growth	Enhancements in agricultural productivity and sustainable food production are likely to increase income of small farmers (++).

Table 3.15 Trade-offs of climate action 7: "agriculture and livestock" with SDG targets

Theme	Targets having trade-offs with Action 7	Trade-offs
Diversity of seeds	**Target 2.5:** Maintain genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species	It is possible that pursuit of efficient water management practices and efficient fertiliser applications might de-incentivise use of local strains of seeds, hence compromise genetic diversity (--).
Pollution	**Target 3.9:** Reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	Promotion of efficient chemical fertilisers can result in adverse impacts on soil pollution, resilience of agricultural practice, and human health (--).

3.8 Interactions between climate actions of forestry and land use, and other SDG targets

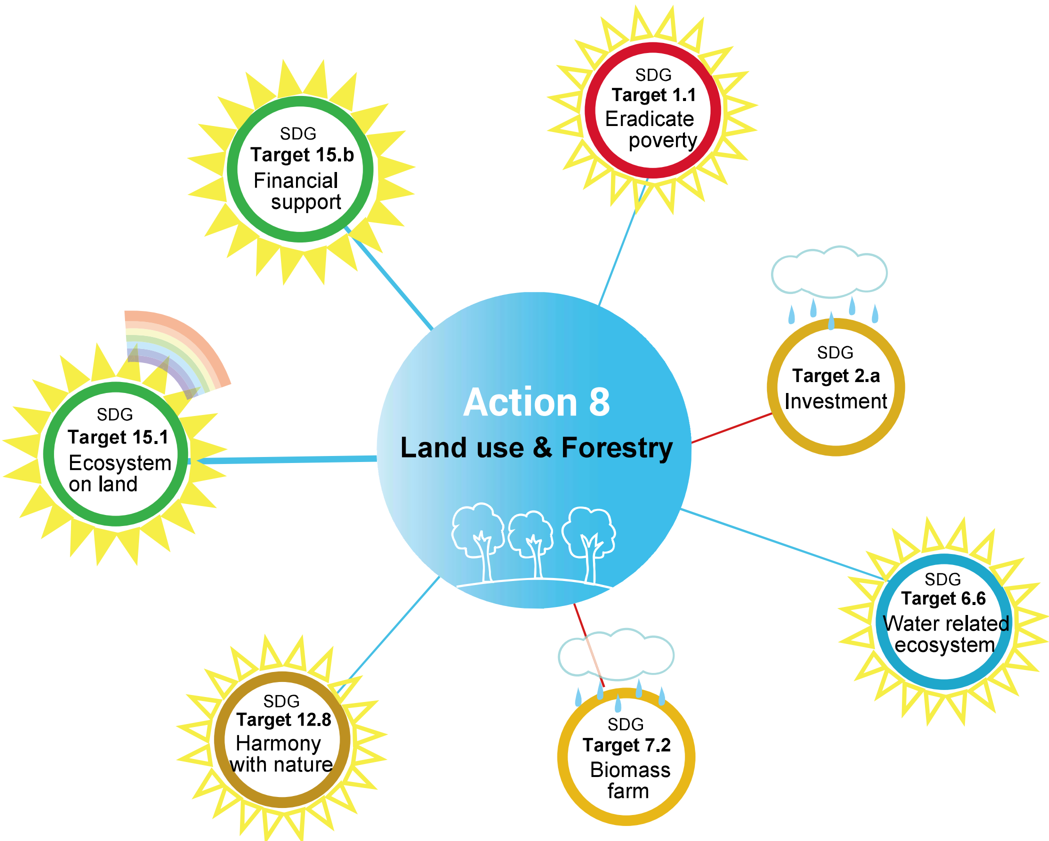

Figure 3.8 Key interactions between actions of land use and forestry, and other SDG targets

Table 3.16 Synergies of climate action 8: "land use and forestry" with SDG targets

Theme	Targets having synergies with Action 8	Synergies
Eradicate poverty	**Target 1.1:** Eradicate extreme poverty	Reduce poverty though the creation of job opportunities based on sustainable forest management (+).
Water-related ecosystems	**Target 6.6:** Protect and restore water-related ecosystems	Sustainable forest management contributes to restoration of water related ecosystems (+).
Harmony with nature	**Target 12.8:** Ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	Preserving forests contributes to lifestyles in harmony with nature (+).
Ecosystem on land	**Target 15.1:** Ensure conservation, restoration of forests **Target 15.2:** Promote implementation of sustainable management of forests **Target 15.3:** Combat desertification, restore degraded land and soil, and strive to achieve a land degradation-neutral world **Target 15.4:** Ensure the conservation of mountain ecosystems **Target 15.5:** Take action to reduce the degradation of natural habitats **Target 15.a:** Mobilise and increase financial resources to conserve biodiversity and ecosystems	All actions to preserve forests contribute to preserving ecosystems on land (+++).
Financial support	**Target 15.b:** Mobilise resources to finance sustainable forest management	Providing financial support to developing countries to advance forest management can contribute to forest preservation (++).

Table 3.17 Trade-offs of climate action 8 "land use and forestry" with SDG targets

Theme	Targets having trade-offs with Action 8	Trade-offs
Investment	**Target 2.a:** Increase investment in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks	Investments in new service infrastructures in rural areas may cause negative impacts on natural ecosystems (--).
Biomass farm	**Target 7.2:** Increase the share of renewable energy	Increase in biomass farms may conflict with forest preservation if not properly managed (--).

3.9 Interactions between climate actions of technologies and finance, and other SDG targets

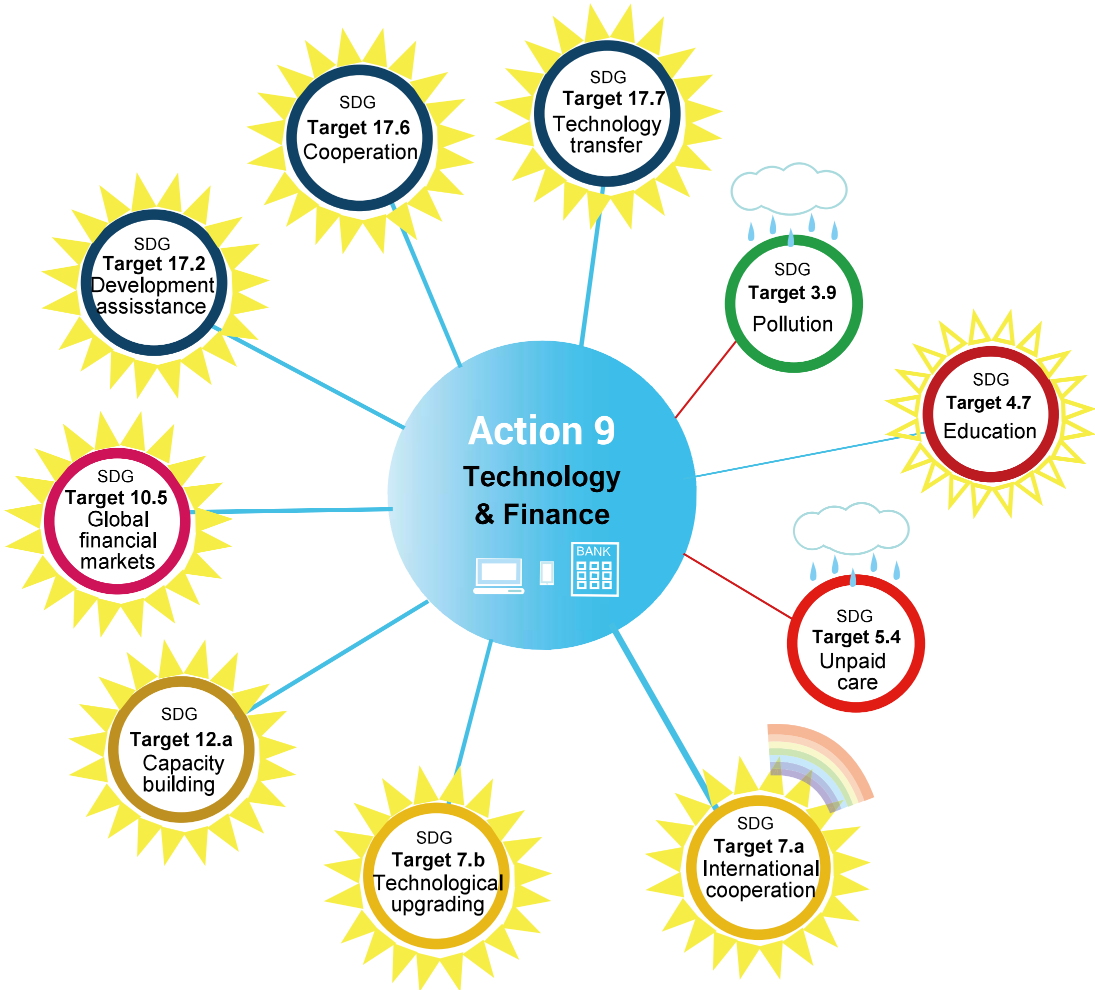

Figure 3.9 Key interactions between actions of technologies and finance, and other SDG targets

Table 3.18 Synergies of climate action 9: "technologies and finance" with SDG targets

Theme	Targets having synergies with Action 9	Synergies
Education	**Target 4.7:** Ensure all acquire knowledge and skills	Acquiring knowledge contributes to technology development (+).
International cooperation to access technology	**Target 7.a:** Enhance international cooperation to facilitate access to clean energy and technology	Mobilise funds through international cooperation to facilitate access to clean energy and technology (+++).
Technological upgrading	**Target 7.b:** Upgrade technology for supplying modern and sustainable energy services for all in developing countries **Target 8.2:** Achieve higher economic productivity	Establish adequate funds to support R&D and technology diffusion, contributing to upgrading of technology and sustainable energy services in developing countries (++).

Regulation for global financial markets	**Target 10.5:** Improve the regulation and monitoring of global financial markets	Improve regulations to establish adequate funding to support R&D and technology diffusion (++).
Capacity building for technology	**Target 12.a:** Support developing countries to strengthen their scientific and technological capacity **Target 17.8:** Fully operationalise the technology bank and science, technology and innovation capacity-building mechanisms for least developed countries **Target 17.9:** Enhance international support for implementing effective and targeted capacity building	Establish strategies for funding mechanisms to support capacity building related to low carbon technologies in developing countries (++).
Development assistance	**Target 17.2:** Developed countries to fully implement their official development assistance commitments **Target 17.3:** Mobilise additional financial sources for developing countries	Establish adequate funding to promote official development assistance (++).
Cooperation	**Target 17.6:** Enhance North-South, South-South and triangular regional and international cooperation on and access to technology and innovation	Establish adequate funding to promote international cooperation (++).
Technology transfer	**Target 17.7:** Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries	Establish adequate funding to promote technology transfer (++).

Table 3.19 Trade-offs of climate action 9: "technologies and finance" with SDG targets

Theme	Targets having trade-offs with Action 9	Trade-offs
Pollution	**Target 3.9:** Reduce the number of deaths from hazardous chemicals and pollution	Excessive pursuit of economic productivity, even with efficient technologies, poses the threat of increasing pollution (-).
Unpaid care	**Target 5.4:** Recognise and value unpaid care and domestic work	Excessive pursuit of economic productivity has the potential to underestimate unpaid care (-).

3.10 Interactions between climate actions of governance and other SDG targets

Figure 3.10 Key interactions between actions of agriculture and livestock, and other SDG targets

Table 3.20 Synergies of climate action 10: "governance" with SDG targets

Theme	Targets having synergies with Action 10	Synergies
Education for all	**Target 4.3:** Ensure equal access for all women and men to vocational and tertiary education	Provide literacy and education for environmental policy and technology (++).
Women's participation	**Target 5.5:** Ensure women's participation and equal opportunities for leadership	Include gender perspective as a cross-cutting issue in national development plans and climate policies (++).
Renewable of energy	**Target 7.2:** Increase the share of renewable energy	Effective governance is indispensable to increase the share of renewables (+).

Voice for decision making	**Target 10.6:** Ensure enhanced representation and voice for developing countries in decision-making in global international economics and financial institutions	Enhance representation of developing countries in international decision making and financial institutions, so that international low carbon policy and supports are aligned with domestic developmental objectives (+).
Development planning for LCS	**Target 11.a:** Support economic, social and environmental links by strengthening national and regional development planning	Construct multi-level administrative frameworks for delivering LCS (+).
Sustainable public procurement	**Target 12.7:** Promote public procurement practices that are sustainable	Implement legal and institutional arrangements for fair and equal resource allocations (+).
Climate policy integration	**Target 13.2:** Integrate climate change measures into national policies, strategies and planning	Establish administrative frameworks for delivering LCS that integrate climate measures with other national policies (++).
Capacity building	**Target 13.b:** Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries	Include mechanisms for enhancing capacity in least developed countries within the programmes for capacity building for technology, policy, and administrative efficiency (++).
Transparent governance	**Target 16.6:** Develop effective, accountable and transparent institutions **Target 16.7:** Ensure responsive, inclusive, participatory and representative decision-making	Establish frameworks to ensure transparent governance which will contribute to effective institutions and transparent business practices (++).
Policy coherence	**Target 17.14:** Policy coherence for sustainable development	Establish and implement legal and institutional arrangements for fair and equal resource allocation which contributes to policy coherence (+).
Global partnerships	**Target 17.16:** Ensure the Global Partnership for Sustainable Development	Establish global partnerships with explicit agenda of low carbon and sustainable development (++).
Civil society partnerships	**Target 17.17:** Encourage and promote public-private and civil society partnerships	Establish mechanisms to enhance public-private and private-private partnerships focused on low carbon and sustainable development objectives (+++).

Table 3.21 Trade-offs of climate action 10: “governance” with SDG targets

Theme	Targets having trade-offs with Action 10	Trade-offs
Export	**Target 17.11:** Increase the exports of developing countries	Overemphasis on exports in developing countries can potentially harm the sustainability and balance of material resources (-).
Partnerships	**Target 17.17:** Promote pubic and public-private partnerships	If the support to partnerships is partial, or if the partnerships are selective, money may not go where it is really needed (-).

Chapter 04 LCS actions: Good practices and policy implications

During 2014–2016, worldwide energy-related CO_2 emissions stayed flat (at 32.1 Gt-CO_2 per year) after rising for decades, while the global economy and GDP of major developed and developing nations grew by at least 3.1% per year, indicating a decoupling of GHG emissions from production and consumption. This was a result of growing renewable power generation, a switch from coal to natural gas, improvements in energy efficiency, as well as structural changes in the global economy. In 2016, renewables supplied more than half the global electricity demand growth. CO_2 emissions declined in the USA by 3% and in China by 1%, and were stable in Europe, offsetting increases in most of the rest of the world (IEA, 2017a). Taken together, they point to the growing success of policies and investments in climate mitigation.

The current worldwide low carbon transition, if accelerated further, will promote a transition of human civilization from that based on industry to that based on ecology, in order to bring human development in line with the earth's biosphere. At this point, earth's limited resources will no longer be blindly taken in the process of economic and social development, wastes will no longer be discharged to the earth's environment, and harmonious, sustainable development between man and nature will be achieved (Jian-Kun, 2016). Whilst at first this scenario may appear merely as an unattainable ideal drawn up to meet the Paris temperature goals, it is in fact a very achievable goal – challenging but realistic.

In particular, the Paris goals can be met if emissions begin to fall by 2020. If they don't, or instead plateau-out, this goal will become extremely unlikely to achieve, as would the UN SDGs (Figueres et al., 2017).

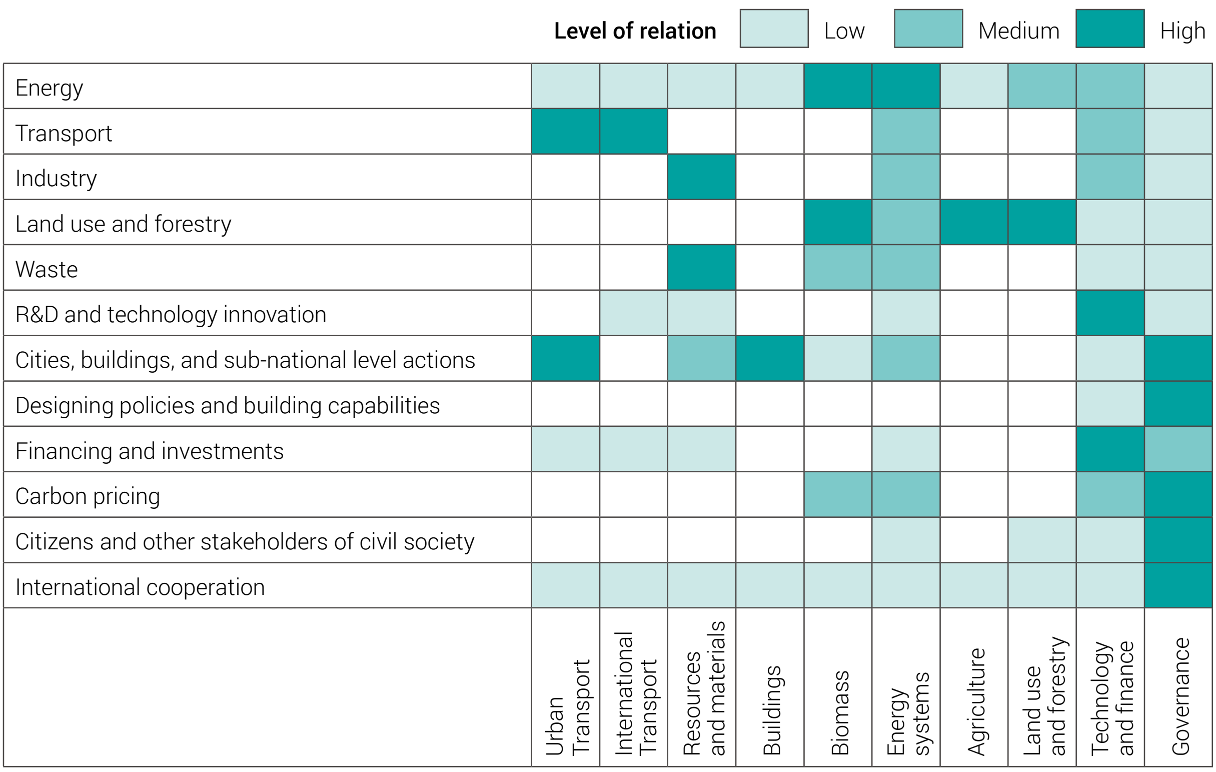

Figure 4.1 Illustrative interrelations between key domains of good practices and climate actions.

Various countries have offered concrete commitments to reduce GHG emissions as part of their INDCs – China and India have committed to 60–65% and 33–35% reductions, by 2030, respectively, in comparison to 2005 levels (Kedia, 2016). However, the INDCs of all countries combined still fall short of achieving the worldwide 2°C climate target, and much urgent work remains to be carried out in order to decarbonise the world.

In this section we discuss some good examples of low carbon practices and policy implications in the domains of energy, transport, industry, land use and forestry, waste, R&D and technology innovation, cities and subnational actions, designing policies and building capacities, financing and investments, carbon pricing, citizens and other stakeholders, and international cooperation. Figure 4.1 depicts interrelations between these domains and the 10 climate actions discussed in the previous sections, after which each topic will be discussed in turn.

4.1 Energy

Clean energy has already become profitable. In 2016, renewables supplied more than half the global electricity demand growth (IEA, 2017a), setting a new record of 161 GW of installed capacity. These included wind, solar, biomass and waste-to-energy, geothermal, small hydro and marine sources. In 2015, investments in renewable energy (excluding large hydro) reached about 300 billion USD worldwide, over half of which derived from developing and emerging economies (FS-UNEP, 2016).Despite a drop in investment in new renewables capacity (excluding large hydro) to 242 billion USD in 2016, this amount was still roughly double that for fossil fuel generation for the fifth successive year (FS-UNEP, 2017). Renewables accounted for 23.7% of power at the end of 2015 and the IEA has predicted that by 2020 they could deliver 26–27% of the world's electricity needs (Figueres et al., 2017). The proportion of global electricity from renewables excluding large hydro rose from 10.3% in 2015 to 11.3% in 2016, avoiding an estimated 1.7 Gt-CO_2 of emissions (FS-UNEP, 2017).

Many countries have emerged as established solar PV markets, largely due to strong policy incentives and other regulatory efforts implemented by their governments, as well as rapid declines in technology and system costs. IEA (2017b) reported that worldwide installed PV capacity had reached 303 GW by the end of 2016. Of this, a record 75 GW was added in 2016 alone, representing about 50% growth in annual capacity addition from 2015 (however, addition of wind power capacity in 2016 was 54 GW, a decline of 14% from 2015). This recent growth in solar PV was driven mainly by China, USA and India, each of which saw almost double the installed capacity in 2016. In the USA, during the first quarter (January-March) of 2017, solar was the second largest source of new electricity generating capacity additions brought on-line, responsible for 30% of new generation, second only to natural gas (GTM, 2017).

The global growth in solar PV over the past few decades has been due to rising investments and markets in many countries. Top countries in terms of installed PV capacity per capita are Germany (511 W/capita), Japan (336 (W/capita), and Italy (322 W/capita). Top countries in terms of cumulative PV capacities at the end of 2016 are China (78 GW), Japan (42.8 GW), Germany (41.2 GW), USA (40.3 GW), Italy (19.3 GW),UK (11.6 GW), India (9 GW), France (7.1 GW), Australia (5.9 GW), and Spain (5.4 GW). Other countries with high PV growth are South Korea, Australia, Philippines, Chile, Belgium, Thailand, Taiwan,South Africa, Switzerland, the Netherlands,Greece, and others. In 2016 the electricity generated from PV represented about 1.8% of global electricity demand, up from 1.2% in 2015. PV generated electricity penetration as a percentage of national electricity demand in 2016 was the highest in Honduras (12.5%), Greece (7.4%), Italy (7.3%), Germany (7.0%), and Japan (4.9%) (IEA, 2017b).

In the EU, wind and solar made up more than 75% of new energy capacity installed in 2016, and coal demand dropped by 10% (WindEurope, 2017). Germany, a nation at the forefront of renewable energy addition in the EU and with a solid history of implementing bold laws – including those relating to feed-in tariff and community-owned renewable power generation– has proposed reducing total primary energy consumption by 50% in 2050, and increasing the proportion of renewable energy in primary energy consumption to 60%, to bring about an 80% CO_2 emission reduction (Jian-Kun, 2016). It is actively converting its national electricity system towards being fully renewable, with a target renewables electricity provision of 80% by 2050. Since Germany ruled out nuclear power and fossil-fuel-based power with CCS options in 2011, renewable electricity generation together with electricity savings are the primary focus for achieving its decarbonisation (Lechtenbohmer and Luhmann, 2013).

Incentives such as feed-in tariff and premium schemes have played a major role in allowing Spain to reach one of the highest penetration rates of wind power (Ibanez-Lopez and Moratilla-Soria, 2017).

As part of its long-term energy strategy, Switzerland plans to phase out nuclear power production and replace almost all its share of national electricity production (40%) with renewables, in particular solar PV and wind power (Dujardin et al, 2017).

In the US, almost two-thirds of electricity-generating capacity installed by utility companies in 2016 was based on renewables (EIA, 2017).

Sweden, Austria, Brazil and China have made good progress in the development and use of biofuel technologies while linking their benefits with rural employment, sustainability and energy security (Kopetz, 2013).

In 2016, two-thirds of China's additional demand for electricity was supplied by carbon-free energy resources, mostly hydropower and wind (IEA, 2016). China has committed to an INDC target for share of non-fossil fuels in primary energy of 20% by 2030 (Kedia, 2016), and has actually revised some of its targets beyond those in its INDCs: the solar PV installed capacity target for 2020 was upgraded from 100 GW to 150 GW, and that for wind power from 200 GW to 250–300 GW. As its energy intensive industries have reached a point of saturation, energy demand increase has slowed down. Coal use has begun to decline. Its Clean Power Plan has committed to reduce CO_2 emissions by 32% from 2005 levels by 2030, and it is promoting renewables, nuclear energy and natural gas to meet additional energy needs (Jiang, Tamura and Hanaoka, 2017).

India has set its INDC target for non-fossil fuels based energy at 40% of cumulative electric power installed capacity by 2030 (Kedia, 2016). It has already seen tremendous growth in solar PV electricity, and compared to other countries is the most competitive in this field.

Experiences of different countries offer valuable lessons for low carbon energy policy. Some of these are discussed in the following subsections. One obvious insight is the imperative of designing multi-pronged, comprehensive policy encompassing interventions at multiple levels of energy supply and end-use.

4.1.1 Clean energy technology innovation

OECD countries and China dominate global clean energy innovation, based on the number of patents filed. Japan, US, China, South Korea and Germany have filed the most patents in the past 10 years in low carbon energy technologies such as grid and storage, solar, wind, and biofuels. These countries' economies will benefit most from investments in low carbon energy research and development (Goldthau, 2017).

Domestic policies in both developed and developing countries focused on fostering development and commercialisation of low carbon energy technology innovations, therefore, makes strategic sense. National governments have an important role to play in terms of providing financing support to universities, companies and entrepreneurs who invest in low carbon energy technologies; easing regulations concerning approvals and import of component or process technologies that are essential for carrying out low carbon technology systems level development; providing incentives for establishment of businesses around manufacture and supply of these technologies, systems and final energy services; and offering economic incentives to consumers (industries, offices, buildings, households and farmers) who use end-use energy services from low carbon supply systems.

Therefore, an eco-system of policy supports could accelerate commercialisation and the spread of low carbon energy innovations such as centralised and decentralised solar PV, wind power, bioenergy, energy storage and other variable load balancing systems. Demonstrations of mass-scale opportunities of various businesses, entrepreneurships and employment around innovations act as triggers for faster penetration. For instance, Zhang et al. (2017) report that the solar PV industry played an important role in generating employment in China during 2009–2015, and call for more financial support for solar PV projects, particularly distributed solar PV, as well as education and training of solar PV professionals.

China's 'Top Runner' programme, which favours tenders with high efficiency PV modules, contributed to 5.5 GW of installations in 2016 (IEA, 2017b). Germany and Australia support storage through financial incentives for 'prosumers' (defined in sub-section 4.1.5) and this has led to spurts in residential PV installations. Malta witnessed increased adoption levels of residential PV systems by households due to a subsidy scheme of the government. In their study of those households, Briguglio and Formosa (2017) found that younger households with higher incomes who owned the dwelling and had unshared roof space invested significantly more in PV panels. Thus, targeted financial support based on ownership status and type of dwelling might be more effective in inducing strata-wise adoption.

An up-and-coming innovation in renewable power is the siting of two different technologies in the same location, to make use of shared land, grid connections and maintenance, and to reduce intermittency. Some 5.6 GW of these 'hybrid' projects have been built or are under development worldwide, including hydro-solar PV, wind-solar PV, solar PV-solar thermal, solar thermal-geothermal, and biomass-geothermal (FS-UNEP, 2017). Policies for facilitating R&D, optimal manufacture and commercialisation of more of such hybrid renewable energy systems, aimed at improving efficiency, reducing intermittency and mitigating investment risk, would play an increasingly important role in the future.

4.1.2 Market development through competitive bidding process

Many countries continue to introduce (or have begun to introduce) competitive calls for tenders to grant power purchase agreements (PPAs) which often include feed-in tariffs (discussed in sub-section 4.1.4), including France, Spain, India, Algeria, Iran, Pakistan, Israel, Mexico, Turkey, Zimbabwe, Abu Dhabi, Dubai and others. While this method has yet to fully prove it can ensure smooth and sustainable PV market development, it engenders the possibility of controlling how the electricity mix will develop and has shown how low the cost of PV electricity could go under constraints (IEA, 2017b).

PV electricity prices have witnessed a sharp decline in recent years as a result of competitive bidding systems, as well as drops in technology and system costs from learning curve effects. Record low prices have been observed recently in India where the system of tenders has produced extremely competitive bidding, resulting in utility-scale PV system prices of 65 cents per watt (or 0.65 USD/Wdc) in early 2017. Other countries which saw low prices in early 2017 are China (USD 0.8/Wdc), Mexico (USD 0.84/Wdc), Egypt (USD 0.93/Wdc), UK (USD 1.0/Wdc) and USA (USD 1.1/Wdc) (Clean Technica, 2017). Prices are expected to fall further in the coming years, and a parallel trend is also observed in wind power generation (especially offshore).

4.1.3 Integrated strategy for co-optimisation of supplies and demands

Brown et al. (2017) demonstrate through their analysis of the US power sector that the transformation to clean power can be made more affordable by improving the efficiency of energy utilisation. That is, an integrated strategy focused on co-optimising demand- and supply-side mitigation options would make both more efficient and economical.

Midttun and Piccini (2017) report that while several business models in the energy industry in Europe failed after the 2008 financial crisis, incumbent firms with greener energy mixes, smaller scales and the flexibility to co-optimise supply and demand fared better than others. These new, successful business models in the energy industry are largely based on low carbon energy resources, and adopt digital technology that allows more flexible interplay between consumption and production of energy and between several service alternatives to fulfill basic needs of customer home comfort.

4.1.4 System planning with appropriate mix of variable renewables and storage options

Policy relating to economic feasibility and penetration of energy storage systems would be crucial to support the adoption of wind power farms (Atherton, Sharma and Salgado, 2017). This is in general true for the adoption of variable renewable energy systems such as solar PV and wind power. National and international policies to promote development and commercialisation of efficient energy storage and battery technologies would be an important factor behind rapid diffusion of variable renewable energy systems.

Dujardin et al. (2017), in an analysis of Switzerland's energy mix and long term target of renewable energy, report that a large fraction of hydropower and significant pumped-storage hydro capacity in the mountain regions would provide valuable balancing for the management of intermittent production from solar PV and wind. Thus it is important to plan the desired mix of PV, wind and storage hydro power (and other storage-based options), based on a country's specific demand profiles, availability of these resources, and renewable power targets.

New policy challenges for the low carbon energy transition are in regulating networks and creating infrastructure for balancing and energy storage to accommodate the intermittent supply from renewables (Midttun and Piccini, 2017).

4.1.5 Joint regulation of feed-in-remuneration scheme and retail electricity price

The idea that electricity producers using PV could be considered as 'prosumers' – both producers and consumers of electricity – is evolving rapidly and policies are being adapted accordingly in several countries (IEA, 2017b). The rate of adoption of decentralised, residential or community scale renewable electricity systems could be accelerated by jointly designing a feed-in remuneration (FiR) scheme and retail electricity price structure, as this combination determines the economic surplus and payback period of such systems for their owners (prosumers).

An analysis of empirical data on FiR policies of 'net metering' and 'feed-in tariffs' from California and Germany during 2005–2016 found that FiR design and its interplay with retail electricity prices and PV system costs jointly determine whether residential PV installations are economical, how they are sized, and self-consumption levels (Ossenbrink, 2017). Germany and UK have introduced feed-in premiums with a variable premium that compensates for the variations in electricity market prices (IEA, 2017b). Thus, as retail electricity prices and solar PV costs change (either through market forces or government subsidies), FiR schemes need to be modified to sustain the momentum of the high adoption rate.

Matisoff and Johnson (2017) studied the state and utility incentives for promotion of installation of residential solar PV panels and found that direct cash incentives when coupled with financing initiatives and net metering have a positive impact on solar PV installations. They report that one dollar of incentives leads to 0.5–1 kW PV capacity per thousand customers.

4.1.6 Planning the right mix of centralised and decentralised systems

In an analysis of the sub-Saharan African region, where almost two-thirds of the population has no access to electricity, Dagnachew et al. (2017) demonstrate that central grid extensions need to be complemented with decentralised off-grid systems (mini-grid and stand-alone) to increase electricity access. They also report that while for regions with high levels of consumption extending the central grid is more economical, for regions with low levels of consumption, off-grid technologies are more important solutions in order to increase the rate of adoption of low carbon energy systems. This strategy is crucial for both increasing electricity access and reducing poverty, as the two are strongly correlated.

4.1.7 Democratic decision process and community participation in renewable energy projects

In any particular country, energy policy preferences vary between local, regional and national levels, and a key risk to policy implementation concerns potential conflicts amongst stakeholders and public opposition to such policies. For instance, multiple energy policy objectives of energy efficiency, sustainable development, electricity reduction and local production are likely to be viewed with different priorities by different stakeholders. A case study on the implementation of a renewable energy project in Switzerland observed that all stakeholders agree on the importance of an inclusive, democratic decision process and the need for enhanced communication of energy policy objectives down to the local context (Diaz, Adler and Patt, 2017).

Community-based and -led energy projects can play an important role in energy transitions, as demonstrated by recent policy proposals in South Wales Valleys to achieve decarbonisation through greater roles for local and community energy (Llewellyn, Rohse, Day and Fyfe, 2017).

4.2 Transport

The past decade has witnessed the rapid emergence of low carbon transport systems and technologies such as electric vehicles and multi-modal freight logistics.

In 2017, there will be 200,000 electric cars in Beijing and about 1 million in the whole of China. By 2020, there will be 0.5 million electric cars in Beijing. In addition, China has set a target of 30% share of public transport in motorised travel for big and mid-sized cities in 2020. It has also finalised next-stage fuel efficiency standards for heavy duty vehicles in 2016 and expects to implement them in 2019 (Jiang, Tamura, Hanaoka, 2017).

As in the case of renewable energy, policies for promoting low carbon transport systems and vehicles need to encompass an eco-system of interventions. For instance, an econometric study of demand for electric vehicles (EVs), plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) in 14 countries in 2010–2015 established a high positive correlation with multiple factors, such as percentage of renewables in electricity generation, charger density, percentage of adults with college education, and population density. In addition, high fossil fuel price is correlated with high demand for BEVs (Li, Chen and Wang, 2017). Thus, a gamut of schemes targeted at addressing each of these factors is likely to be more successful than an isolated scheme at effecting faster diffusion of low carbon transport systems.

4.2.1 Low carbon transport technology innovation

Investments in low carbon vehicle technologies and transport systems by private companies and governments have increased enormously over the past decade. This has resulted in early and rapid introduction of these technologies in developed country markets, and in turn, speeded up their learning curves.

In an integrated energy and technology analysis of Ireland's private car sector, Mulholland, Rogan and Gallachoir (2017) report that efficiency measures and biofuel blending would be insufficient, and that new technologies such as electric vehicles and drop-in biofuels (renewable hydrocarbon biofuels unlikely to require changes to existing vehicles and fuel supply infrastructures) are essential in order to achieve the target of 95% decarbonisation by 2050. Besides EVs and drop-in biofuels, technologies such as fast chargers, efficient public transport systems and multi-modal freight logistics would also play key roles in low carbon transition. Therefore, policies aimed at more intensive research, development and commercialisation of these transport technology innovations are indispensable.

4.2.2 Network footprint of charging infrastructure including fast chargers

The footprint of charging infrastructure in a city or region would strongly determine the accessibility to different segments of population, and therefore, rate of adoption and use of electric vehicles. The type of charging technology is important too, as it would determine the ease and efficiency of charging.

For instance, since charger density, percentage of adults with college education and population density have a positive effect on EV demand, more infrastructure for charging stations can be built in areas of high concentrations of college educated populations (Li, Chen and Wang, 2017).

Neaimeh et al. (2017) surveyed the usage of BEVs in the US and UK, and compared the effect of standard chargers with the new technology of fast chargers, and report that development and implementation of fast charging public infrastructure could accelerate mass adoption of BEVs, since fast chargers enable longer journeys above the single-charge range (which would be impractical using standard chargers) and thus could help overcome perceived and actual range barriers.

4.2.3 Co-designing policies for electric vehicles and renewable energy

Complementarities between renewable electricity generation units and electric vehicles could be exploited to create mutually reinforcing positive impacts in the two sectors. Li, Chen and Wang (2017) observed that a1% increase in renewables in electricity generation led to 2–6% increase in EV demand.

Thus governments must co-design policies to promote both renewable energy and EV technologies as their characteristics are complementary. For example, through pricing incentives, EV batteries can be made to act as energy storage banks to smooth the intermittent variations of solar and wind power generation. In addition, taxes on fossil fuels are likely to result in increase in BEV demand.

4.2.4 Role of government subsidies and standards for fuel economy and emissions in transport

A direct government subsidy (for producers and consumers) has been a common, easy to implement and effective mechanism to increase adoption of low carbon vehicles. For instance, a subsidy provided by the Japanese government to buyers of PHEVs made by Japanese automakers aided in enhancing their economic attractiveness vis-à-vis full petroleum vehicles, and thus, in boosting sales. This enabled the automakers to quickly reach the required scale and achieve efficiencies in technology development, production, procurement and quality control. An analytical study carried out by Gu, Liu and Qing (2017) found that an increase in government subsidy increases the optimal production quantity as well as utility of electric vehicle (EV) manufacturers.

In addition to subsidies, regulations on fuel efficiency and emissions have also proven to be equally effective. Sen, Noori and Tatari (2017) underscore the role of fuel economy regulations, such as the US Corporate Average Fuel Economy Standards (CAFÉ) in conjunction with financial support and greater deployment of recharging stations, in accelerating EV market penetration.

Other examples of national or state-level policies to decarbonise transport fuels are the US Renewable Fuel Standard (RFS2), which sets a minimum biofuels use target and GHG emission reduction threshold for each category of biofuel; California's LowCarbon Fuel Standard (LCFS), which mandates a 10% reduction by 2020 in carbon intensity of transport fuels sold in the state; European Commission's Fuel Quality Directive (FQD), which incorporates an LCFS-like target; and British Columbia's Renewable and Low Carbon Fuel Requirements Regulation (RLCFRR), which sets targets for both renewable content in transport fuels and reduction in their carbon intensity (Yeh and Sperling, 2013).

In a survey of freight vehicle fleet characteristics in India, Malik and Tiwari (2017) suggest that nationwide and timely implementation of stringent emission standards would lead to significant emission reductions due to high fleet turnover.

4.2.5 Integrating transport system optimisation within urban planning and redevelopment

The experiences of cities designed with sustainability objectives have shown that appropriate urban development and planning could cut significant amounts of transport demand as well as enable a switch towards public transport systems and fuel efficient private routes, which could provide a big boost to efficiency and emissions mitigation.

For example, road network geometry has a significant impact on overall fuel consumption and emissions (Luin, Petelin and Mansour, 2017). Therefore, urban redevelopment – including road network re-configuration – could be an important intervention to undertake deep cuts in transport fuel use.

4.3 Industry

Energy intensive industries such as steel, cement, aluminium, paper, fertiliser and others have immense potential to mitigate GHG emissions by both improving energy efficiency of processes and productively using the byproducts (for example, heat in flue gas) for energy needs.

4.3.1 Standards for energy efficiency and emissions in industries

Many countries use regulatory restrictions regarding energy efficiency and emissions in industries. The majority of developed countries including the USA, most EU countries and Japan, and some developing countries such as China, India, Brazil and Thailand have such regulations in place.

A study of industrial enterprises from nine EU member states found that regulatory stringency significantly impacts on the energy-efficient transformation of enterprises. More energy-intensive enterprises also respond positively to high energy prices (Garrone, Grilli and Mrkajic, 2017).

4.3.2 Emission trading scheme for industry

Some countries have implemented emission trading schemes that allow their industries and commercial entities to trade emissions. This is expected to promote energy efficient and emissions reduction methods.

From around 2011–2012 onwards, China established several regional emission trading schemes (ETS) in some of its provinces and cities, aiming to cover about 700 Mt-CO_2 of emissions at the pilot level. Later on, it announced nationwide ETS to be run in 2016, which is likely to be postponed to 2018–2019 (Kedia, 2016). Since 2010, the Tokyo Metropolitan Government (TMG) has made it mandatory for large-size industrial and commercial facilities in Tokyo to participate in a 'cap and trade' scheme for emissions reduction, and achieved successful results (LCS-RNet, 2016).

4.4 Land use and forestry

Sustainable land use and forest management offers a huge potential for GHG emissions mitigation by creating carbon sinks as well as for sustainable development, by linking economic activities of local communities with protection of biodiversity. At the same time, sustainability of land use and forestry is impacted by the global trade of biomass. Therefore, sustainable management of land use at multiple levels – local, national and global – will become unavoidable as lands around the world come under increasing pressures from efforts to feed the growing populations, grow energy crops, increase afforestation, and sequester atmospheric CO_2.

Many nations have committed to increase their forest covers. For instance, China's INDC target is to increase the forest stock volume by around 4.5 billion m3 by 2030 as compared to 2005. India's INDC target is to create an additional carbon sink of 2.5–3.0 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030 (Kedia, 2016).

4.4.1 Community led sustainable land and forest management

Successful examples of local community schemes of sustainable land management include the communal tenure of high mountain meadows and forests of Switzerland, and shared management of canals and water by the Zanjera community in the Philippines (Creutzig, 2017).

4.4.2 State and municipality led sustainable land and forest management

State led sustainable land use examples include the municipality of Curitiba, Brazil, which is directing urban growth along transit axes to protect surrounding ecological riches. Singapore and Tokyo, where space is limited, tax land to finance public transport and other services for citizens (Creutzig, 2017). The Tokyo Metropolitan Government's programmes in the city of Tokyo for energy efficiency improvement and emissions reduction aim to extend their scope to cover residential and transport sectors (besides industries and commercial facilities that they presently cover), and thus, regulate the city's land use towards sustainable development (LCS-RNet, 2016).

4.4.3 International cooperation and governance mechanisms for sustainable management of land and forests as global commons

Creutzig (2017) professes the case for land to be designated as 'global commons'. He argues for a nested regime for international governance of land use in four areas: (i) international financing for scaling up conservation and carbon storage on land, (ii) harmonising ambitious conservation standards, (iii) transfer of technology and management innovations of improving yields and food storage, and (iv) promoting sustainable patterns of consumption that reduce the amount of land embedded in trade. At present some countries provide their citizens with adequate food, shelter and natural spaces for recreation, but they import lots of products and commoditiesthat feed on land resources globally. A global cooperation can achieve an open world-trade system that manages land-based production and consumption footprints in a sustainable and equitable manner.

4.5 Waste

Many of the poorest cities in Africa and Asia are likely to double the waste they generate in the next 20 years, most of which ends up in poorly operated landfill sites or is dumped or burned. About 3 billion people worldwide are not served by controlled disposal facilities. It is therefore crucial for the developing countries to enforce regulations to stop open dumping and burning of waste and to finance sanitary landfill and recycling programmes, for sustainable urban planning (Duan, Li and Liu, 2017).

4.5.1 Regulations and incentives to set up supply chains for waste management in urban and rural areas

A combination of regulations to stop dumping or burning of waste and incentives for municipalities and businesses to operate supply chains for waste collection, refurbishment, recycling, reuse and disposal is an urgent need, especially in developing countries.

4.5.2 Co-locating industries to enable byproduct waste-to-energy conversion and recycling

Co-locating different industries with complementary characteristics of generation and use of byproduct waste as energy could go a long way in addressing both waste handling and energy efficiency. Policies of energy and waste sectors need to be designed together to harness such inter-industry complementarities.

4.5.3 Regulations for extending life of products

Penalising short lifecycle products and providing incentives for adoption of longer lifecycles could significantly reduce the resource and carbon footprint of products. However, this would call for questioning some of the fundamental drivers of the present economic development model that incentivise businesses and markets towards ever-shortening product life-cycles. Policies that force companies to internalise the lifetime costs of products in their prices, including the cost of disposal and repeat purchases, could help de-incentivise short lifecycle products.

4.6 R&D and technology innovation

Although this point has been partially covered in the subsections on energy and transport, it relates to all sectors and thus deserves a separate mention.

4.6.1 Financial support for low carbon technology innovations

A greater share of research and development investments from the governments, universities and private sector needs to be prioritised for low carbon innovations. Financing of technology R&D needs to be combined with supports directed at commercialisation and risk management in order to assure successful adoption of those innovations. This is discussed further in section 4.9 on financing and investments.

4.6.2 International mechanisms for transfer of low carbon innovations

A new international trade governance system that overcomes barriers of national trade restrictions, intellectual property regulations and weak financial strength of developing economies, and permits seamless transfers of low carbon innovations between countries, could be an important step towards their rapid and widespread diffusion.

4.6.3 Education programs to raise awareness of costs and benefits of low carbon technologies

A survey of adoption of residential solar systems in Australia revealed that the factor strongly influencing adoption among 'early adopters' was the awareness of (and interest in) technical and environmental aspects of solar energy. The factors that strongly influenced adoption among the vast majority were (i) financial incentives (that reduced the payback period of systems), and (ii) level of education (of self-education) about the environmental or technical reasons. The majority indicated that education is needed to understand the costs and benefits of solar energy (Simpson and Clifton, 2017). This lesson holds true for most of the low carbon technology alternatives.

4.7 Cities, buildings, and sub-national level actions

Covering just 3% of the Earth's surface but home to more than half of its population, the world's cities account for 70% of global energy demands (Agarwala, 2015). About 50–80% of the investments for GHG mitigation and up to 100% of the investments for climate change adaptation happen at the sub-national and local levels (UNDP, 2010). Some regional and municipal governments are demonstrating serious involvement to engage with local stakeholders to generate awareness and push for concrete low carbon changes in infrastructures, institutions and behaviour.

4.7.1 Networks among cities and municipalities for sharing low carbon practices

Several city level governance structures and actions have emerged as concrete responses to mitigate climate change and shift towards sustainable development patterns. For instance, C40 Cities – a network of megacities committed to addressing climate change – has adopted a strategy called 'Deadline 2020' that aligns its emissions-reductions plans with the Paris Agreement (Figueres et al., 2017).

Besides C40, WMCCC (World Mayors Council on Climate Change – an alliance of local government leaders concerned about climate change) has helped several urban centers to integrate climate objectives into current policy and long-term planning. The Cities for Climate Protection campaign, run by the global cities network ICLEI, has prevented emissions equivalent to some 54 million tonnes of carbon dioxide from more than 1,000 cities (Agarwala, 2015).

4.7.2 Policies of governments targeted at states, cities and facilities within cities

Beginning in 2010, and extending in 2012, China has been undertaking low carbon pilots in a total of 42 provinces and cities that account for 57% of China's GDP, 42% of its population and 56% of its energy related CO_2 emissions. As part of the pilots, these provinces and cities are developing low carbon development plans including policies for low carbon green growth, establishment of low carbon industrial systems, GHG emission statistics and data management systems, and encouragement of low carbon lifestyles and consumption patterns. Provinces and cities have been granted flexibility in terms of setting sectoral priorities and targets. Several of these pilot provinces and cities are already showing greater rates of decline in carbon intensity than the national average. While there is scope to further strengthen decision-support systems and financial systems, these pilots are an important step towards integrating low carbon development planning at sub-national levels in accordance with local conditions to enable technological leap-frogging along with sustainable development (Kedia, 2016).

In addition, China intends the share of green buildings to reach 50% of newly built buildings in cities and towns by 2020 (Jiang, Tamura, Hanaoka, 2017). Deployment of autonomous HVAC (heating, ventilating and air-conditioning) control systems in three metro stations in Beijing demonstrated energy reductions of 20–30% compared to conventional control systems (Wang, Feng and Xi, 2017).

As part of its National Action Plan for Climate Change (NAPCC) (launched in 2008), India's Ministry of Environment, Forests and Climate Change (MoEFCC) endorsed state level action plans in 2016 that have been formulated by state governments (Kedia, 2016).

There are also several good examples of regulations set by prefecture or municipal governments, which are aimed at implementing low carbon actions at facilities and regions through engaging local stakeholders. For instance, Iskandar Regional Development Authority – a planning body in charge of developing the Iskandar region of Malaysia – has been working closely with climate change researchers from Universiti Teknologi Malaysia (UTM) and the AIM team of Japan to set a low carbon society (LCS) target, prepare a LCS blueprint, implement its recommendations, and interact with local stakeholders including communities, schools and businesses to spread awareness (Ho and Matsuoka, 2012).

Several 'eco-cities', like Heidelberg in Germany and Vaxjoin Sweden, have reported significant cuts in CO_2 emissions by implementing multiple local measures such as a shift to public transport and increase in renewable energy, waste recycling and reuse (Joss, 2010).

The Tokyo Metropolitan Government's programme of combining a cap and trade system with a system of monitoring and reporting energy efficiency and carbon intensity performance of commercial buildings in Tokyo has led to several innovative measures and significant savings. It has attracted worldwide attention and is viewed as a benchmark of what a city government can do to enable commercial buildings and industries to move toward low carbon practices (LCS-RNet, 2016).

4.8 Designing policies and building capabilities specific to domestic conditions

Each country's demographic, resource, economic, political and cultural conditions require policies to be molded around them in order to be successfully accepted.

4.8.1 Low carbon policies specific to a country's demographic and economic condition

China and India, both being developing countries, like other developing countries, have expressed the intention (of low carbon transition) not in terms of absolute emission targets but in terms of development trajectories. China, with an ageing population, has expressed targets in terms of emission peaking and emission intensity of GDP. India, on the other hand, with a young workforce has expressed targets in terms of emission intensity of GDP alone (Kedia, 2016).

4.8.2 Building domestic capabilities in information, knowledge and skills useful for undertaking low carbon actions in a country

Solar datasets created by Muller et al. (2017) based on the years 1999 to 2014 provide a comprehensive overview of solar resources in India. This kind of database improves the quality of long-term estimations and reduces uncertainty and risk associated with renewable energy planning, and is also a good example of a domestic capability that needs to be built into developing countries in order to enhance confidence in the viability of specific renewable energy projects, and hence speed up their implementation.

4.9 Financing and investments

There are huge financial gains to be made through low carbon investments. International Renewable Energy Agency (IRENA) and International Energy Agency (IEA) report that efforts to stop climate change could boost the global economy by 19 trillion USD (IEA/IRENA, 2017). However, this requires significant investments by governments as well as private sectors in low carbon solutions.

Global investments in new renewables capacity for electricity generation rose for most of the past decade except in the past few years, which has been blamed on reduced financing as well as lower costs of solar PV and wind power (both onshore and offshore) due to increased competitiveness. Investment in developing countries fell 30% in 2016 (to 116.6 billion USD), while that in developed economies fell by 14% in 2016 (to 125 billion USD). China saw investment fall by 32% in 2016, breaking an 11-year rising trend. USA saw commitments slip 10% in 2016. Japan plunged by 56% in 2016. Europe enjoyed a small increase in renewables investment thanks to a boost in offshore wind (FS-UNEP, 2017). While new installed capacity in renewables has been increasing every year, the recent slowdown in new investments needs to be reversed if ambitious targets of decarbonisation and 2oC have to be met. Dasgupta (2015) argues that a shift to massive climate finance, of the order of trillions of USD (rather than billions), is necessary for a successful shift towards a decarbonised world.

Strong incentives are required to guide energy investment decisions towards low carbon solutions in cases of high capital costs and in the early stages of deployment before economies of scale are achieved. However, this capital will not be mobilised automatically, requiring policies which reduce the risks for private investors in low carbon technologies. It is important to note that the investment required in low carbon technologies, while being significant, does not represent a large increase compared with investment in the absence of climate policy. Rather, it represents a shift away from fossil fuels towards low carbon technologies and higher efficiency technologies (DDPP, 2015). Kainuma et al. (2013) also point out that the investment required for research and development (R&D) as well as deployment of low carbon technologies is a small fraction of the currently available private sector capital stock. Dasgupta (2015) states that there is no shortage of savings to finance the needed investments, nor paucity of technologies – rather, it is the lack of bold public policy frameworks designed to mitigate private risks and uncertainty that is holding up the release of private funds.

4.9.1 Mandating financial institutions to disclose strategy and actions towards low carbon portfolios

The G20 is in the process of adopting the recommendations of the Financial Stability Board's Task Force on Climate-related Financial Disclosures, on how the global finance system will manage the risk of climate change. This requires financial institutions to design, disclose and implement a transition strategy with a view to full decarbonisation of operations, value chains and portfolios by 2050 (Figueres et al., 2017).

Norway's 960 billion USD sovereign-wealth fund declared that it will ask the bank in which it has invested to disclose how their lending contributes to global GHG emissions (Figueres et al, 2017).

4.9.2 Global mechanism to spread information of climate-related investment risks

A global mechanism is needed to share information about climate-related investment risks, so that investors are able to plan and make better choices by knowing the chances of an asset losing or gaining value. For example, some major insurers and pension funds such as AXA in Paris, Allianz in Munich and health-benefits agency CalPERS of California are veering away from holdings in coal companies (Goldthau, 2017).

4.9.3 Mechanisms for low carbon credit, grants, subsidies, budgetary allocations, risk management instruments, and special funds and bonds

Various measures to reduce low carbon investment risks already being implemented are climate investment funds, carbon pricing, feed-in tariffs, green building certificates, carbon off-set markets, the UK's green investment bank, and several public-private initiatives (World Bank, 2011; GIBC, 2010).

China has established an elaborate green credit policy system, with the China Banking Regulatory Commission promulgating "Instructions to Energy Saving and Emission Reduction Credit Work" in 2007, "Guidance to Green Credit" in 2012, and "Instructions on Green Credit Work" in 2013. This system spurred green credit and accounted for over 7% of the total amount loaned by banks in China (Kedia, 2016).

China's government has also announced total support of 2.5 trillion Yuan (about 363 billion USD) as a state subsidy and grants to be invested in research, innovation and infrastructure related to sustainable energy by 2020 (Dreyer, 2017).

There are various financial mechanisms for low carbon development in India, including public finance (for example, cess on coal), traditional finance (for example, regular budgetary allocations, subsidies on renewable energy end-use devices and tax rebates on green buildings), financing platforms (for example, National Clean Energy Fund, indices such as Greenex and Carbonex for Bombay Stock Exchange, Green Bonds for renewable energy, Clean Development Mechanisms, Renewable Energy Certificates, Energy Saving Certificates, and priority sector lending norms for renewable energy by the Reserve Bank of India), risk management instruments (for example, Partial Risk Guarantee Fund under the National Mission on Enhanced Energy Efficiency), market based tradable instruments, and international sources (for example, Green Climate Fund, Adaptation Fund, and other bilateral and multilateral sources). Although there is no domestic carbon market in India, instruments such as renewable energy certificates are traded at Power Exchange India Limited (Kedia, 2016).

4.9.4 Global guarantee fund

In addition to earmarking finance for green projects, Sirkis et al. (2017) propose a global guarantee fund that would allow developing countries to finance the sustainable transition themselves. They suggest establishment of a new green global finance architecture to enable such a fund, comprising four blocks: (i) a regulatory framework to allow climate assets (both loans and securities) to be held on the balance sheets of any financial institution or investor; (ii) risk-sharing and de-risking mechanism; (iii) policies to promote the creation of new markets and instruments; and (iv) specific policy instruments that can implement such policies. Such an architecture involves the use of public resources (voluntary contributions and pledges) for setting up the guarantee fund. Guarantees would be used to mitigate the risks involved in low carbon infrastructure investments.

4.10 Carbon Pricing

Carbon pricing mechanisms such as carbon tax and cap-and-trade based emission trading schemes (ETS) have been among the preferred policy instruments of economists and policymakers for achieving emissions reduction targets. Many countries have introduced (or are in the process of introducing) carbon taxing in the wake of the Paris Agreement.

Carbon pricing is expected to result in higher prices for commodities and activities that generate greater carbon emissions (for example, those based on fossil fuel use), and thus, internalise the externalities.

At present, some 40 countries and more than 20 cities, states and provinces already use carbon pricing mechanisms. Together the carbon pricing schemes now in place cover about half their emissions, which translates as about 13% of annual global GHG emissions (World Bank, 2017).

Even before the Paris Agreement, carbon taxing existed in many countries, such as India, Japan, South Korea, Denmark, Finland, France, Ireland, the Netherlands, UK, Norway, Switzerland, Costa Rica, parts of Canada, and parts of the USA. Cap-and-trade schemes existed in New Zealand, 24 EU countries, Japan, parts of Canada, and parts of the USA. In addition, there have been hybrid schemes involving cap-and-trade systems that act as taxes through revenue-raising and price stability provisions (floor and ceiling prices).

There have also been schemes that indirectly price carbon, such as fuel taxes (or energy taxes), removal of fossil fuel subsidies, and regulations that may incorporate a 'social cost of carbon'. GHG emissions can also be priced through payments for emission reductions (World Bank, 2017).

Nordic countries of Europe such as Finland, Norway, Sweden and Denmark began experimenting with carbon taxation since the 1990s. Sweden is considered one of the successful examples to demonstrate environmental results through carbon pricing together with economic growth. With a record carbon price of EUR 120 per tonne of CO_2, Sweden sent a strong price signal to its economic actors (Rocamora, 2017).

4.10.1 Recognising the 'social' value of carbon reduction and linking it to carbon taxes and public funds for mitigating risk

The role of positive pricing of mitigation actions that is decided collectively but urgently, with the goal of moving trillions of dollars towards decarbonising the world, has been forcefully argued by Sirkis et al. (2017). They recommend that governments and international institutions decisively agree on an initial minimum base in terms of the social value of carbon reduction, which would determine the minimum level of taxes and help generate initial public funds. These funds could be used to back up credible public guarantees against the risk of failure of low carbon investment, provide global reimbursements for low carbon investments, and facilitate refinancing parts of the assets being financed through regular market channels. Such proposals need early collective agreement and action.

4.10.2 Preparedness, communication, transparency and stakeholder consultation

Drawing lessons from France's long experience with carbon taxation, Rocamora (2017) suggests that the legality and social acceptability of carbon taxing depends on its transparency, fairness, stability and predictability. Mobilising high-level political support, holding broad stakeholder consultations and communicating benefits to the public can facilitate the creation of a social consensus. It is crucial to clarify to all stakeholders and the public at large that carbon taxing is a cornerstone of the economic, social and fiscal reform required for the low carbon transition. Therefore, it is not merely another environmental tax but an element of the strategy to create social and economic benefits as part of the low carbon transition.

4.10.3 A global carbon price regime

Nordhaus (2013), Weitzman (2013) and others have suggested an international carbon price regime that would require every nation to commit to a carbon price but not to a specific policy instrument. A certain nation could select a mix of policy instruments (such as taxes, caps and hybrid schemes) that its policymakers and other stakeholders find most suitable for its market and economic conditions.

MacKay et al. (2017) also argue that individual commitments do not deliver strong collective action, and a global carbon price – so far excluded from consideration in international negotiations – would be the ideal basis for a common commitment. Based on trust and reciprocity, such a global common commitment can lead to a strong treaty. It is easy to agree and handle, relatively fair, less vulnerable to gaming, and consistent with climate policies already in place such as fossil fuel taxes and emissions cap-and-trade. Cramton et al. (2017) point out that since all proceeds from global carbon pricing stay in the country, it substantially reduces a country's risk exposure and makes it easier to take into account 'differentiated responsibilities'.

4.11 Citizens and other stakeholders of civil society

In democracies, bottom-up citizen-led initiatives have the power to force governments to take pro-people and pro-environment decisions. For instance, Germany's 'Energiewende' – an ambitious low carbon transition project – has been significantly driven and successful owing to the grassroots efforts of citizens and citizen associations. It enjoys the support of Germany's political parties and most of its population.

Sometimes, when a government does not enact sustainable and pro-environment policies, enlightened citizen movements can even trigger local actions that are in contradiction with those of their government. In spite of President Trump's negative stand there are encouraging signs from several important stakeholders in the US. For example, #WeAreStillinCampaign – involving more than 1,000 governors, mayors, businessmen, investors and universities from across the US – has declared that it will ensure the nation remains a leader in reducing carbon emissions (Figueres et al., 2017).

4.11.1 Mechanisms for providing feedback to consumers about energy use patterns, their impacts, and alternatives

From a field study in Southern France, Kendel, Lazaric and Marechal (2017) confirm the importance of consumer feedback as an efficient instrument for reducing household energy consumption. In addition, they observe that more sophisticated feedback leading to higher degree of absorbed knowledge might help in higher and distinctive types of energy saving.

4.11.2 Democratic decision processes and communication for low carbon project implementation

As mentioned in sub-section 4.1.6, energy policy preferences vary amongst local, regional and national levels in a country, and multiple energy policy objectives of energy efficiency, sustainable development, electricity reduction, local production, and employment generation are likely to be differently prioritised by different stakeholders. Therefore, inclusive and democratic decision-making processes and enhanced communication of energy policy objectives down to the local context is needed to avoid potential conflicts amongst stakeholders and public opposition to such policies.

As one of the many examples of communication and democratic implementation processes, the local governments of certain Midwestern counties in the USA have played an important role in the development of wind farms in their rural communities and enhanced community acceptance by raising awareness about local benefits to the economy and environment (Mulvaney, Woodson andProkopy, 2013).

Education and communication efforts can also enable citizens to spell out unambiguous preference for sustainable options even if they are not the most economical. For instance, a survey of 1,460 households in Hong Kong in 2016 indicated that almost half showed a willingness-to-pay higher electricity bills (up to 40% higher than existing) if coal based power generation were replaced by natural gas and renewable energy (Cheng et al., 2017).

4.11.3 Collaborative forums combining expertise of scientists and creative artists with mass citizen movements

A good example of citizens-artists-scientists collaboration to spread awareness of the urgency of action against climate change is the "Shanghai Project: Seeds of Time", which is a creative and compelling attempt to visually describe the disturbing prospect of impact of climate change on the city of Shanghai by 2050. The project is described as an 'ideas platform' on near-future sustainability and was kick-started by the Shanghai Himalayas Museum. A collaboration among artists and scholars from China, US and Europe, it comprises live events, artworks, workshops and publications that collectively imagine a future of Shanghai of harmonious co-existence between nature and humanity. It is viewed as a small step towards a zero-carbon China (Dreyer, 2017).

4.12 International cooperation

IPCC WG III (2014) emphasises the criticality of international cooperation to effectively mitigate GHG emissions and to further the development, diffusion and transfer of knowledge and environmentally sound technologies.

Paulo and Porto (2017) observe that collaboration and cooperation at various levels has been a key driver of research and innovation in solar energy technologies. International cooperation is prevalent in countries like the Netherlands, UK, Spain and Germany, national partnership exists in Japan, USA, France, Italy and South Korea. China has a predominant local cooperation profile but will become a major international collaborative actor in the near future.

International cooperation aimed at developing markets for low carbon technologies can reduce costs and barriers for all countries, relative to a go-it-alone approach, by achieving economies of scale in R&D, manufacturing and logistics much earlier and speeding up the transfer of learning and innovation. For instance, Huang, Du and Tao (2017) studied China's energy trends during 2000-2013 and observed that indigenous R&D and technology spillovers from openness of foreign direct investment and import played important roles in the declining energy intensity. This improvement, though not enough to realise a low carbon transition, underscores the importance of mechanisms for international cooperation.

International cooperation is also necessary to resolve concerns of equity and fairness that arise due to country-based differences in past and future atmospheric emissions of GHGs, different challenges and circumstances and capacity to address mitigation and adaptation (LCS-RNet, 2016).

4.12.1 Institutions for international transfer of low carbon technologies, practices, and resources

An international channel backed with strong financial and political support from high income countries needs to be established for cooperation and easy transfers of knowhow and capital between countries, especially between high-income and low-income countries, so as to enable widespread and quick dissemination of low carbon technology systems (LCS-RNet, 2016). Kainuma and Pandey (2015) suggest creating institutional network channels which facilitate easy transfers of knowhow of technological and management practices between (i) nations, (ii) research organisations, (iii) companies and (iv) research organisations and companies.

As mentioned in sub-section 4.6.2, a special international governance system would be required to remove the restrictions of trade, intellectual property, and weak financial strength of developing countries, in order to hasten transfers of low carbon innovations.

Kanie, Suzuki, and Iguchi (2013) argue that in order to remove barriers to rapid technology development, international institutional networks need to have both decentralised and centralised components, i.e., a fragmented governance architecture to provide decentralised, information-rich and flexible systems, coordinated by a hub that is capable of quickly accessing usable information and transmitting it to appropriate institutional nodes in the network. Such international networks and partnerships could be aided by sustained funding from intergovernmental organisations.

As discussed in sub-section 4.9.2, international institutions can play an important role in spreading information about climate-related investment risks and low carbon investment options across all countries so that investors can make well informed decisions.

International cooperation and governance mechanisms would also be needed for sustainable management of land and forests and reaching international consensus on treating forests as a global commons, as pointed out in sub-section 4.4.3.

4.12.2 International networks for universalising, sharing and standardising low carbon systems and skills

International networks among similar types of industries and sectors focused on low carbon goals would be useful to share and spread best practices. C40 and WMCCC are good examples (as discussed in sub-section 4.7.1) of networks of cities making efforts to share low carbon practices and evolve common strategies and standards.

In order to verify that countries are living up to their promises, they need to set up processes to gather reliable and transparent data. To assure the success of this system, Tollefson (2016) highlights the importance of building capacity to produce a network of carbon accountants across the world, especially in developing countries. International networks of climate change researchers and policymakers could play an important role towards this end.

Chapter 05

Barriers and challenges to low carbon policy implementation

There is broad agreement that while the INDCs and some of the good practices mentioned in section 4 are important steps in the right direction, a lot more needs to be done in order to make the low carbon transition successful. Climate change researchers and policymakers from across the world seem to agree that drastic and early actions and policies, such as those discussed in chapters 2, 3 and 4, are necessary. However, there are several barriers that need to be overcome, which together represent one of the chief and immediate challenges for national and international communities of policymakers, financial investors, researchers, industries, civil society groups and other stakeholders.

Progress on SDGs too suffers from gross underachievement. As an example, typical systemic inefficiencies and inadequate capacities have prevented the poor from accessing electricity. Nearly a fifth of the world's population has no access to electricity and two fifths have no access to modern cooking technologies.

In this section we discuss some of the barriers. The list is not exhaustive but highlights some examples in order to indicate the kind of hurdles that must be surmounted and the type of preparations that must be undertaken.

5.1 Role of governments in promoting viable business models, entrepreneurships and professionalisation around low carbon and sustainable activities

The absence of profitable business, entrepreneurial and commercial opportunities is often a key barrier to implementation of low carbon systems. Governments have not played an active role towards enabling environments that engender widespread business and professional activities based on low carbon and sustainable products and services.

For instance, Germany's feed-in tariff system created a conducive environment for emergence of about 1,000 Renewable Energy Cooperatives (RECs). However, recent changes in feed-in tariff policy have made the REC business model less profitable or unprofitable, resulting in uncertainty about their continuation and growth. Herbes et al. (2017), in their study of several RECs, observed that three barriers need to be overcome in order to enable further REC growth – (i) risk aversion on the part of both members and management, (ii) concerns about environmental impact or legal validity of certain business models, and (iii) lack of competency and time of the mostly unsalaried REC management. Thus, professionalisation of REC management and fresh policy initiatives by the government to support new and economically attractive business models are crucial to enable further growth of RECs. This would play an important role in achieving Germany's low carbon targets and set encouraging examples for other countries to adopt. Klein and Deissenroth (2017) also support this finding through an analysis of the German feed-in tariff system using prospect theory and report that people's investment in residential PV systems is not only determined by profitability but also by the change in profitability compared to the status quo.

Barring exceptions like China, Vietnam and Brazil where public sector-led grid expansion achieved incredible gains in access to electricity, in most developing countries both public and private sector-led approaches have been unsuccessful. With the current population growth rate continually outpacing the rate of interventions, there is an urgent need to accelerate the penetration of interventions of energy access. A worthwhile hybrid policy option might be to juxtapose social welfare objectives of public sector with enterprise development and growth objectives of the private sector (Rehman et al., 2017). Rapid creation of economic opportunities with low carbon and sustainable options for the private sector is a key challenge for governments.

5.2 Trade-offs between climate and sustainable development actions and between different sectors

There are many examples of real and potential trade-offs between the objectives of different sectors. Designing and implementing policies and actions in a particular sector without integrating concerns and objectives of other sectors is a common reason. Existing institutions and processes that work within compartmentalised, non-integrated goals and boundaries result in trade-offs.

As an example, renewable energy actions need to explicitly consider concerns in the land use sector. Shum (2017) estimates that solar intensive decarbonisation scenarios in the US would require large land areas for rapid build-up of utility-scale solar PV generating capacity (yearly land-use conversion would average 79,000–470,000 acres during 2015–2050). To facilitate this scale of land-use conversion, fundamental changes in land-use policy are required.

As another example, trade-offs between biomass energy and food security, and between the impact of biomass on poverty reduction and on the environment have been widely reported. In a case study of Italy, Bartolini, Gava and Brunori (2017) point out that although biomass energy production can help farmers stabilise their income, there are environmental risks associated with farming intensification. In another study of biofuel policies in USA, Brazil and EU, Oliveira, McKay and Plank (2017) found that such policies are not developed and implemented according to environmental or inclusive pro-poor development purposes, but according to state interests in energy security and its intersection with tense alliances between corporate sectors, rendering many policy mechanisms ineffective or counterproductive to facilitate socially and environmentally sustainable energy production and agricultural practices. They argue for land reforms and stronger anti-trust, environmental and labour protections.

Yet another example is the emerging trade-off between growing use of efficient and renewable energy devices by consumers and unintended impacts of their byproduct wastes on the environment and health of people. The absence of preparedness to counter such impacts often results in large, unaccounted damages. For instance, survey data from seven Sub-Saharan African countries shows that a transition has taken place in recent years, without external support from government or non-government organisations: the rural population without electricity in Africa has replaced kerosene lights and candles by simple, yet more efficient and cleaner LED lamps powered by non-rechargeable batteries. While this is a positive trend, the batteries are often disposed of in nature with harmful consequences for health and environment (Bensch, Peters and Sievert, 2017). A system for appropriate waste battery management is therefore urgently needed to contain the side-effects of LED diffusion.

5.3 Financing and investment policy: quantum of investment, institutions and processes of financial support, and management of investment risks

Present investments in low carbon actions are utterly inadequate. According to an estimate, investing 120 trillion USD in low carbon energy projects between 2016 and 2050, at twice the current annual rate of 1.8 trillion USD a year, will deliver a 66% chance of achieving the Paris target (Goldthau, 2017).

Investments in SDGs are also highly insufficient. A key challenge, therefore, is to rapidly ramp up the rate of investments in climate and SDG actions and achieve maximum synergy between the two.

For instance, Cheung and Davies (2017) highlight the absence of substantial capital investment to provide policy certainty and stability as one of the main barriers (besides the absence of a target-driven policy framework) behind Australia's underachievement of renewable energy.

Another challenge is to ramp up decarbonisation and SDG investments in developing countries. Developing countries need access to green and smart technology, but lack an investment climate that attracts capital and have few institutions that cultivate domestic enterprises and investors. Hence, deployment of low carbon investments on a large scale remains a challenge for them (Goldthau, 2017). China, India and other developing countries need to strengthen capacities of financing and relevant institutions at all levels – national, sub-national and local – in order to implement low carbon actions.

Jiang et al (2016) report that the investment required to realise a low carbon pathway in China that is compatible with the 2oC target is estimated to be (in CNY trillion) 2.8 by 2020, 2.8 by 2030, and 2.9 by 2050. The figures respectively represent about 2.5%, 1.3%, and 0.6% of China's GDP, which are small investments for realising the goal of low carbon development. However, raising these investments has remained a challenge.

Dagnachew et al. (2017) report that cumulative investment to achieve universal electricity access in Sub-Saharan Africa in the period 2010–2030 could be 2.5 trillion USD.

The government of India's low carbon action plans, especially at the level of states, are facing problems of inadequate financing. Despite several financial mechanisms in place, the overall financial space for low carbon development in India has been impeded due to inadequate subsidies, inadequate mechanisms for support of low carbon development by financial institutions, and poor awareness of low carbon projects. Additionally, interventions other than renewable energy and energy efficiency that promote sustainable development and low carbon society (for instance, in sectors of buildings, agriculture, industry, waste and forestry), are not adequately covered under various low carbon policies and schemes. It is estimated that 2.5 trillion USD (at 2015–2015 prices) will be required to meet India's climate change actions (as committed in its INDCs) between 2016 and 2030 (Kedia, 2016).

Besides inadequate investments, internal institutional processes for providing financial support for low carbon actions are weak and inefficient in developing countries. For instance, China's green credit system has produced limited market participation as the policy was voluntary. Ensuring a binding role of regulation alongside capacity building and internal incentives for banks could remove some of the process and institutional barriers (Kedia, 2016). In a feasibility analysis of grid-connected solar PV rooftops for households under the present feed-in tariff framework in Thailand, Tantisattayakul and Kanchanapiya (2017) reported that the existing feed-in tariff and loan financing scheme were not sufficient to promote investment in PV rooftops in the residential sector, and low interest rate loans appeared to be the best complementary measure to accelerate them.

Yet another challenge to attracting private investments in low carbon and SGD projects is poor risk and return characteristics. Small scale and rural projects suffer the most from this problem. Small-scale electrification projects are often unattractive for private investors due to un-favourable risk-return profiles and small investment values. Malhotra et al. (2017) suggest identification and classification of investment risks for renewable energy mini-grid projects and de-risking investments through aggregating small-scale projects into spatially diversified portfolios, as a way to boost investment in rural electrification in order to achieve both the SDGs of universal electricity access and climate targets of low carbon energy.

5.4 International cooperation, support, trust and common climate commitments around carbon pricing, standards of industrial practices, and other mechanisms

Pledge-and-review based agreements of Kyoto, Copenhagen, Cancun, and even Paris, have led to some progress in mitigation actions, but they have failed to produce strong and early actions. Cramton et al. (2017) place the blame on the lack of structure in these agreements to ensure international cooperation, trust and reciprocity. MacKat et al. (2017) explain that, although COP21 in Paris formulated an ambitious global climate goal, this will only progress if the collective goal is translated into a reciprocal, common climate commitment.

The ‘Pledge-and-review’ approach is likely to fail if it is solely based on individual commitments (Gollier and Tirole, 2017). The dominant approach pursued until now, i.e., responses to domestic pollution concerns and technological miracles, in the absence of international cooperation and a common global commitment, will not be enough to solve the dilemma (Parry, 2017).

While some experts recommend an international cap-and-trade agreement to implement a global carbon price, Cooper (2017) points to the difficulty of negotiating a global cap-and-trade scheme because the global ‘caps’ would be too high and the process of allocation of permits to domestic agents might suffer from intense corruption.

While domestic ETS and carbon taxes have been implemented in several countries, they have met with limited and varying successes. For instance, China’s pilot ETS has faced problems of allowance allocation, liquidity, lack of historical emission data at the enterprise level, unreliable third party verification process, low market efficiency due to fluctuating prices, and limited legal binding force (Kedia, 2016). Designing and monitoring such a mechanism within an internationally binding common commitment framework can possibly overcome such problems.

The International Organisation for Standardisation (ISO) conducted a survey of 378 standards developers and policymakers in 37 countries, and identified a disconnect between them as a potential barrier to developing effective and relevant standards for energy efficiency and renewable energy. Greater dialogue and better coordination between these agencies is crucial to develop international standards, which can act as an important tool for providing structure and guidance in rapidly evolving energy efficiency and renewable energy markets, thus improving their positive effect on global climate and energy access goals (McKane, Daya and Richards, 2017).

The conferences of the parties to the Basel, Rotterdam and Stockholm Conventions in 2017 on Sustainable Development called for better global management of chemicals and waste to meet the UN SDGs, particularly 3, 6, 12 and 14. However, the assistance provided from developed nations to developing nations for such plans is inadequate (Tan and Li, 2017). Joint funding for climate actions and SDGs in areas where there are synergies might help overcome trade-offs of competing funding requirements.

As discussed in section 4.12 (international cooperation), the decline of energy intensity in China during 2000–2013 benefitted significantly from technology spillovers from foreign direct investment, and cooperation at various levels in countries like the Netherlands, UK, Spain, Germany, Japan, USA, France, Italy, South Korea and China was a key driver of innovation in solar energy technologies. Although these trends underscore the importance of international support and cooperation, they are not enough. Yan et al. (1027) report that the gap of low carbon technology between OECD and Non-OECD economies has enlarged, and stress the importance of worldwide low carbon technology cooperation in accelerating technology diffusion across regions and promoting projects of technology transfer to regions with low-technology levels.

Therefore, an efficient institutional and infrastructural system for better international cooperation is needed to further accelerate research, innovation and commercialisation of solar energy and other low carbon technologies.

5.5 Addressing concerns of citizens and stakeholders, their participation in decision making processes, and building capacity and knowledge at sub-national and local levels

Aligning the collective developmental well-being of communities, stakeholders at local and other sub-national levels with the objectives of the low carbon transition remains a key challenge of policy and implementation. One of the reasons for less-than-satisfactory implementation of low carbon projects has been non-acceptance or inadequate acceptance of communities and stakeholders, which in turn has been due to weaknesses in the processes of communication of costs and benefits, evaluation, community participation, eliciting and resolving stakeholders' concerns, and implementation.

Ribas, Lucena and Schaeffer (2017) investigate the potential incompatibility between efforts towards the achievement of higher collective well-being and those associated with climate stabilisation. They report that if new climate policies were adopted, emissions associated with higher well-being in all regions where improvements are needed could still reach one and a half times the estimated 2oC budget. They conclude that efforts to reduce the carbon impact of higher well-being are most needed in Asia, and advanced countries may need to make room for higher collective well-being emissions.

Studies of local renewable energy projects have often reported that even though there is national level support for such projects, local communities might oppose them. Klain (2017) reported than local acceptance and smooth implementation of renewable energy projects require good public engagement, which boils down to (i) enabling bidirectional deliberative learning, and (ii) providing community benefit. Decision processes are perceived as fair and effective if (a) participants, including experts and local stakeholders learn from each other while reconciling technical expertise with citizen values, and (b) outcomes include the provision of collaboratively negotiated community benefits. Rand and Hoen (2017) also observe from the 30 years of North American research on public acceptance of wind energy that issues of socio-economic impacts of wind development are strongly tied to (community) acceptance; fairness, participation and trust during the development process influence acceptance; and viewing opposition as something to be overcome prevents meaningful understanding and implementation of best practices. They also find that sound and visual impacts of wind facilities are strongly tied to annoyance and opposition, and ignoring these concerns can exacerbate conflicts.

The absence of adequate capacity, skills and knowledge among citizen groups and other stakeholders at local and sub-national levels is also a gap that needs to be urgently redressed. This would require both building capacity and knowledge at local levels and efficient coordination between national and local governmental agencies. Kedia (2016) emphasises that, in countries such as China and India, among the important skills needed at sub-national and local levels is the knowledge relating to GHG inventories and disaggregated resource and socio-economic assessments (Kedia, 2016). India's state level low carbon action plans, endorsed by the Ministry of Environment, Forests and Climate Change (MoEFCC), are facing problems of lack of good inventories and data management systems at sub-national levels, weak coordination between the central government and state governments, and absence of efficient institutional mechanisms at local levels. This is partly because the state level action plans were largely guided by adaptation rather than mitigation goals, and partly due to weak governance linkages between national and sub-national levels (Roy et al, 2017).

In a survey of multiple stakeholders in a province of Canada, Mercer, Sabau and Klinke (2017) identified lack of knowledge at sub-national and local levels (besides political and economic factors) as one of the impediments to wind energy development. They suggest comprehensive policy solutions comprising not only financial but also educational, legislative and consultative components, especially at the local level, to overcome the barriers.

5.6 Spreading low carbon innovations in developing countries and aligning them with domestic SDGs and economic development objectives

Developing countries are struggling with generating, adopting and diffusing low carbon technology innovations. This is a challenge that almost all developing countries face.

For instance, Kedia (2016) observes that both China and India have faced difficulties in developing, deploying and adopting low carbon technologies due to the additional cost associated with them and, in some cases, technical barriers to implementation. While China and India have shown political willingness and introduced some good domestic policies and international engagement, the key to their low carbon transition is through innovation and commercialisation of new technologies and focusing on indigenous solutions, facilitated by joint R&D with, and technology transfer from, developed countries. Although, as Dasgupta and Roy (2016) note in their study of Indian manufacturing sector, low carbon technologies have been adopted by industries to the extent they helped in market competition, role of policy is crucial for a wider scale diffusion. Developing financial, institutional and the relevant skill capacities at all levels – national, sub-national and local – is also important.

In addition, these countries need to meet a series of social and economic challenges in order to achieve a low carbon future, such as reducing poverty, expanding access to energy services, ensuring energy security, increasing employment rate, reducing local environment pollution, and protecting biodiversity.

5.7 Resistance from incumbent industries and vested interests, and inertia of existing technological stocks

Existing industries with business interests tied to fossil fuels, which have prospered and grown over the past decades, is a big impediment to the rapid adoption and diffusion of industries based on low carbon energy and sustainable technologies and innovations.

In an empirical study of business actors across the US energy industry, Downie (2017) reports that resistance from incumbent fossil fuel industries is one of the main reasons behind energy policies falling well short of achieving a rapid transformation to low carbon energy supply systems. He argues for three strategies to overcome this resistance: (i) entrench and build existing interests via targeted sector specific policies, (ii) exploit inter-industry and intra-industry divisions, and (iii) shift existing interests with policies that induce changes in industry investment and structure.

Besides vested business interests, large existing stocks of technologies that are inefficient and highly GHG emitting represent an inertial barrier to quick replacement by new, low carbon alternatives. This barrier is especially overwhelming in widely dispersed, consumer-owned devices that have long lives and are also capital intensive, such as private vehicles and buildings.

For example, to meet the targets of the Paris agreement, road vehicle fleets will have to undergo a massive energy transition towards vehicles with drastically higher energy efficiency and/or lower carbon intensity. Vehicle fleet renewal could take up to 25 years after market uptake of new technology, and tough policy intervention is needed to accelerate penetration of zero or low emission vehicles (Fridstrom, 2017). More specifically, measures aimed at increasing the rate of vehicle turnover would significantly decrease the time lag.

Chapter 06

Discussion

As the impacts of climate change have increased and intensified, the need for early climate actions to be implemented is also intensifying. Although NDCs have been submitted to the UNFCCC, they alone cannot achieve the 2°C target. Moreover, the final goal is carbon neutrality, and additional efforts are necessary to stabilise the climate.

Many countermeasures have been considered and implemented, most of which are sector- and technology-specific. Naturally, such measures and efforts to develop innovative technologies are essential to meet the 2°C target. However, climate policies and their implementation require integrated efforts as each action is closely related to others and the combined impact differs from the sum of multiple isolated impacts.

Most countries are making efforts to achieve their NDCs as well as SDGs, and implementing both will lead to mutual reinforcement. To achieve Goal 13 (climate action), it needs to be implemented in alignment with other SDGs as funds, human resources and other resources are shared among different actions and innovations.

It is also necessary to integrate climate actions with more fundamental efforts to develop infrastructure and economy. New trends of increasing investments in low carbon technologies are a good sign for innovation.

However, there are trade-offs among SGDs and barriers, which are discussed in chapters 2 and 5. Such issues, some of which are posed below as questions, need further studies.

1) How can we tackle the trade-offs between climate and sustainable development actions?

To end hunger, it is necessary to increase arable land areas, which might have a trade-off with increasing areas for biomass energy. To increase agricultural productivity and income of farmers, chemical fertiliser is often used which could harm land as well as water ecosystems. Increasing areas for biomass energy could also have adverse impacts on forest resources and ecosystems on land, which in turn affects water resources.

Investment in urban infrastructure would accelerate migration from rural to urban areas, which causes congestion and deterioration of the urban environment. On the other hand, investments in new service infrastructures in rural areas may cause negative impacts on natural ecosystems. There is therefore an urgent need for integrated planning of urban and rural areas that considers both human settlements and natural ecosystems.

2) Which goal is of higher priority – access to efficient energy for all or climate stabilisation? Is there a way to achieve both?

It is a fundamental development need to provide access to efficient energy services for all sections of earth's population; however, it should be provided with low and/or zero carbon energy. Renewable energy is one of the prominent options which also addresses the concern of energy security. The share of renewable energy in global power generation was still only 11.3% in 2016, most of which was from hydro power. However, renewable energy excluding large hydro accounted for 55.3% of the new electricity generating capacity added worldwide in 2016 (FS UNEP Center, 2017). Some countries have higher shares of renewables in installed electricity generating capacity, e.g., 33% in Philippines (Delos Santos, 2017) and 35% in Germany (Independent, 2017).

However, new problems are being reported with the increase of renewables that need to be fixed in the near future for low carbon energies to be accepted and diffused widely.

For instance, there are growing concerns about the costs of the feed-in tariff, waste treatment of used solar panels, increase in nearby temperatures, dazzling of neighborhoods, requirement of large land areas for mega solar plants, low frequency noise and irritating rotating shadows associated with wind turbines, and damage to landscapes.

There are many more problems with nuclear energy, such as the treatment of nuclear fuels (nuclear waste) and exposure to radiation as a result of accidents. Technologies that completely remove radioactivity from used rods do not exist, although levels can be lowered. Moreover, additional space is needed for safe storage over hundreds of years, which most countries are not prepared for except Finland. Accidents in nuclear plants result in enormous levels of damage, as was witnessed at Japan's Fukushima-daichi plant. Most accidents have so far resulted from human error, but sources that have recently emerged as real threats, such as terrorism – direct bomb attacks as well as cyber terrorism – need to be considered seriously. In 2010 a nuclear power plant in Iran was attacked by Internet terrorists. America's Internet grid has also been damaged by cyber-attacks. According to a New York Times report (Perlroth, 2017), since May 2017 "hackers have been penetrating the computer networks of companies that operate nuclear power stations and other energy facilities, as well as manufacturing plants in the United States and other countries".

Another problem that could surface is that of the many stranded assets of technologies based on fossil fuels that would become unusable in the wake of the low carbon transition. The current remaining CO_2 emissions budget for staying below 2°C with 66% probability is about 1,000 $GtCO_2$; 739 $GtCO_2$ will be used through 2030 under the current NDCs (UNFCCC, 2016). As fossil fuel-fired power plants are still being constructed, they could become stranded assets.

3) What kinds of innovative technologies can we expect to drive the low carbon transition?

A GHG reduction can only occur through significant contributions from reductions on the energy supply and demand sides. It is projected that the global temperature increase will be more than 2°C by the end of 2100 if we rely only on implementing the NDCs. Increasing the level of ambition of the NDCs is therefore an urgent task. It is also projected that even if we secure a pathway well below 2°C, the temperature could still overshoot during this century, which means that the technology for carbon capture and storage (CCS) will also be needed in such a situation.

As regards CCS, there are many unresolved issues to be overcome before such technologies can be commercialised at the visible scale, i.e., costs, storage sites, and environmental impacts of possible CO_2 leakages caused by earthquakes or other factors. As the total storage capacity of CCS is limited, it could only act as a bridging technology before innovative zero emission technologies come online. The question is therefore, is it worth investing in such stop-gap technology?

Geoengineering technology is also considered as a possible option to mitigate the global warming aspect of climate change (Pope, 2012). However, to date no promising geoengineering technology has emerged as there are several potential and unresolved adverse effects on the environment.

There is also the challenge of deploying demand-side technologies. Several policies to promote energy-saving technologies, such as Best Available Technologies (BAT), do exist, but are limited. Stronger mechanisms are needed to accelerate the deployment of existing energy-saving technologies as well as developing innovative ones that can cut energy use substantially.

4) Can climate stabilisation be one of the main agendas for land planning?

Developing low carbon infrastructure and land-use plans is an important action in the transition to a carbon neutral world. Designing a low carbon transport system, including public transport, safe pavement and bicycle tracks, is a part of this action.

Integrated development of urban and rural areas is also an essential part of this action. Among the several concerns of development that it needs to address is excessive urbanisation that increases the stress on urban areas on the one hand and leads to neglect of management of rural areas on the other, causing grave impacts on ecosystems in the process.

5) Are there viable business models for a carbon neutral world?

The absence of profitable business, entrepreneurial and commercial opportunities is often a major barrier to implementation of low carbon systems. Governments have not played an active role towards creating enabling environments that engender widespread business and professional activities based on low carbon and sustainable products and services.

Present investments in low carbon actions as well as SGDs are highly insufficient. A key challenge is to rapidly ramp up the rate of investments in climate and SDG actions and achieve maximum synergy between the two.

Existing industries with business interests tied to fossil fuels, which have prospered and grown over the past decades, are a big impediment to rapid adoption and diffusion of industries based on low carbon energy and sustainable technologies and innovations. As mentioned earlier, considering the carbon budget for a world that's safely under the 2°C limit, stranded assets are becoming a serious problem. However, little attention is paid to this issue when approving and constructing new fossil fuel plants.

6) To what extent is the importance of achieving NDCs and SDGs recognised by stakeholders? Is carbon neutrality recognised and taken seriously?

Aligning the collective developmental well-being of communities and stakeholders at local and other sub-national levels with the objectives of the low carbon transition remains a key challenge of policy and implementation. One of the reasons for less-than-satisfactory implementation of low carbon projects has been non-acceptance or inadequate acceptance by communities and stakeholders, which, in turn, is due to weaknesses in the processes of communication of costs and benefits, evaluation, community participation, eliciting and resolving stakeholders' concerns, and implementation.

Disseminating low carbon innovations in developing countries and aligning them with domestic SDGs and economic develop development objectives are key challenges to the low carbon transition. The engagement of all stakeholders and cooperation among them are essential elements of this transition.

7) Is international cooperation working effectively?

Pledge-and-review based agreements of Kyoto, Copenhagen, Cancun, and even Paris have led to some progress in mitigation actions, but have failed to produce strong and early actions.

Although the Paris Agreement has an ambitious global climate goal, cooperation at various levels remains a challenge. Every stakeholder must be made aware of the necessity and feasibility of climate and sustainability goals, and be induced to act with required collaborative supports at multiple levels.

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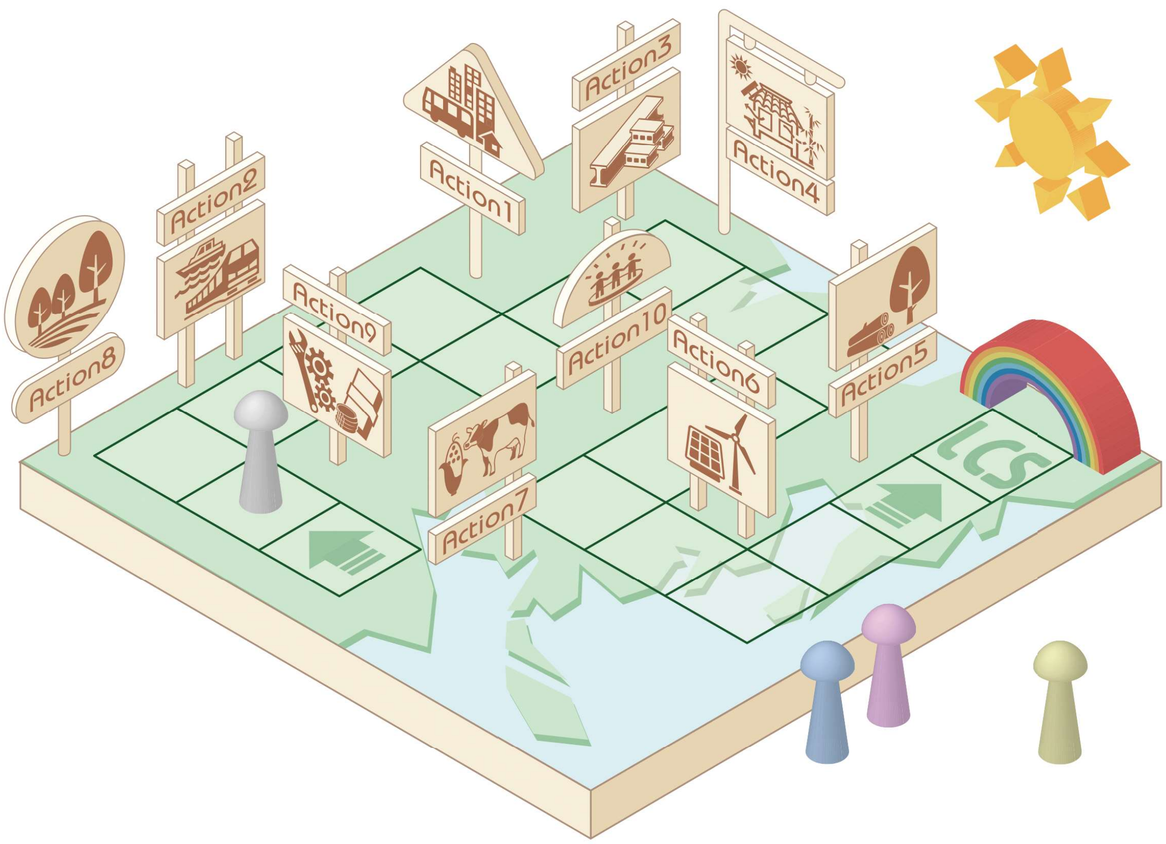

Ten actions

http://2050.nies.go.jp/file/ten_actions_2013.pdf

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Appendix:

The target of NDCs and the gap between the NDCs and well below 2°C scenarios

Table A.1 The target of NDCs and the gap between the NDCs and well below 2°C scenarios (China, India and Indonesia)

	China	India	Indonesia
Main targets for NDC scenario	1) Peak CO_2 emissions by 2030 at the latest. 2) Reduce the CO_2 emissions per unit of GDP by 60-65% from 2005 the level by 2030. 2) Increase non-fossil fuel sources in primary energy consumption to about 20% in 2030.	1) Reduce overall emission intensity of GDP by 33-35% from 2005 level during 2005-2030. 2) Achieve 40% of electric generation capacity from non-fossil fuels by 2030.	1) Reduce carbon emissions by 29% (unconditional) - 41% (conditional) in 2030 compared to BaU. 2) Reduce CO_2 emissions by 11% (unconditional) and 14% (conditional) in the energy sector and 17.2% (unconditional) and 23% (conditional) in the land use change and forestry sector in 2030 compared to BaU.
Scenario assumptions	1) Production of iron and steel increases to 670 Mt in 2020 and decreases to 360 Mt in 2050. 2) Production of cement increases to 1.7 Bt in 2020 and decreases to 900 Mt in 2050.	1) BaU: GDP grows at 8% CAGR during the period 2015-2030, and population grows at 1.2% CAGR, reaching 1.5 billion by 2030. 2) NDC: follows national climate policies. 3) Two-degree scenario: more aggressive efforts.	1) The annual population growth rate is about 1.1% up to 2020, and then decline to 0.6% until 2050. 2) The GDP per capita rises at an annual average rate of 4.8% during 2010-2050.
Low carbon scenarios	1) CO_2 emissions peak before 2025. 2) CO_2 reduction is more than 70% in 2050 compared to the level in 2020.	About 20% reduction of CO_2 emissions in the NDC and 46% reduction in 2°C scenario compared to BaU in 2050.	1) Agriculture, forestry and other land use (AFOLU) sector could contribute to about 60% of the target while energy sector covaers about 36% in 2030.
Aim of Policies to fill the GAP	1) Increase the share of renewable energies. 2) Much faster improvement of electric appliances such as LED TVs, higher efficiency air conditioners and high-efficiency cars. 4) Rapid GDP growth supporting low carbon development.	1) Increase demand reduction. 2) Introduce CCS in power and industrial sector (critical if coal remains dominant fuel). 3) Shift to public transport and electrification in the passenger vehicles scenario in 2050.	1) Increase efficiency measures, deployment of renewable energy, natural gas and clean coal technology. 2) Reduce deforestation and forest degradation. 3) Increase peat restoration and reforestation. 4) Improve water management in peatland.

Policy actions	1) Introduce/increase carbon pricing (carbon tax and/or emission trading). 2) Introduce/increase caps for CO_2 emissions. 3) Increase investment in renewables to make them compete with coal-fired power plants, and become the biggest investor in the world.	1) Adopt higher vehicular emission standards. 2) Reduce the share of coal: 32% in BaU, 24% in NDC, less than 21% in 2°C scenario in 2050. 3) Increase the share of renewables: 22% in BaU, 32% in NDC, and 35% in 2°C scenario.	1) Enhance active participation of the stakeholders. 2) Increase the share of renewable energy: 19.6% in pre-NDC to 22.5% in NDC. 3) Apply for mandatory certification for sustainable forest management and palm oil plantation. 4) Mandate sector and local governments to mainstream climate change into their development plan, program and policies. 4) Accelerate agrarian reform and social forestry to address the concerns of land tenure and access. 5) Revise fiscal policies ~ provide incentive for conserving forest and controlling deforestation.
Costs	US$35 to US$155 /t CO_2 in 2030 depending on low carbon countermeasures.	CCS will be picked up under US$ 40-60/t CO_2 for gas and US$ 60-100 for coal in 2°C scenario.	Additional investments for implementing peat restoration, and land rehabilitation and peat water management for unconditional NDC and conditional NDC compared to the BaU are estimated to be about US$ 618 and 997 million respectively up to 2030.
Co-benefits	1) Reduce air pollution. 2) Increase energy security 3) Increase exports of clean energy technologies (solar PV and wind)	1) Support sustainable development. 2) Increase resource efficiency.	1) Increase energy security. 2) Support sustainable forest management. 3) Serve food security by increasing crop productivity and cropping intensity.
Challenge	1) By 2010, cement and steel output was 1.8 billion and 630 million tons respectively, which is already higher than or close to the expected production in 2020. China has undergone a period of rapid infrastructure development. 2) Uncertainty is whether the grid could adopt a large influx of renewable energy, although renewable energy development policies are crucial to reach the 2-degree target.	1) Reliability and uncertainty in adopting CCS technologies. 2) Transform urban infrastructure to low carbon. 3) Cultivate the younger generation to adopt low-carbon consumption lifestyle.	1) Infrastructure for gas distribution lines, and natural gas fuel stations. 2) High investment for application of clean coal technology. 3) Ambitious emission reduction target for AFOLU requires high investment for improvement of crop productivity and irrigation infrastructure. 4) Economic impacts of mitigation actions.

(Boer, 2016; Boer et al., 2017; Dai, 2017; Fujimori et al, 2017; Jiang et al, 2016; Shukla and Dhar, 2016, Shukla et al., 2017)

Table A.2 The target of NDCs and the gap between the NDCs and well below 2°C scenarios (Japan, Thailand and Vietnam)

	Japan	Thailand	Vietnam
Main targets for NDC scenario	Reduce GHG emissions by 26% in 2030 from the 2013 level (22.7% relative to 2005, excluding AFOLU emissions).	Reduce GHG emissions by 20 (unconditional) - 25% (conditional) by 2030 from the BaU (approx. 555 $MtCO_2$).	Reduce GHG emissions in 2030 by 8% (unconditional) - 25% (conditional) relative to the BaU (approx. 614.9 $MtCO_2eq$).
Scenario assumptions	1) 1.7% increase of annual GDP during 2013-2030. 2) Population decrease from 127 million to 117 million. 3) Crude steel production increases from 112 to 120 Mt by 2030.	1) Increase the share of renewables from 5.9% in BaU to 38% in NDC in 2030. 2) The average GDP growth and the population growth are expected to increase about 3.94% and 0.03% annually.	1) Population and GDP growth rate during 2005-2030 are 0.9% and 6.2%, respectively.
Low carbon scenarios	GHG emissions in 2030 decrease by 29% below the 2005 level. 80% reduction of GHG by 2050.	Low carbon share of electricity generation of 28-61% across different scenarios.	Low INDC scenario is to reduce at least 8.0% and high INDC scenario to reduce 25.0% in 2030 compared to BaU.
Aim of policies to fill the GAP	Rapid and large-scale transformation of energy system, including electrification in the end-use sectors.	1) Significant penetration of renewable energy. 2) The nuclear power plant and CCS are also included in this dimension to provide choices in the power sector after 2030. 3) Substantially increase the rate of penetration of low carbon technologies.	1) Increase the capacity of renewables. 2) More actions in the agriculture, forestry and land use sectors (AFOLU). 3) More policies in the waste management sector (domestic sewage and solid waste landfill).
Policy actions	1) Introduce/increase carbon pricing. 2) Extend best available technologies. 3) Promotion of renewable energies	1) Provide more efficient public transport system to increase modal shift, and energy efficiency of vehicles. 2) Increase the share of biofuels. 3) Introduce stringent building codes, and efficiency improvement. 4) Increase fuel substitution in industries.	Shift in production, investment and labor from energy intensive industries to industries using alternative energy sources and consuming less energy.
Costs	1) US$ 165/t-CO_2 in 2030 and US$ 654/t-CO_2 in 2050 in NDC. 2) US$ 260/t-CO_2 in 2030 and US$ 607/t-CO_2 in 2050 in Low-carbon scenario.	1) US$ 0-1000/t-CO_2 (starts from 2020 onwards depending on scenarios). 2) Less than US$ 6.2/t-CO_2eq for 20% target, and US$ 15.7/t-CO_2eq for 25% target in 2030.	Less than US$ 5.0/t-CO_2eq for the Low NDC target, US$ 89.2/t-CO_2eq for high NDC target.
Co-benefits	Increase energy security.	Avoid impacts of climate change.	1) Increase energy security. 2) Avoid impacts of climate change. 3) Reduce air pollution.

Challenge	1) Safety concerns of particular technologies, such as nuclear and CCS 2) Integration of variable renewable energies (VREs) into electricity grid. 3) Transformation of lifestyle and industrial structure towards low-carbon society.	1) Cope with high patent acquisition costs. 2) Cope with lack of local expertise. 3) Increased investment required from foreign countries. 4) Achieve consensus among different stakeholders.	1) Energy sector is still dependent on domestic fossil fuels. 2) Solutions to reduce GHG emissions can cause a significant impact on the goal of social economic development. 3) Increased investment required in renewables. 4) Raise food productivity. 5) Rising energy prices reduce the real wages of workers.

(Lam, 2016; Limmeechokchai, 2016; Limmeechokchai et al., 2017; Masui et al, 2016; Oshiro et al., 2016a, 2017b; Oshiro 2017; Tu et al., 2017; Vishwanathan, 2017)

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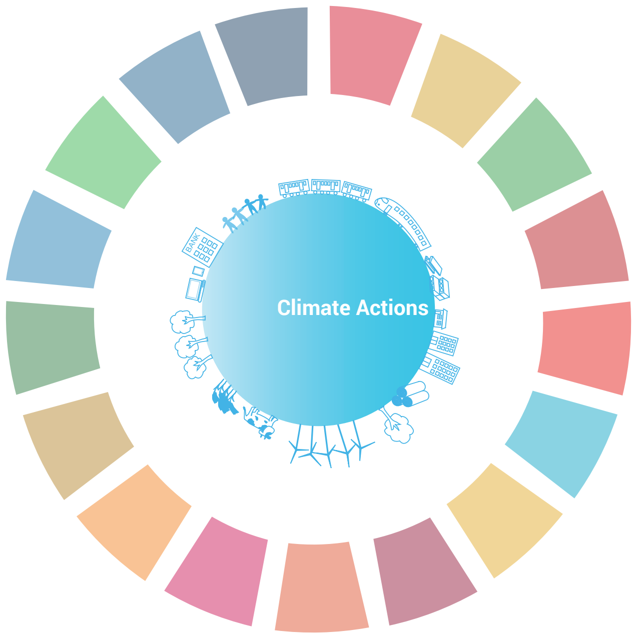
Climate Actions