Analysis of the interlinkages among the Sustainable Development Goals (SDG): Methodology, tools and applications

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Teaching Sustainability and Localising the Sustainable Development Goals in the Hindu Kush Himalaya, *26 September–23 December 2022, online*

IGES SDGs Aspiration to Action

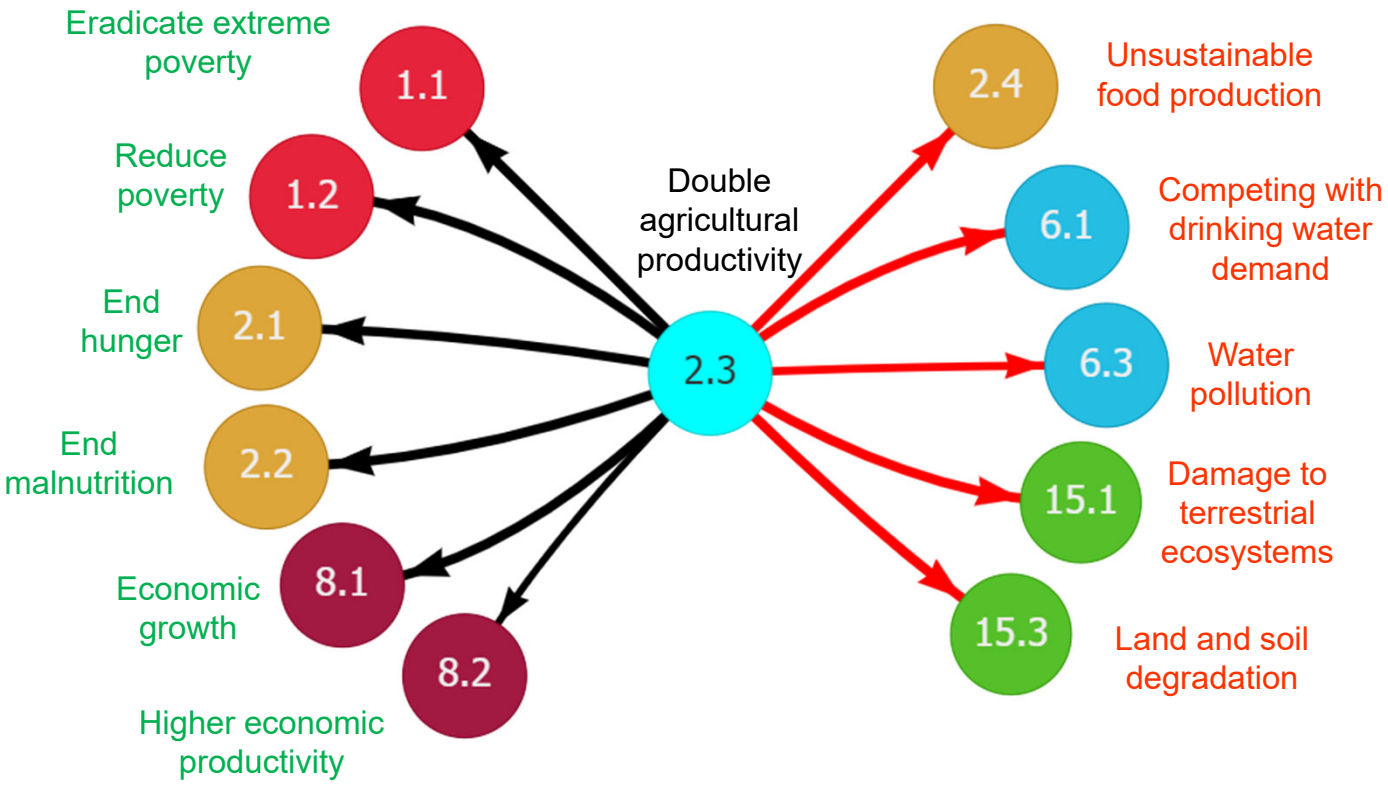
Outline of the lecture

- Integrated SDG planning: *Importance and existing practices*
- SDG interlinkages analysis: *Knowledge gap and existing methods*
- SDG Interlinkages Aanalysis & Visualisation Tool: The four-step methodology
- Applications of the SDG interlinkage tool and recent development
- A demo on the functions of the tool
- Future research agenda
- Q&A

The United Nations' Sustainable Development Goals (SDG) form an interacted and indivisible system

Complex interactions involving both synergies and trade-offs

- Examples of the synergies and trade-offs of Target 2.3
  - **Synergies**: Poverty reduction, ending hunger, and economic growth
  - **Trade-offs**: Competition for water use, water pollution, and environmental degradation



Source: Based on the SDG Interlinkages Tool. https://sdginterlinkages.iges.jp/visualisationtool.html

Importance of taking an integrated approach for SDG achievement

- Intrinsic SDG interlinkages require a shift from a siloed approach to an integrated approach.
- Understanding the interlinkages is important for taking an integrated approach which helps address issues such as:
  - *How will achieving one target impact on achieving others and how strong are the impacts?*
  - *Where are the synergies and trade-offs between the SDG targets?*
  - How countries are different in terms of the SDG interlinkages?
  - What are the policy implications for priority setting and institutional and financial arrangement, etc.

A siloed approach cuts off the interlinkages

An integrated approach takes account of the interlinkages

Integrated SDG planning: Existing practices in Asia and challenges

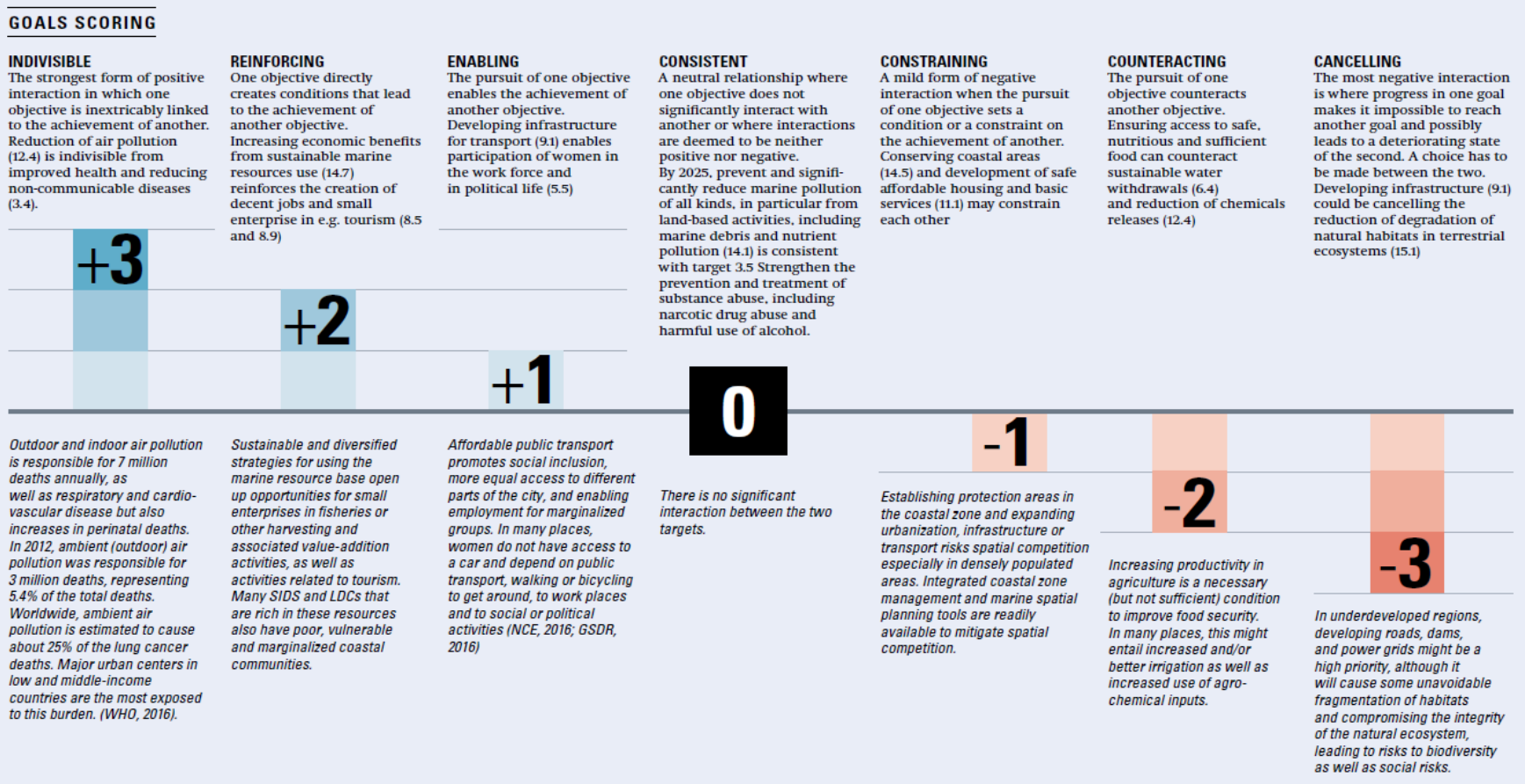
- **Existing practices of SDG integrated planning and implementation in Asia**
  - Set up a SDG Secretariat or Committee as an inter-agency institution for integrated coordination, with ministries responsible for the planning and implementation of specific SDGs: e.g. Indonesia established a "SDG National Coordination Team" for SDG planning and implementation.
  - The Prime Minister and its Office takes the lead: e.g. Malaysia has a National SDG Council chaired by the Prime Minister for monitoring the SDG implementation.
  - A lead ministry is in charge of SDG planning and implementation through the collaborations with other ministries: e.g. In Cambodia, the Ministry of Planning leads the delivery of the. In Viet Nam, the Ministry of Planning and Investment is the lead agency for SDG implementation.
- **Challenges for practicing an integrated approach**
  - Broad coverage of social, economic and environmental dimensions;
  - Complicated interactions possibly consisting of 169 x 168 pairs of relations;
  - Gap in scientific knowledge about how the SDGs are interlinked.

Existing methodologies and tools for analysing SDG interlinkages

Methodology	Scope	SDG coverage	Level of interlinkages	Nature of interlinkages analysis
Le Blanc, 2015	General	All	Goal level, target level	Linguistic approach, network visualisation
Nilsson et al., 2016	General	-	Target level	Analytical framework on seven-point typology
ICSU, 2017	General	Goals 2, 3, 7, 14	Goal level, target level	Literature review, expert judgement, seven-point typology
UNESCAP, 2017	General, app. in three countries	Goal 6	Target level	Qualitative analysis, leverage point identification, visualisation
IGES, 2017, 2018, 2019.	National,27 countries	All	Target level	Literature review, expert judgement, statistical analysis, network analysis
OECD, 2018	General	Goals 6, 7, 11, 12, 15	Goal level, target level	Policy Coherence for Sustainable Development (PCSD)
Millennium Institute, 2017	National, a few countries	All	Goal level, target level	System Dynamics model
Weitz et al., 2018	Sweden	34 selected targets	Target level	Expert judgement, seven-point typology, cross-impact matrix, network analysis
Allen et al., 2019	Arab regional	Environment-related SDGs	Target level	Cross-impact matrix, network analysis, multi-criteria analysis
Jaramillo et al., 2019	45 wet landscapes	33 relevant targets	Target level	Questionnaire survey, seven-point typology, network analysis

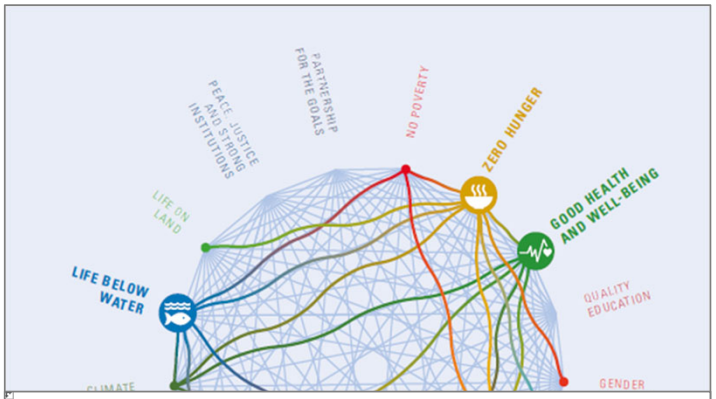
Source: Zhou and Moinuddin, 2017

Typology approach: Mapping SDG interactions based on a seven-scale framework



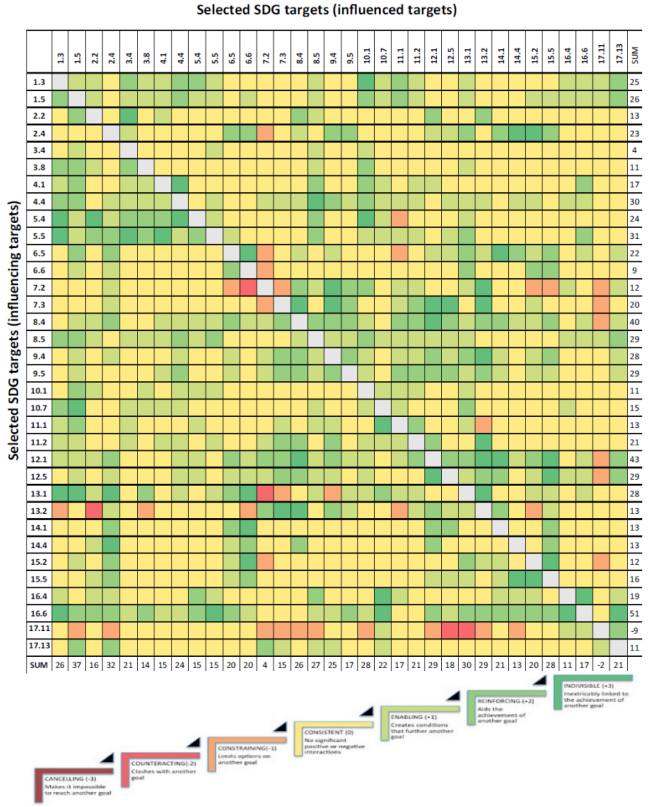
Source: Nilsson, et al., 2016

Applications of the seven-scale typology approach and expert opinions



	KEY INTERACTIONS AT THE GOAL LEVEL	KEY INTERACTIONS AT THE TARGET LEVEL
Goal 2	Goal 1, Goal 3, Goal 5, Goal 6, Goal 7, Goal 13, and Goal 15	75 target-level interactions: 50 (positive), 1 (neutral) and 24 (negative)
Goal 3	Goal 1, Goal 2, Goal 8, Goal 11, and Goal 13	86 target-level interactions: 81 (positive) and 5 (negative)
Goal 7	Goal 1, Goal 2, Goal 6, Goal 8, and Goal 13	58 target-level interactions: 46 (positive), 10 (neutral) and 2 (negative)
Goal 14	Goal 1, Goal 2, Goal 8, Goal 11, Goal 12, and Goal 13	96 target-level interactions: 61 (positive), 1 (neutral) and 35 (negative)

Source: ICSU, 2017

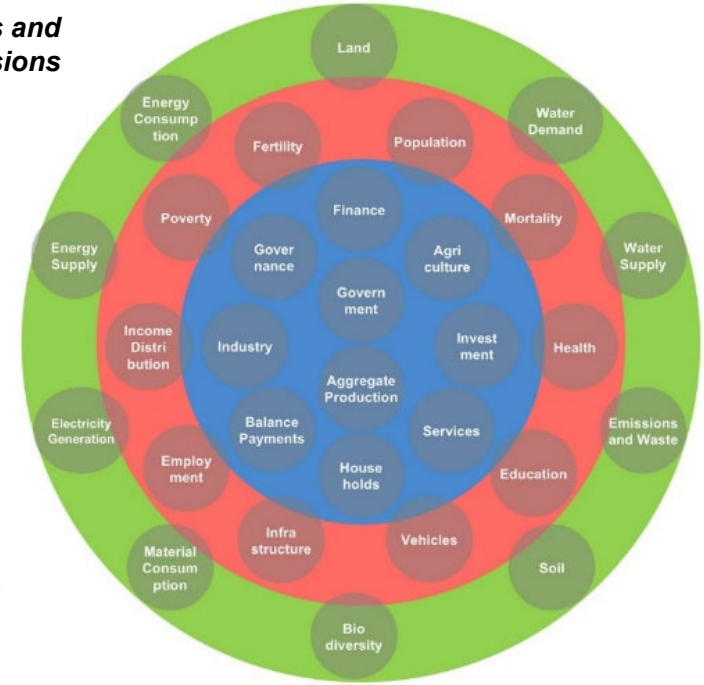


Source: Weitz, et al. (2018)

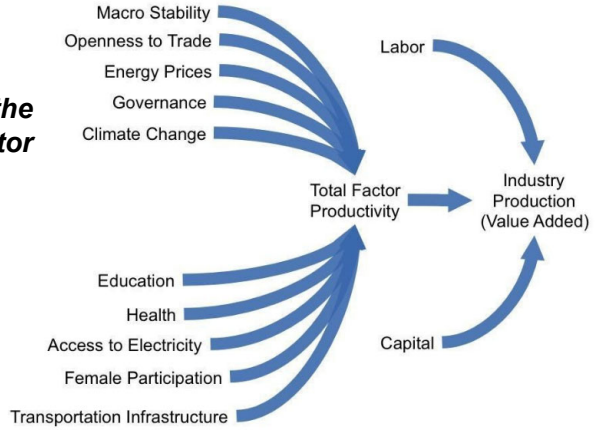
A System Dynamics model: Integrated Sustainable Development Goals Planning Model (iSDG)

- All SDGs and 78 SDG indicators
- Three dimensions and 30 sectors
- Calibrated with country data and the context for the interactions
- Medium to long-term scenario analysis (2030)
- Policy simulations

iSDG sectors and three dimensions

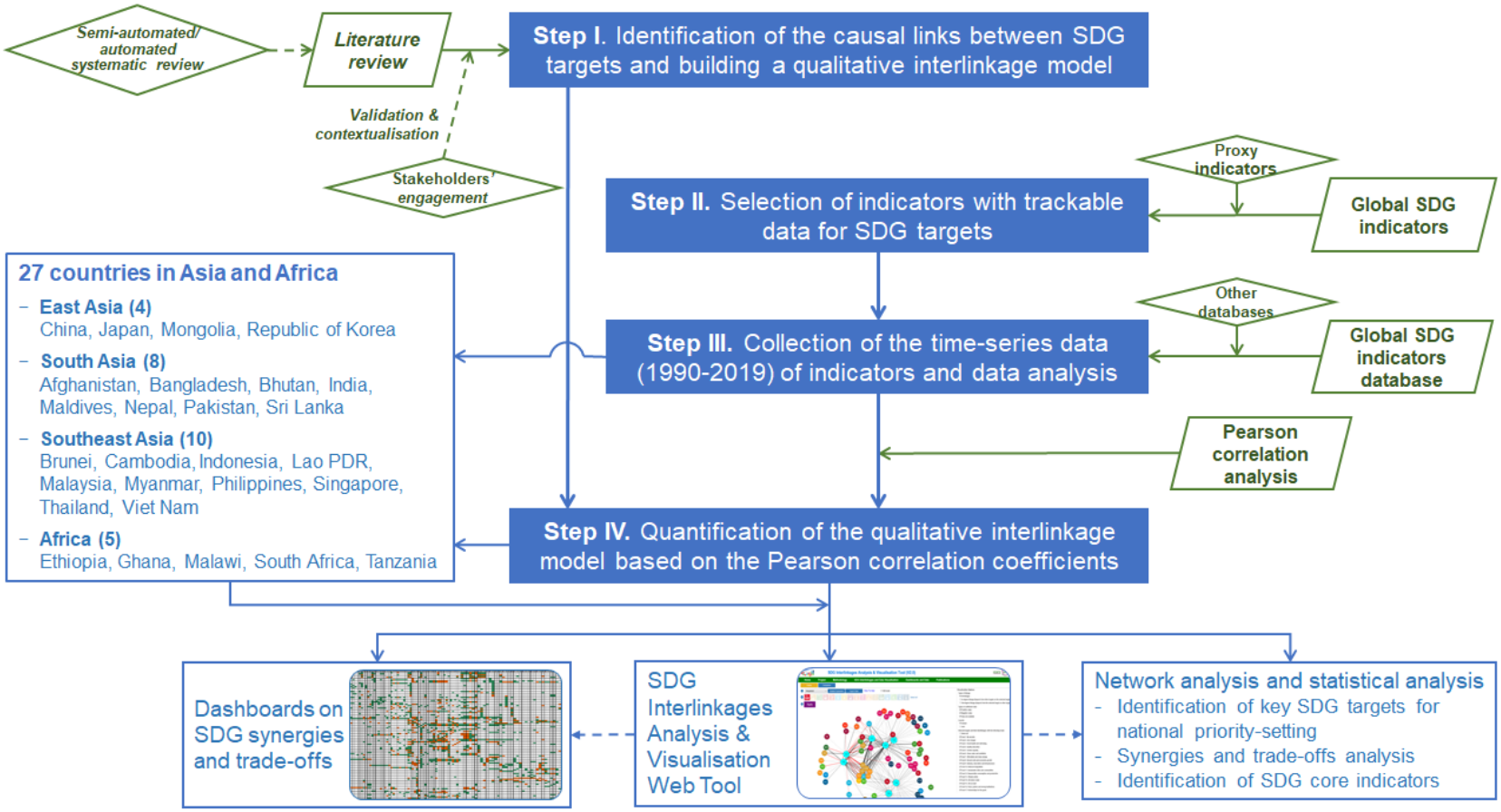


An example of the industrial sector



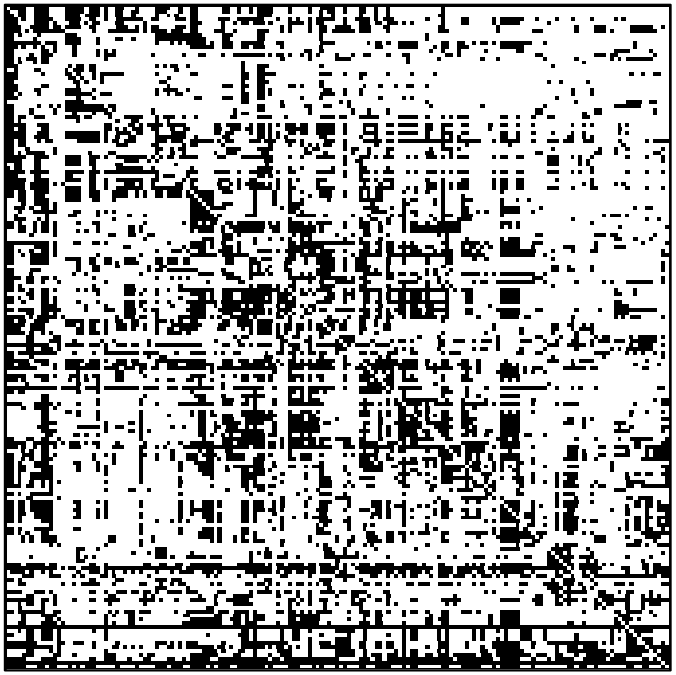
Source: Millennium Institute, 2017. https://www.https://www.millennium-institute.org/documentation.org/documentation

SDG Interlinkages Analaysis & Visualisation Tool and Methodology

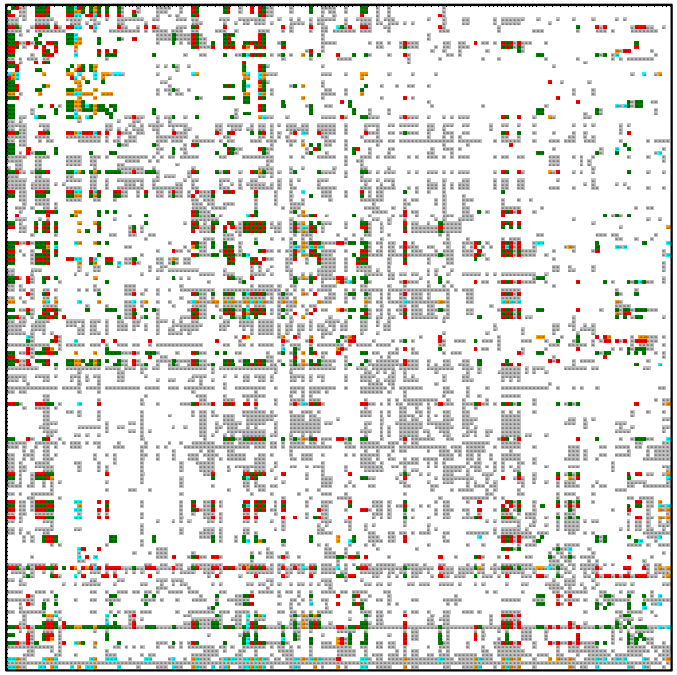


Source: Zhou, et al., 2021 (https://sdginterlinkages.iges.jp/methodology.html)

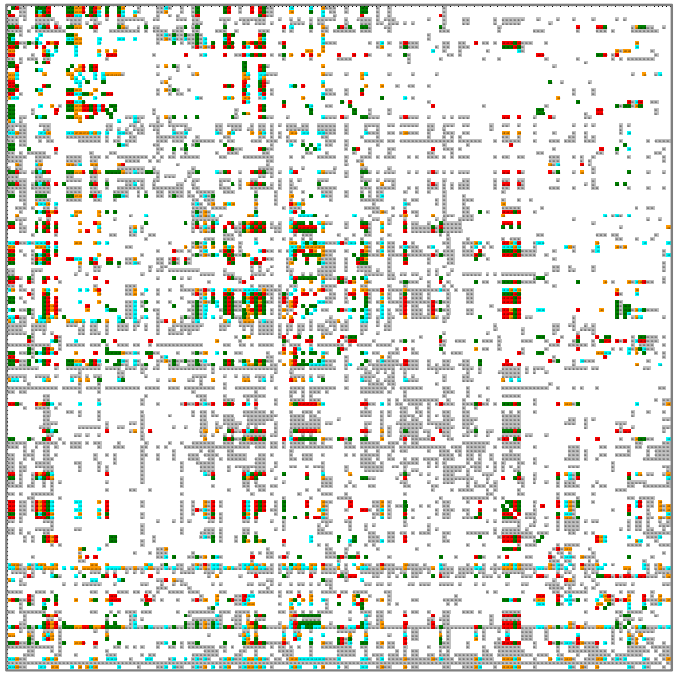
Step I Qualitative SDG interlinkage model



A generic SDG interlinkage model



An interlinkage model for Bangladesh



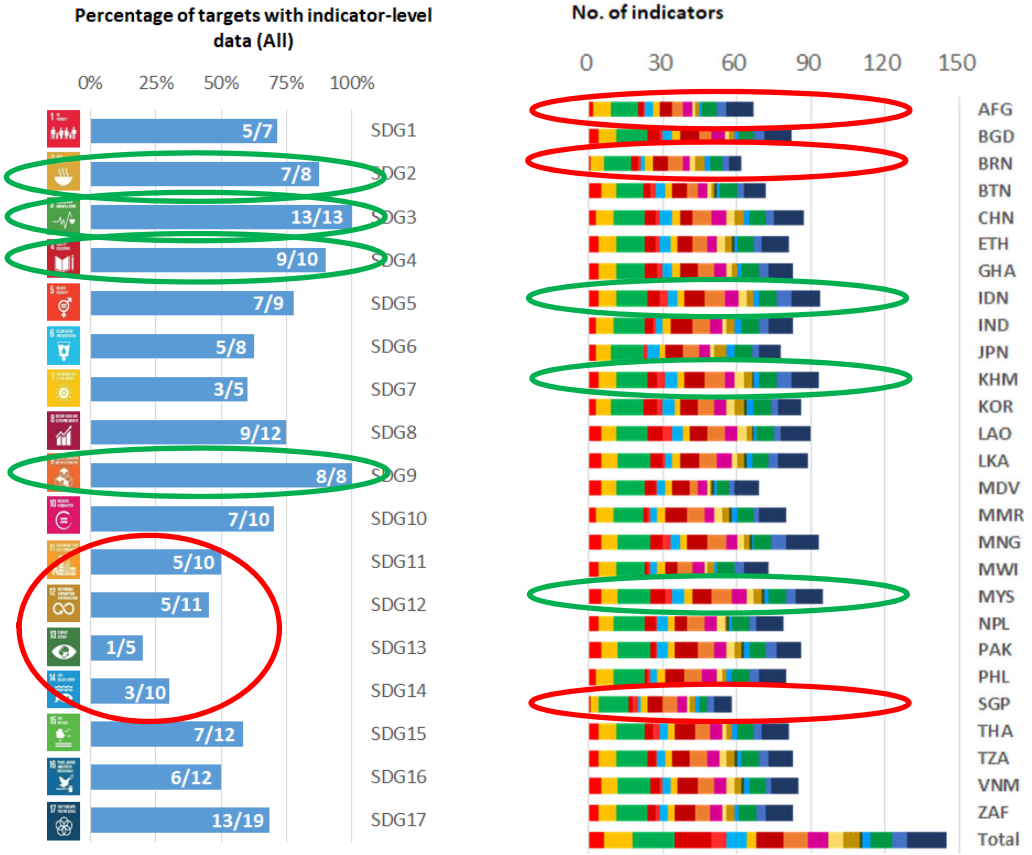
An interlinkage model for Indonesia

Source: SDG Interlinkages Analysis & Visualisation Tool (Zhou, et al., 2021)

Step II SDG indicators and data availability

Indicators and data availability

- Indicators: 231 global SDG indicators and data from UNSD Global SDG Indicators Database;
- Other proxy indicators: World Bank Indicators Database, etc.;
- 145 indicators with trackable data corresponding to 113 SDG targets were selected;
- Uneven data availability across Goals (20%-100%) and countries;
- Time series data (1990 – 2019) collected for 27 countries.



Source: Compiled based on the SDG Interlinkages Analysis & Visualisation Tool (Zhou, et al., 2021)

Step III Pearson correlation analysis based on the time-series data (1990-2019) for 27 countries

- A full time series is generated for each indicator using linear regression to estimate the missing data;
- Pearson correlation coefficients are calculated [-1, 1], indicating the linear relationship between relevant pair targets;
- Positive coefficients (positive linear relations) vs. negative coefficients (negative linear relations);
- Strong linkages vs. weak linkages;

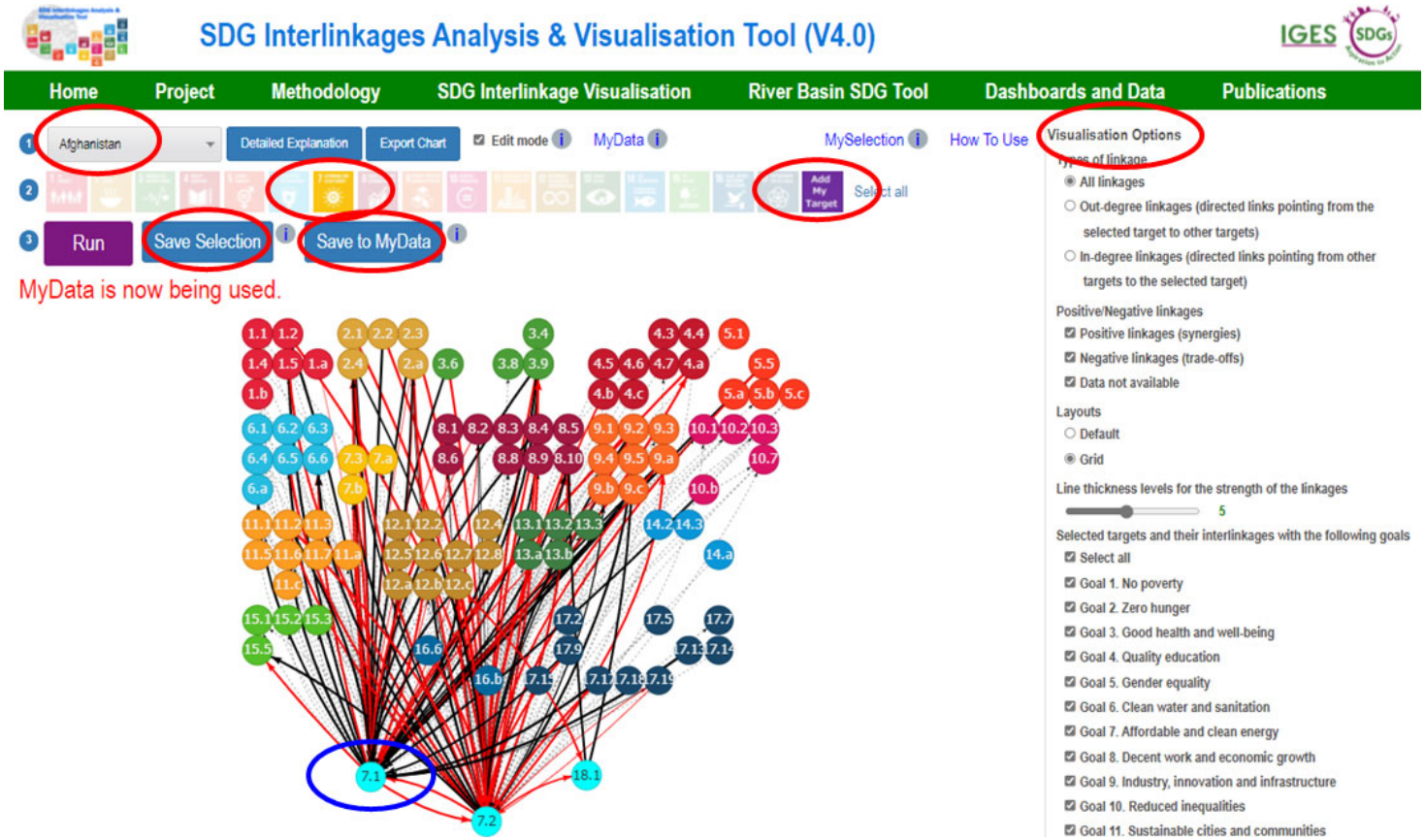
  - Strong positive : Correlation value (0.7, 1]
  - Weak positive: Correlation value (0, 0.7]
  - Weak negative: Correlation value [-0.7, 0)
  - Strong negative: Correlation value [-1, -0.7)
  - Data not available for quantification.
  - No linkage.

- Interlinkage matrix model for 27 countries.

	1.1	1.2	1.3	1.4	1.5	1.a	1.b	2.1	2.2	2.3	2.4	2.5	2.a	2.b	2.c
1.1		0.99	N/A	N/A	0.95			0.99	0.99	0.84	-0.93				
1.2	0.99			N/A	0.95			1.00	1.00	0.87	-0.94				
1.3	N/A	N/A		N/A	N/A			N/A	N/A	N/A	N/A				
1.4	N/A	N/A	N/A		N/A			N/A	N/A	N/A	N/A	N/A			
1.5	0.95	0.95	N/A					0.95	0.95	0.74	-0.87		0.28		
1.a	0.98	0.98	N/A	N/A			N/A	0.98	0.98	0.84	-0.93		0.37	N/A	
1.b	N/A	N/A	N/A	N/A		N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.1	0.99	1.00		N/A					1.00						
2.2	0.99	1.00						1.00							
2.3	0.84	0.87	N/A	N/A	0.74	0.84	N/A	0.86	0.86		-0.87	-0.90	0.20		
2.4	-0.93	-0.94	N/A		-0.87			-0.93		-0.87			-0.27		
2.5	-0.84	-0.87								-0.90	0.88		-0.11		
2.a	0.25	0.28					N/A			0.20	-0.27	-0.11			
2.b	N/A	N/A		N/A		N/A	N/A	N/A		N/A	N/A				
2.c	-0.99	-1.00		N/A				-1.00		-0.86	0.94				
3.1	0.99	1.00	N/A												
3.2			N/A					1.00	1.00						
3.3	0.95	0.95	N/A							0.78					
3.4	0.99	1.00	N/A												
3.5	-0.95	-0.96													
3.6	-0.93	-0.93	N/A							-0.82	0.91				
3.7	0.98	0.99	N/A					0.99	0.99						

Source: A snapshot of the correlation coefficient matrix for Ethiopia (Zhou, et al., 2021)

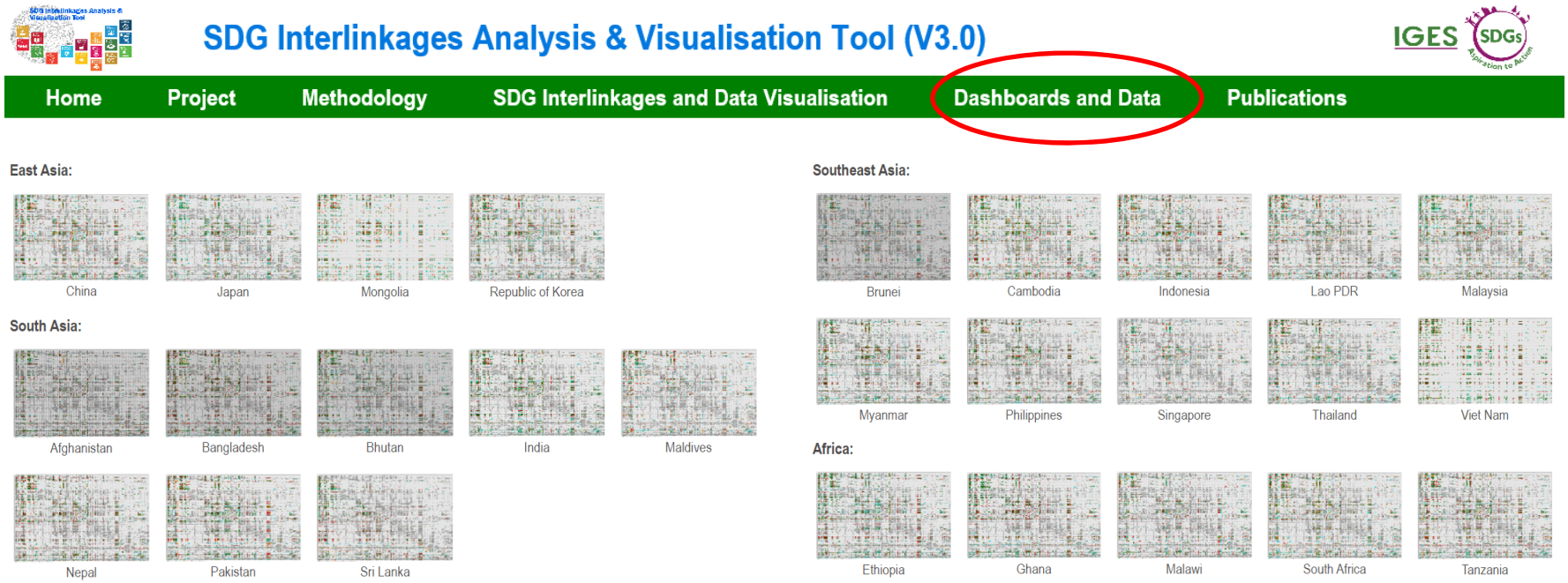
SDG Interlinkages Analysis & Visualisation Tool (4.0)
(https://sdginterlinkages.iges.jp/visualisationtool.html)



https://sdginterlinkages.iges.jp/visualisationtool.html

- The Tool covers 27 countries including 22 countries in Asia and 5 countries in Africa.
- Users can select a country and targets and visualise the interlinkages of selected targets with other targets.
- Using the Edit Mode, users can save their selections and results or add new linkages or new targets of their own.
- Using Visualisation Options, users can show the interactions from one or both directions, and positive or negative linkages, etc.

Dashboards on SDG synergies and trade-offs for 27 countries



Source: Available from https://sdginterlinkages.iges.jp/Dashboards%20and%20Data.html (Zhou, et al., 2021).

SDG Interlinkages Analysis & Visualisation Tool: Usage analysis as of 11 November 2022

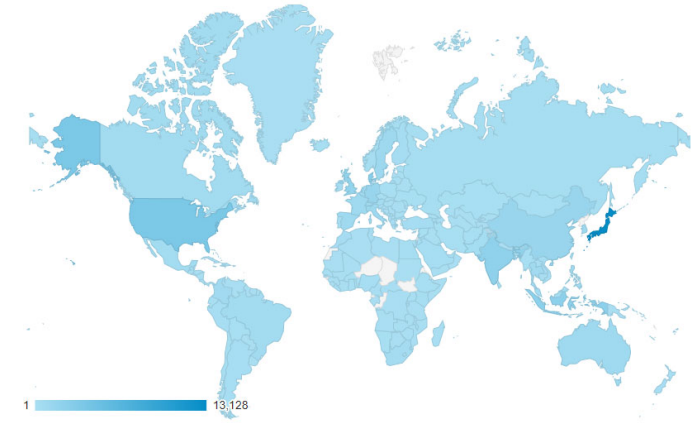
Overall usage of the SDG Interlinkages Tool

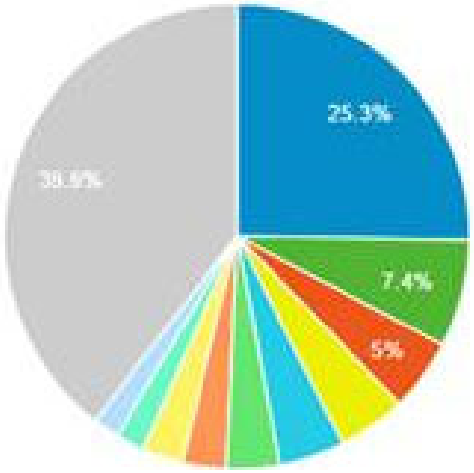
- Since its launch, accessed from **192 countries** around the world
- Total sessions: **130,000**

Top 10 countries

- Increased access worldwide
- More than three-fourth accesses are from outside Japan

1.	Japan
2.	United States
3.	Indonesia
4.	Denmark
5.	India
6.	United Kingdom
7.	China
8.	Germany
9.	Italy
10.	Netherlands





Recognition of the SDG Interlinkages Tool from UN organisations and applications by the national government in several countries

- UN 2020 HLPF on Sustainable Develop Exhibition (as one of ten selected good practices and cases) https://sustainabledevelopment.un.org/hlpf/2020#exhibit
- UN DESA 2020 Handbook for VNR (p.25, Ghana as an example for the basic template of SDG interlinkages) https://sustainabledevelopment.un.org/content/documents/25245 Handbook_2020_EN.pdf
- UN ESCAP SDG Helpdesk Toolboxes https://sdghelpdesk.unescap.org/toolboxes?field_sdgs_target_id=All&title=&page=2 .
- United Nations Interagency Task Team on STI for the SDGs (IATT), Reference List for STI Roadmaps https://sustainabledevelopment.un.org/TFM
- Ghana VNR 2019 (p.87-88 on synergies and trade-offs) https://sustainabledevelopment.un.org/content/documents/23420VNR_Report_Ghana_Final_print.pdf
- Indonesia VNR 2019, VNR 2021 and national SDG roadmap https://sustainabledevelopment.un.org/content/documents /2380320190708_Final_VNR_2019_Indonesia_Rev3.pdf
- Vietnam National Action Plan on Sustainable Consumption and Production 2020–2030, approved by Vietnam's Prime Minister in June 2020 (an SDG interlinkage analysis of the draft version informing potential synergies and trade-offs) https://www.switch-asia.eu/site/assets/files/2533/national_action_plan_on_scp_vietnam_pdf_pdf.pdf.

Application of an SDG interlinkages analysis at the river basin scale

Sustainability Science
https://doi.org/10.1007/s11625-021-01065-z

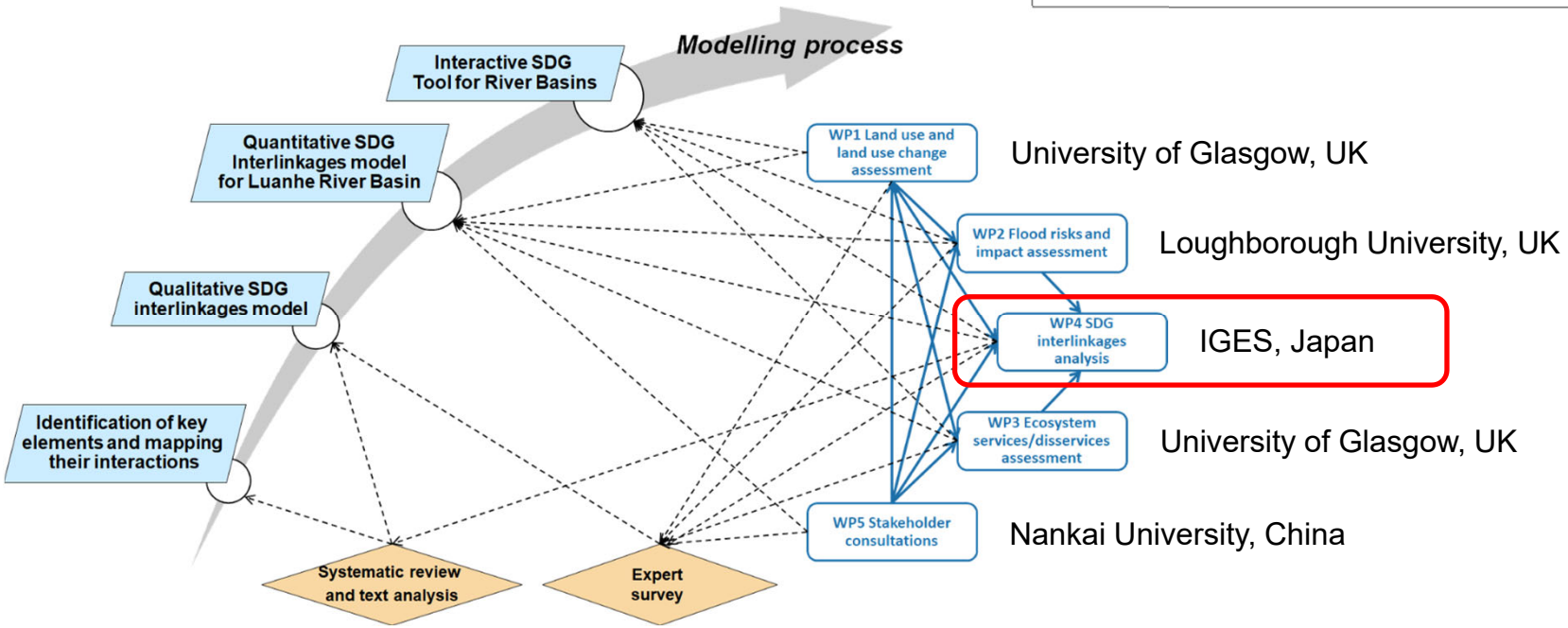
SPECIAL FEATURE: ORIGINAL ARTICLE

Synergies and Trade-offs between Sustainable Development Goals and Targets

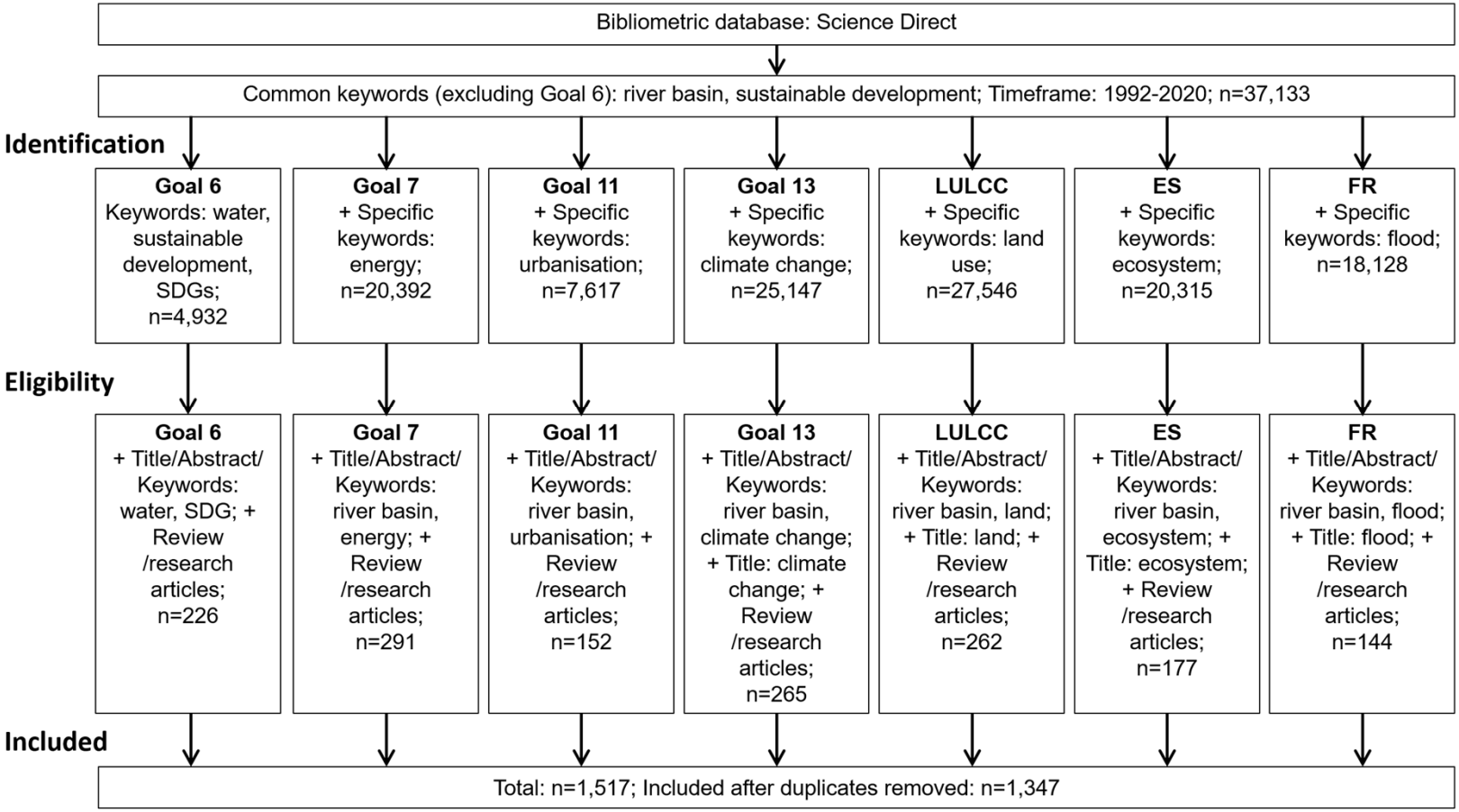
Development of an SDG interlinkages analysis model at the river basin scale: a case study in the Luanhe River Basin, China

Xin Zhou[1] · Mustafa Moinuddin[1] · Fabrice Renaud[2] · Brian Barrett[3] · Jiren Xu[2] · Qiuhua Liang[4] · Jiaheng Zhao[4] · Xilin Xia[4] · Lee Bosher[4] · Suiliang Huang[5] · Trevor Hoey[6]

Received: 7 May 2021 / Accepted: 7 November 2021



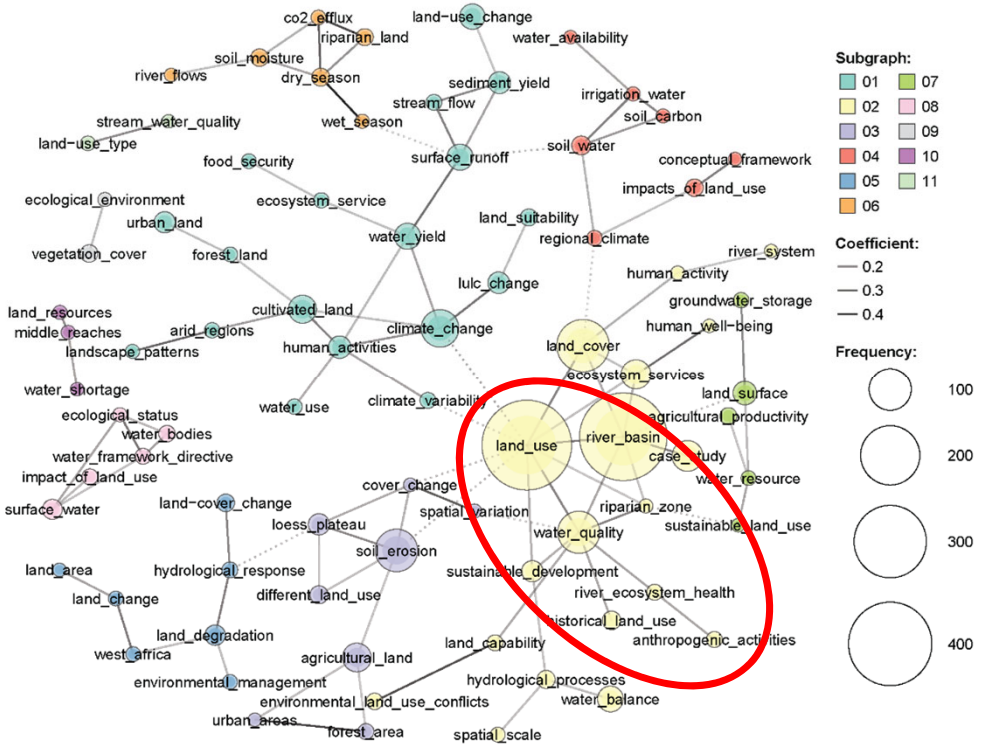
A systematic review of the SDG interlinkages at the basin scale



Source: Zhou, et al., 2021.

A systematic review through text mining and text analysis to identify key elements and mapping their linkages

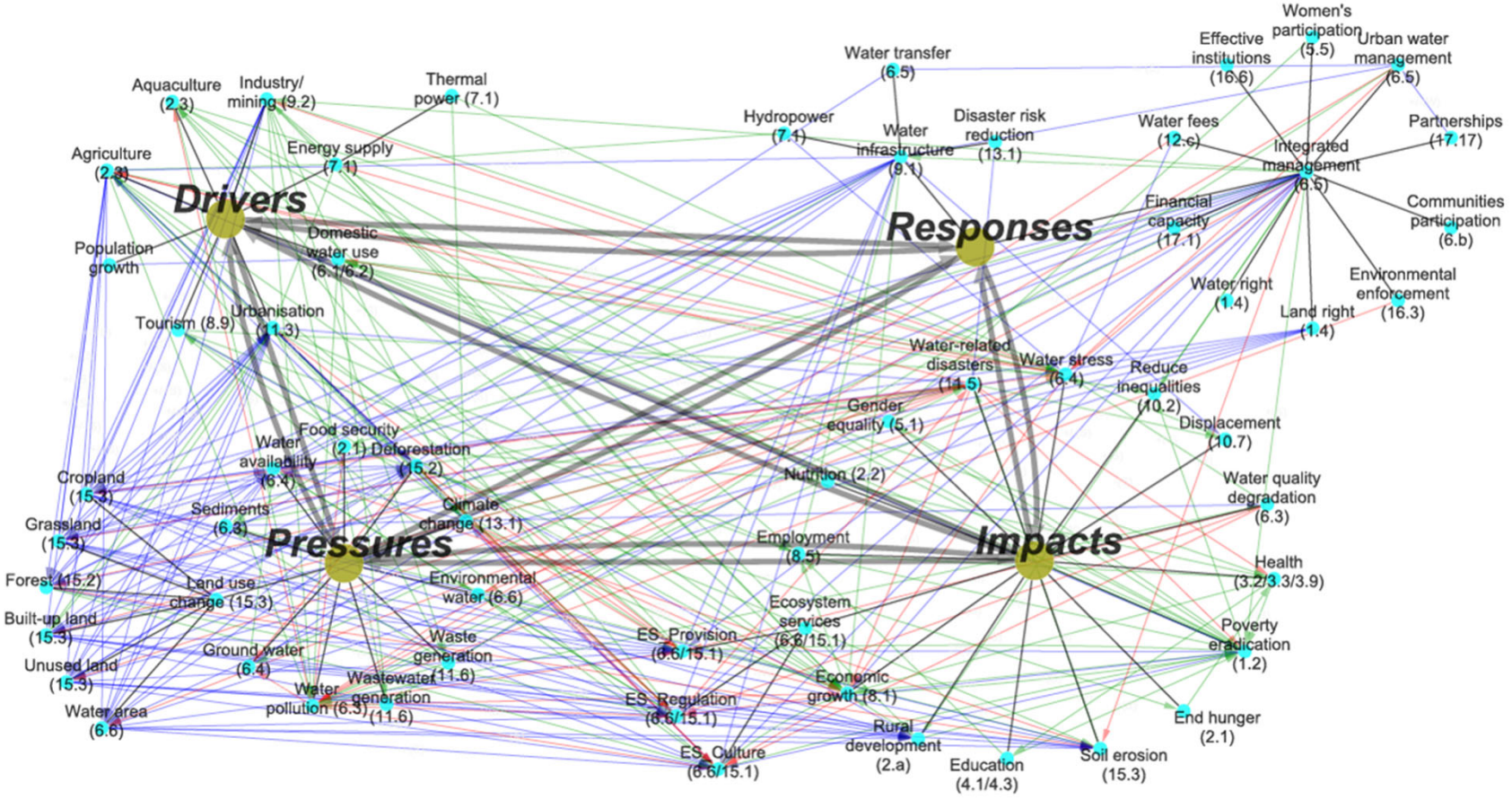
Text analysis on top words and top terms



Text analysis to map the linkages between top words/terms

Source: Zhou, et al., 2021.

An SDG interlinkage model for river basins



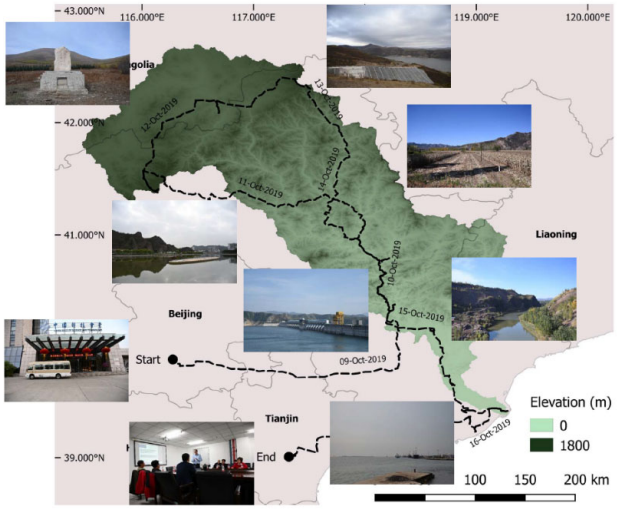
Source: Zhou, et al., 2021.

Validation and tailoring the model to China's Luanhe River Basin

Luanhe field survey with local officials, 9-17 October 2019.

Stakeholder workshop jointly developing future land use and policy scenarios (18 October 2019).

Source: Luanhe Living Lab (https://luanhelivinglab.home.blog/)

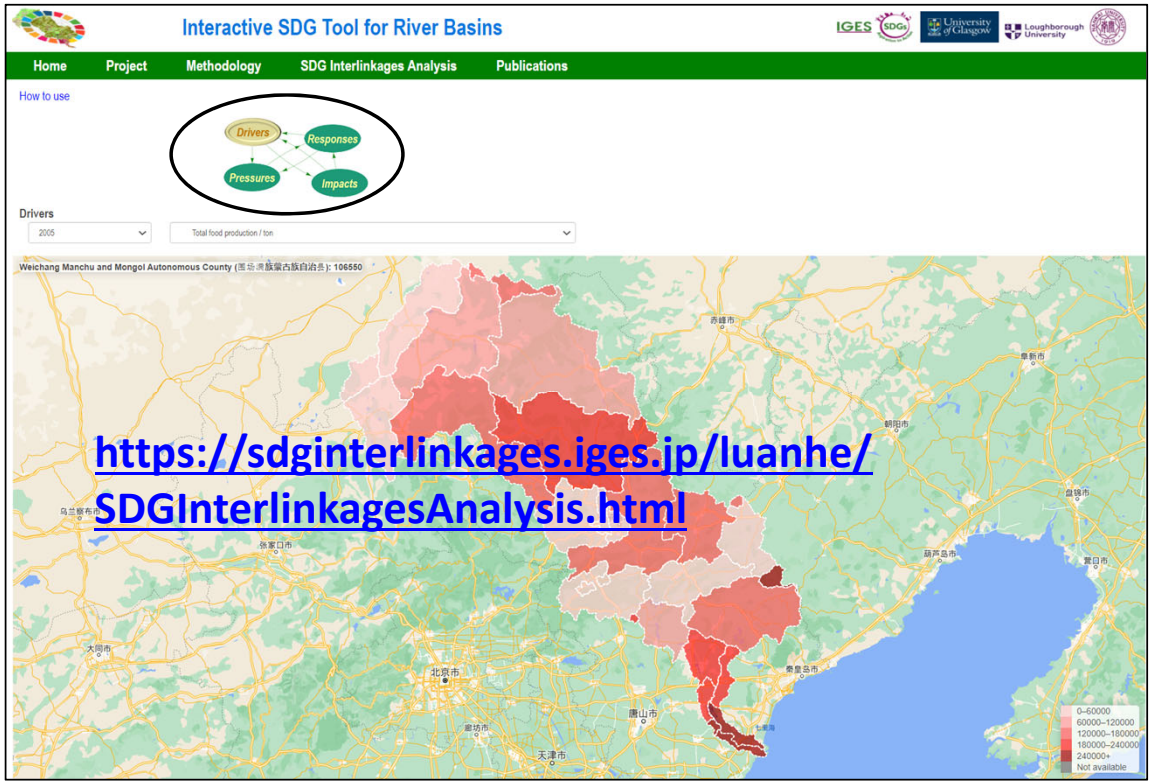


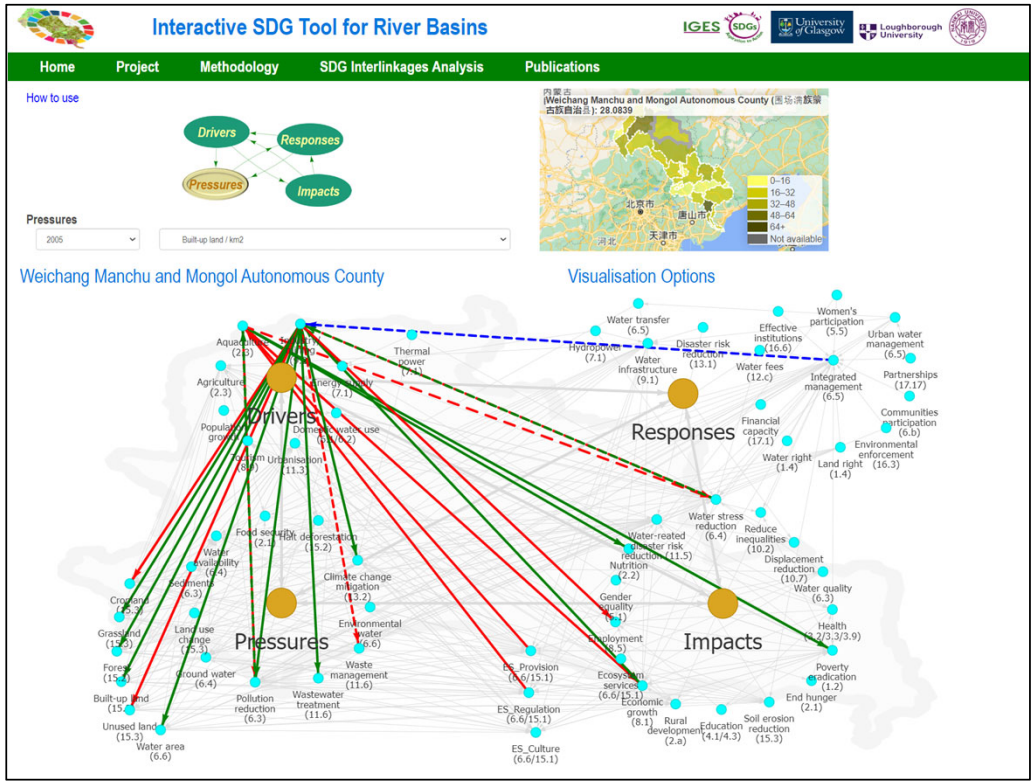
Source: Renaud, et al. 2020.

Identification of SDG interlinkages for Luanhe River Basin

- Literature review (UN flagship reports, etc.);
- Expert judgement (11 experts);
- Field trips along the river basin (1,800 km) and meetings with local officials and experts;
- Stakeholder consultation workshop and the following-up questionnaire survey through email.

Interactive SDG Tool for River Basins





Source: Zhou, et al. (2022). https://sdginterlinkages.iges.jp/luanhe/SDGInterlinkagesAnalysis.html

Application for Goal 13 (climate actions) and using AI-based Natural Language Processing to systematically extract key SDG linkages

Climate Change AI

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Using Natural Language Processing for Automating the Identification of Climate Action Interlinkages within the Sustainable Development Goals

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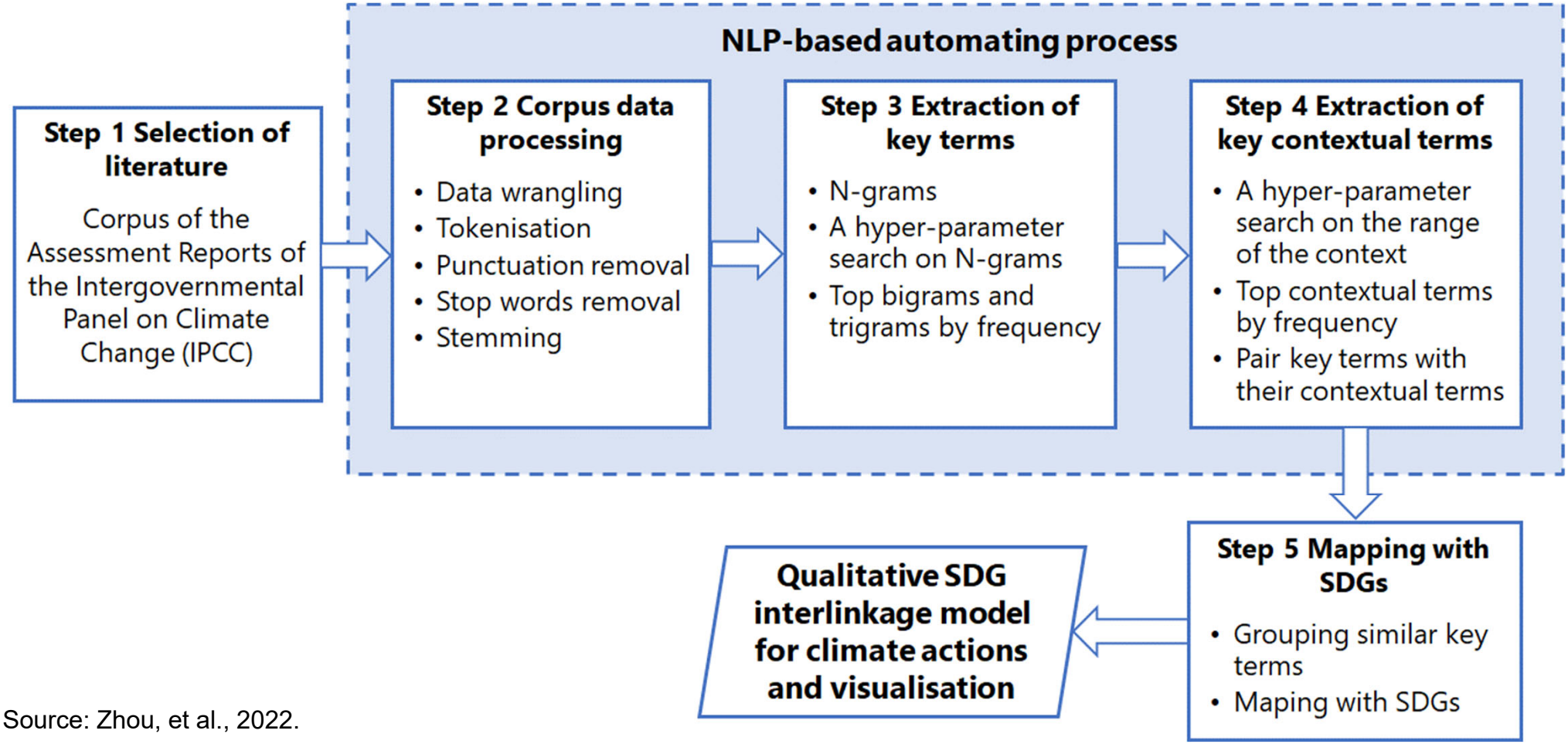
Abstract

Climate action, Goal 13 of the UN Sustainable Development Goals (SDG), cuts across almost all SDGs. Achieving climate goals can reinforce the achievements in many other goals, but at the same time climate mitigation and adaptation measures may generate trade-offs, such as levelling the cost of energy and transitioning away from fossil fuels. Leveraging the synergies and minimizing the trade-offs among climate goals and other SDGs is an imperative task for ensuring policy coherence. Understanding the interlinkages of climate action within the SDGs can help inform about the synergies and trade-offs.

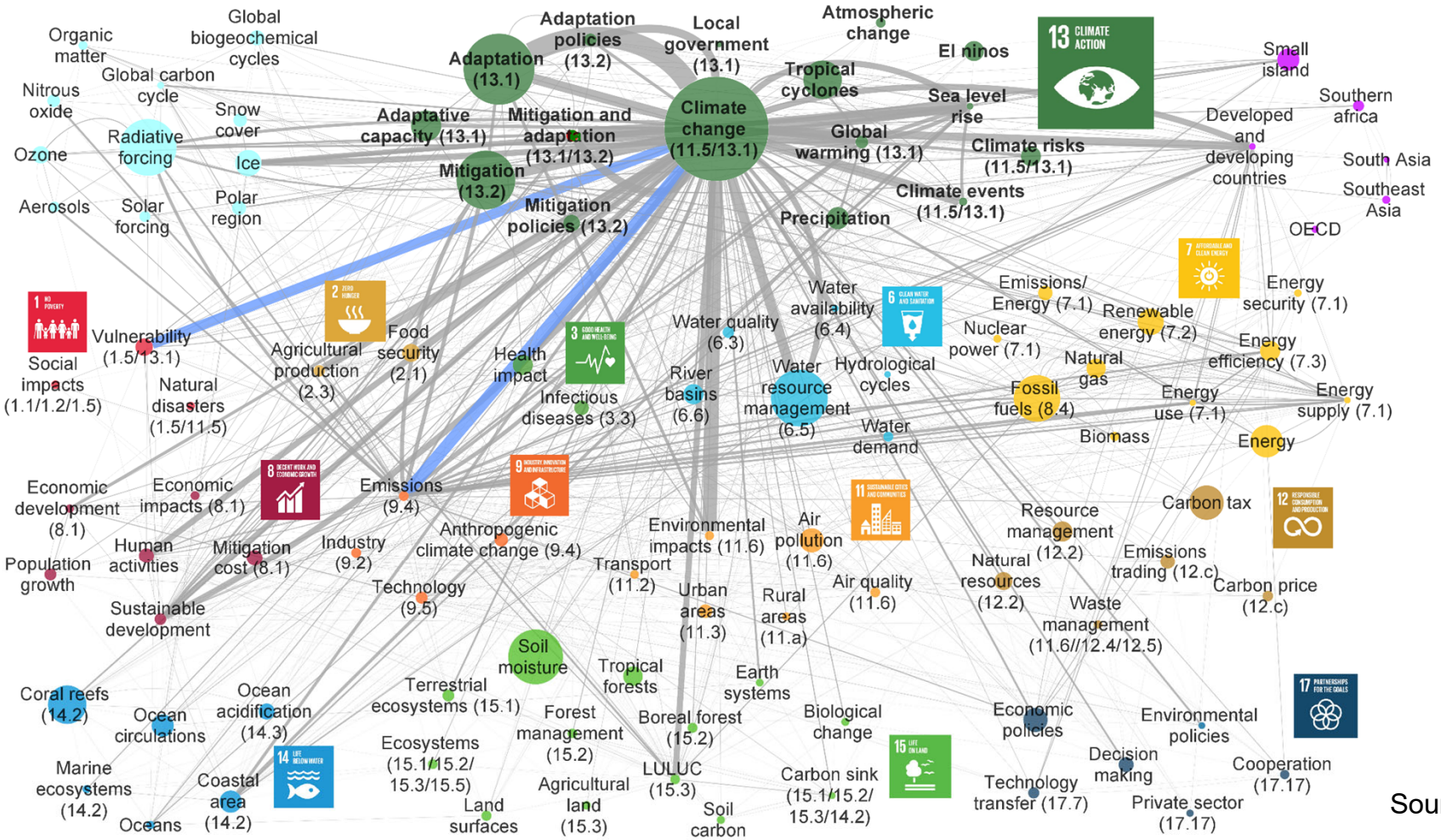
There is a gap in the scientific knowledge about how the

Methodology: Using NLP to systematically extract key SDG linkages from climate change literature



Source: Zhou, et al., 2022.

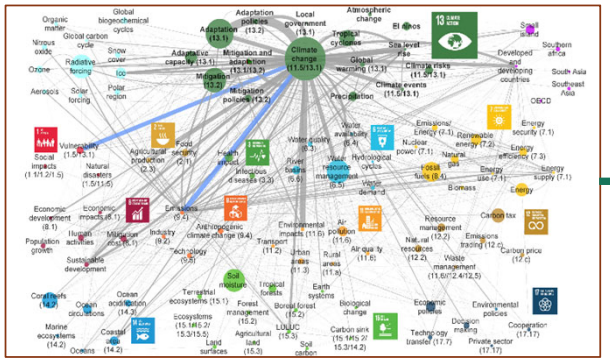
A qualitative SDG interlinkage model for Goal 13 on climate action



Note: The figure was generated by using Cytoscape. Each node indicates a top term and the size of nodes indicates their frequency. The code in parentheses indicates the corresponding SDG targets. The edge indicates a linkage between paired terms. The width of an edge indicates the frequency of the paired terms.

Source: Zhou, et al., 2022.

Stakeholders' consultation and development of the long-term climate mitigation strategy in West Java

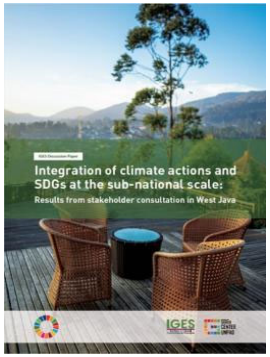


Stakeholders' consultation on the synergies and trade-offs of climate actions with the SDGs

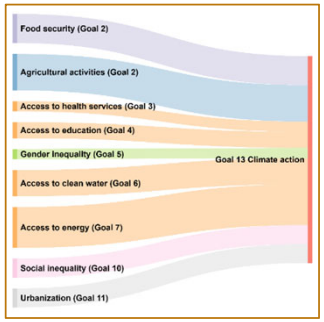
Online questionnaire survey (100 respondents)

Focus group discussion (20 participants)

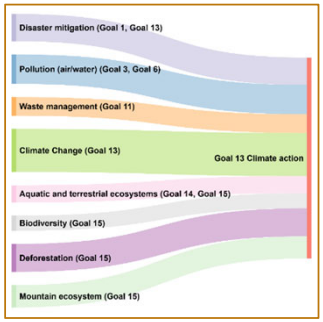
Raise awareness and co-generation knowledge on CC-SDG linkages



Economic links



Social links

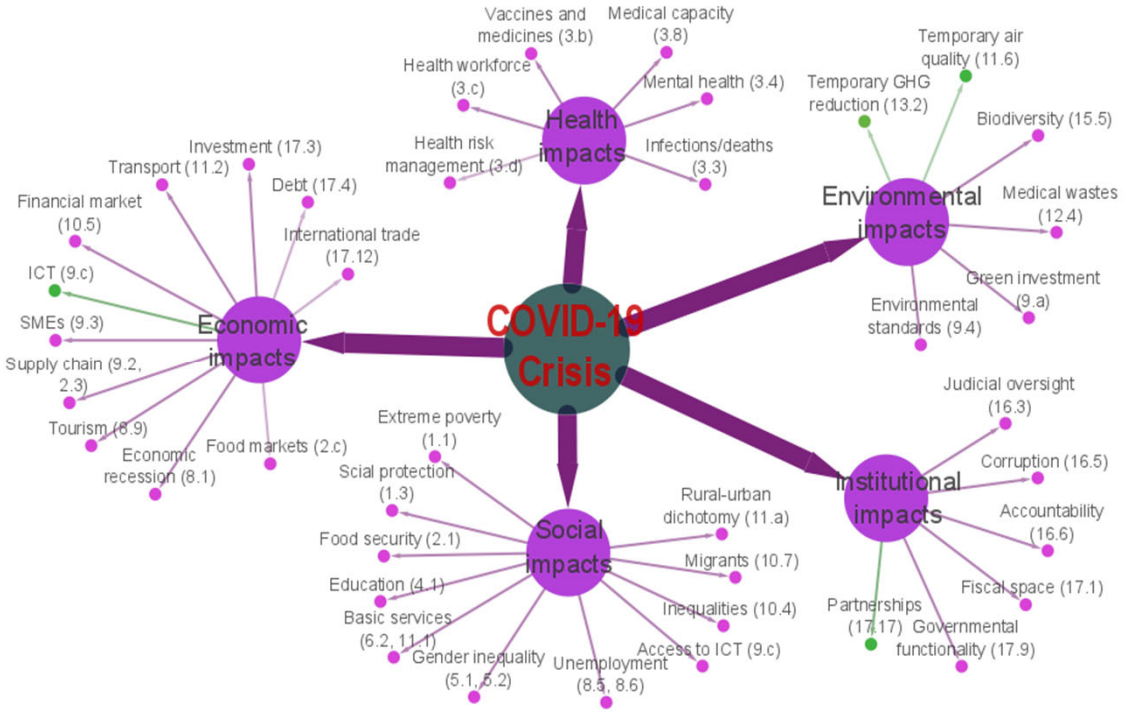


Environmental links

Governance links

Source: Moinuddin et al. (2021)

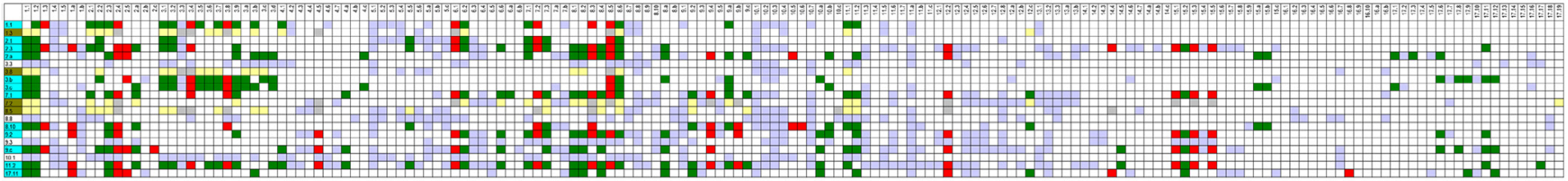
Application of the SDG Interlinkage Tool for assessing the impacts of COVID-19 in Bangladesh and the Republic of Korea



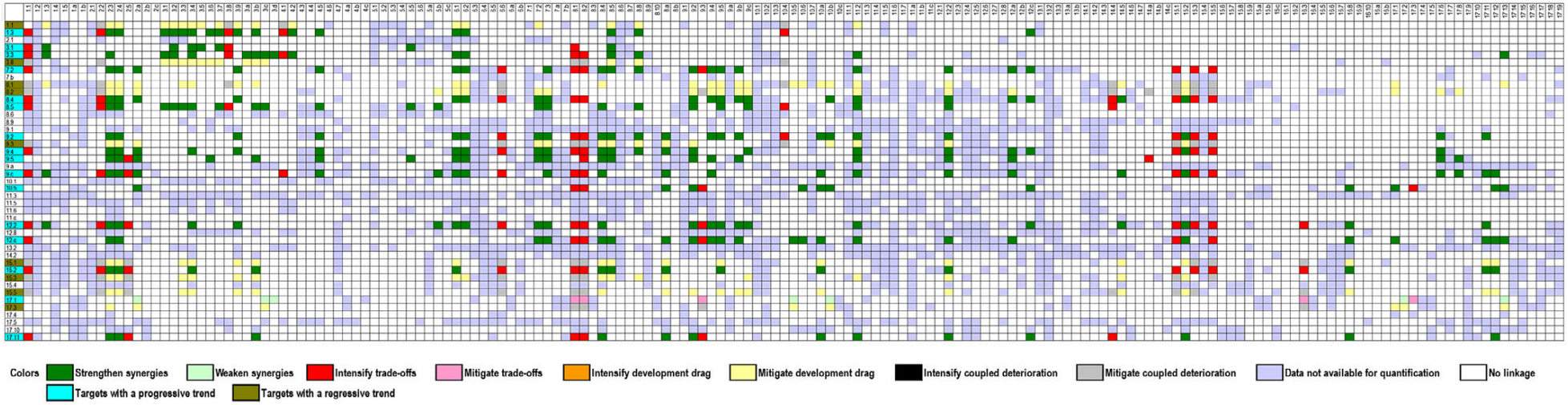
Zhou, X. and Moinuddin, M. (2021) 'Impacts and implications of the COVID-19 crisis and its recovery for achieving Sustainable Development Goals in Asia: A review from an SDG interlinkage perspective', in A.L. Ramanathan et al. (eds) *Scenarios of Environmental Resilience and Transformation in Times of Climate Change: Effects and Lessons from the COVID-19*. Elsevier.

Application of the SDG Interlinkage Tool for assessing the impacts of COVID-19 recovery measures in Bangladesh and the Republic of Korea

AIII. Dashboard on the impacts of COVID-19 measures on achieving SDGs in Bangladesh

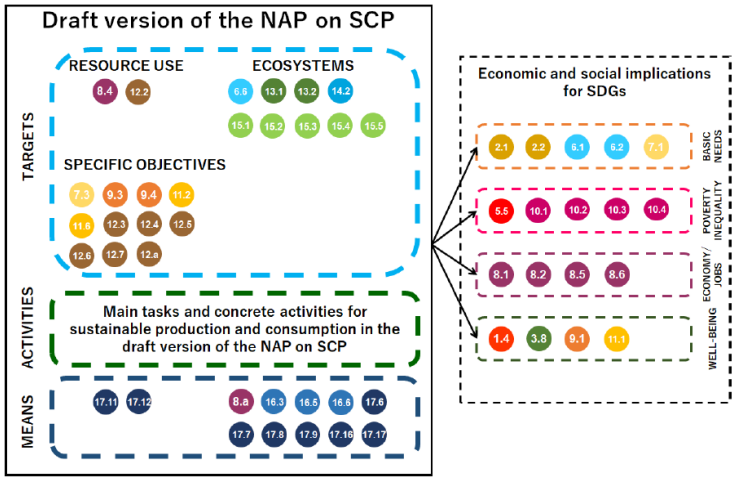


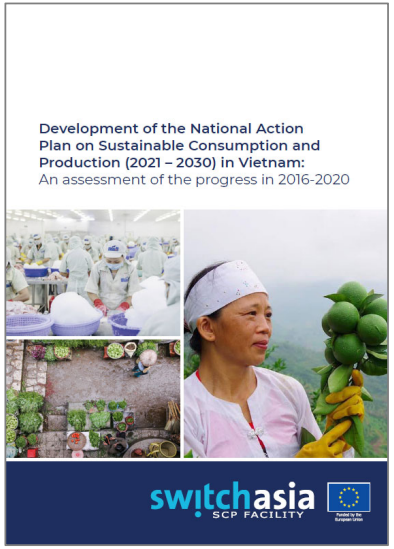
AIV. Dashboard on the impacts of COVID-19 measures on achieving SDGs in the Republic of Korea

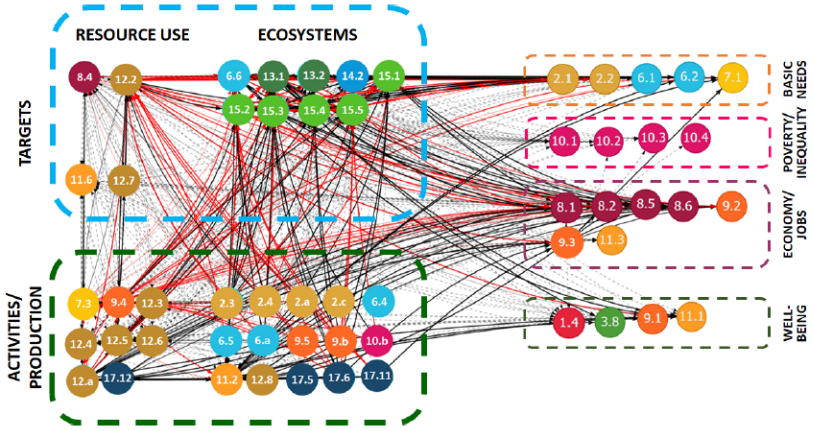


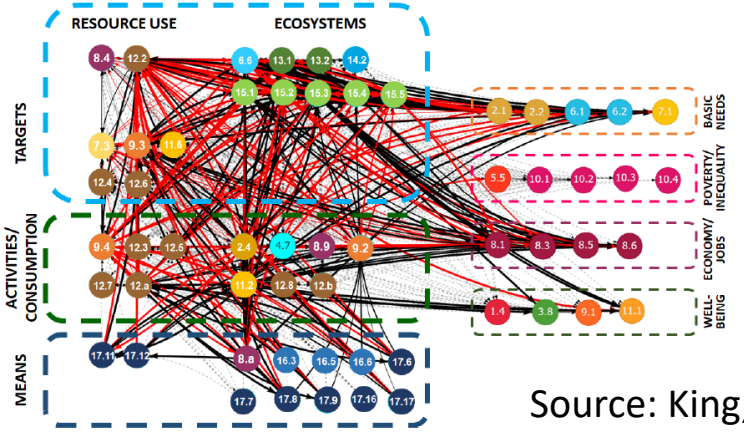
Source: Zhou, X. and Moinuddin, M. (2021)

Application of the SDG Interlinkage Tool to support the development of the National Action Plan on SCP (2021-2030) in Viet Nam



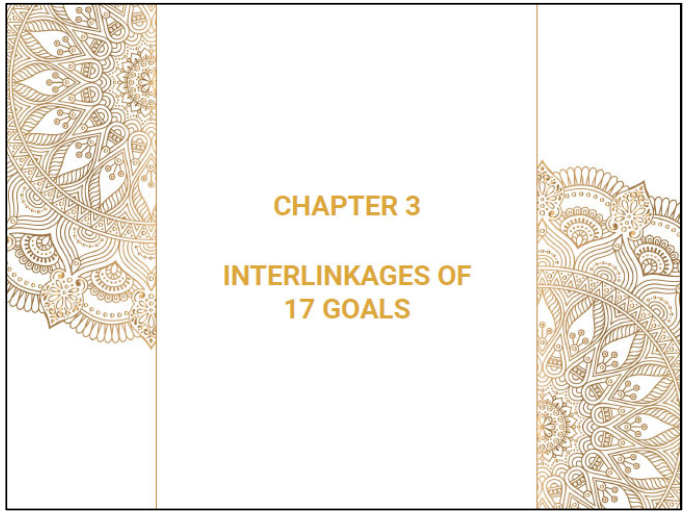


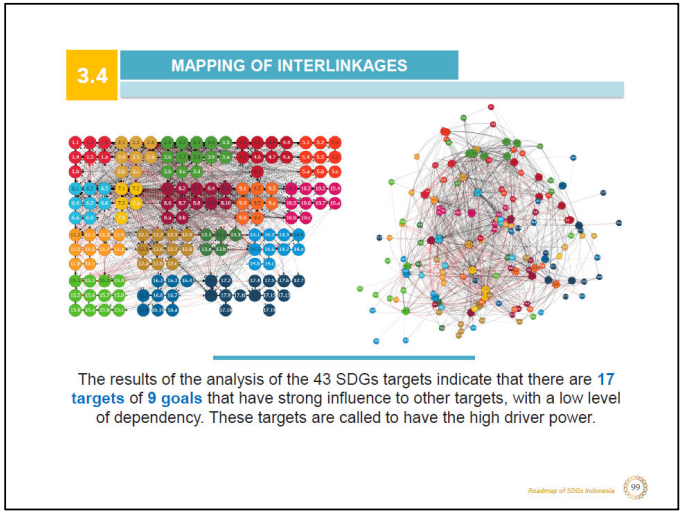




Source: King, et al. (2021)

Indonesia's Ministry of National Development Planning developed the Roadmap of SDGs Indonesia including one chapter on SDG interlinkages





Source: Indonesia's Ministry of National Development Planning, 2019.

Application of a network analysis of SDG interlinkages to support integrated priority setting and institutional arrangement in Bangladesh

Priority targets that are identified by both GIU-PMO and IGES			
1.1 End extreme poverty 1.2 Halve national poverty 2.2 End malnutrition 2.4 Build sustainable food production systems 5.5 Enhance women's participation in decision-making 6.1 Universal access to safe drinking water 6.2 Universal access to sanitation and hygiene		7.1 Universal access to energy 8.5 Decent work for all 8.6 Improve youth employment 10.1 Income growth of bottom 40% population 10.7 Improve equality of migrants 11.2 Universal access to sustainable transport system 15.1 Sustainable use of terrestrial and inland freshwater	
GIU-PMO draft priority targets		***IGES recommended key targets***	
3.2 End preventable young children deaths 3.6 Halve traffic deaths 4.1 All for free primary and secondary education 4.4 Increase skilled workers for decent jobs 4.a Improve education facilities 5.3 Eliminate forced marriage 7.2 Increase renewable energy 8.1 Sustain inclusive economic growth 9.1 Develop resilient infrastructure 9.2 Promote inclusive and sustainable industrialization 9.c Universal and affordable access to ICT	12.5 Reduce waste generation 13.1 Strengthen resilience to climate change 14.5 Conserve 10 per cent of coastal areas 15.3 Combat desertification and soil degradation 16.9 Provide legal identity to all 16.a Capacity building for preventing violence and terrorism 17.1 Capacity building for tax collection in developing countries 17.8 Enhance ICT in LDCs	1.5 Build resilience of the poor to climate and other disasters 2.1 End hunger 2.3 Double agriculture productivity 3.4 Reduce pre-mature mortality from non-communicable diseases 4.5 Estimate gender disparities in all levels of education 4.7 Acquire knowledge needed for sustainable development 5.c Strengthen policies for gender equality 6.4 Increase water use efficiency 9.4 Resource-efficient and clean technology-based industrial retrofit	9.a Enhance international aid to build sustainable infrastructure 11.5 Reduce losses from disasters 11.a Strengthen development planning for sustainable cities 12.8 Enhance awareness of sustainable lifestyles 13.2 Integrate climate change measures into national policies 14.2 Sustainable management of marine ecosystems 15.2 Sustainable management of forests 16.6 Develop accountable institutions

Source: Based on GED (2012) and Zhou & Moinuddin (2017)

Application of the SDG Interlinkage Tool for assessing the interlinkages of sustainable infrastructure in Ghana

Sustainability Science
https://doi.org/10.1007/s11625-021-00929-8

TECHNICAL REPORT

Urban–rural linkages: effective solutions for achieving sustainable development in Ghana from an SDG interlinkage perspective

Gideon Baffoe[1] · Xin Zhou[2] · Mustafa Moinuddin[2] · Albert Novas Somanje[3] · Akihisa Kuriyama[2] · Geetha Mohan[3,4] · Osamu Saito[2,4] · Kazuhiko Takeuchi[2,4]

Received: 10 July 2020 / Accepted: 4 February 2021
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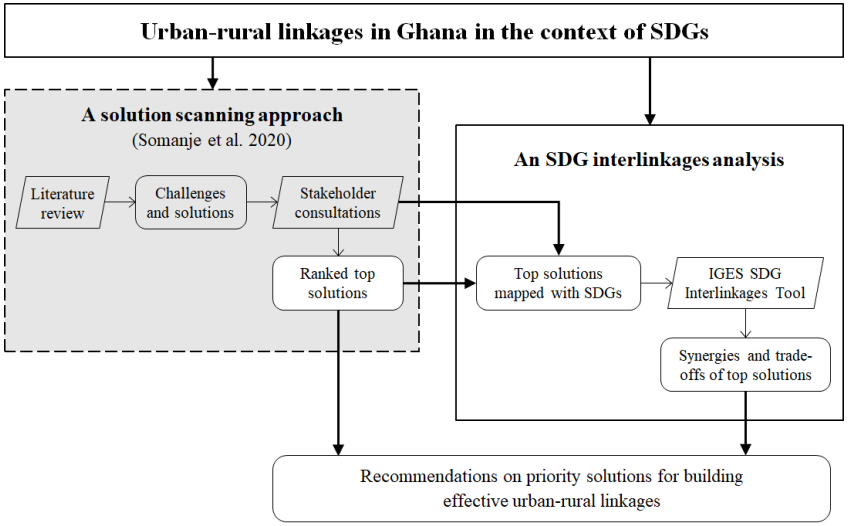
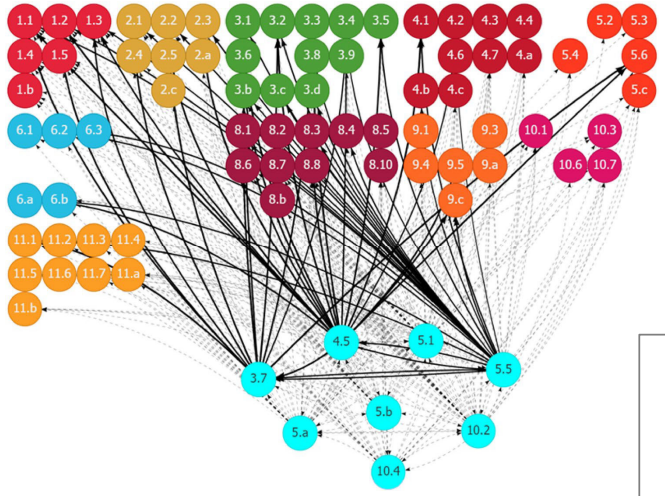
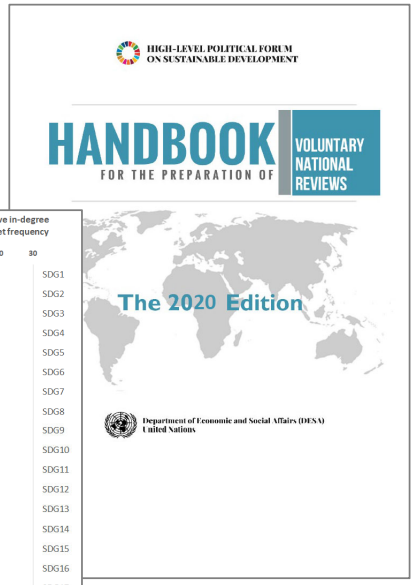
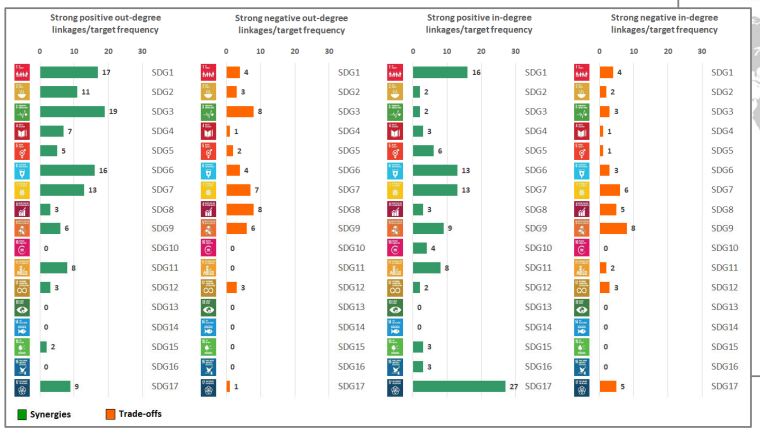


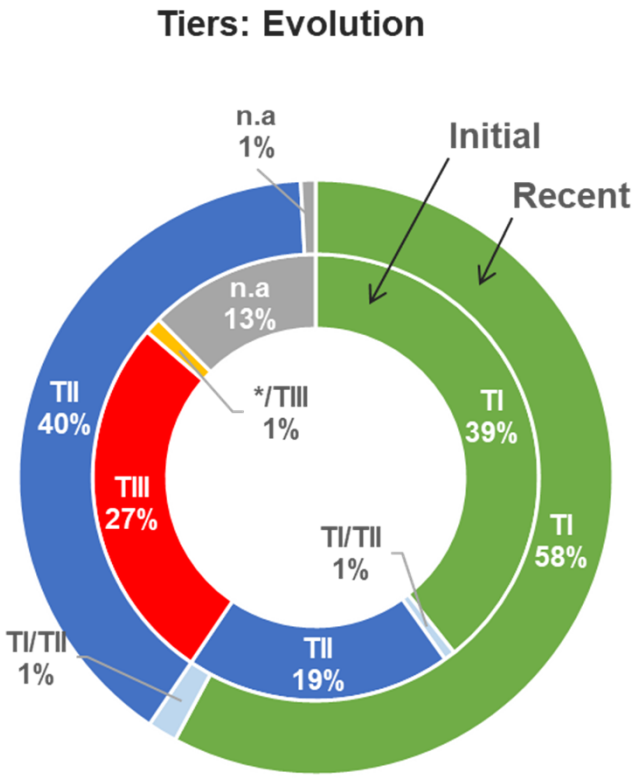






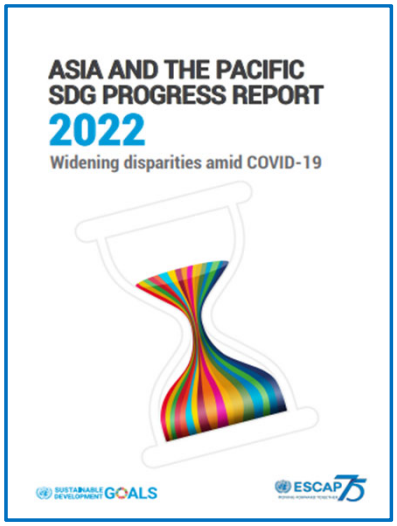
Limitations: SDG indicators and status

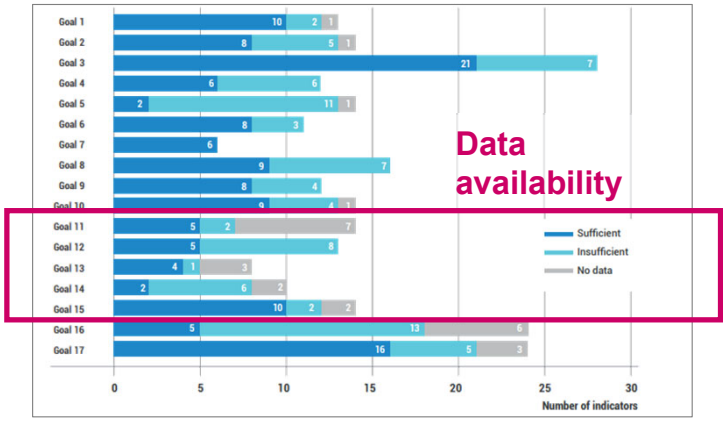
Tiers	Definition (as of 4 February 2022)
Tier 1	Indicator is conceptually clear, has an internationally established methodology and standards are available, and data are regularly produced by countries for at least 50 per cent of countries and of the population in every region where the indicator is relevant.
Tier 2	Indicator is conceptually clear, has an internationally established methodology and standards are available, but data are not regularly produced by countries.
Tier 3	No internationally established methodology or standards are yet available for the indicator, but methodology/standards are being (or will be) developed or tested. (As of the 51st session of the United Nations Statistical Commission, the global indicator framework does not contain any Tier III indicators)

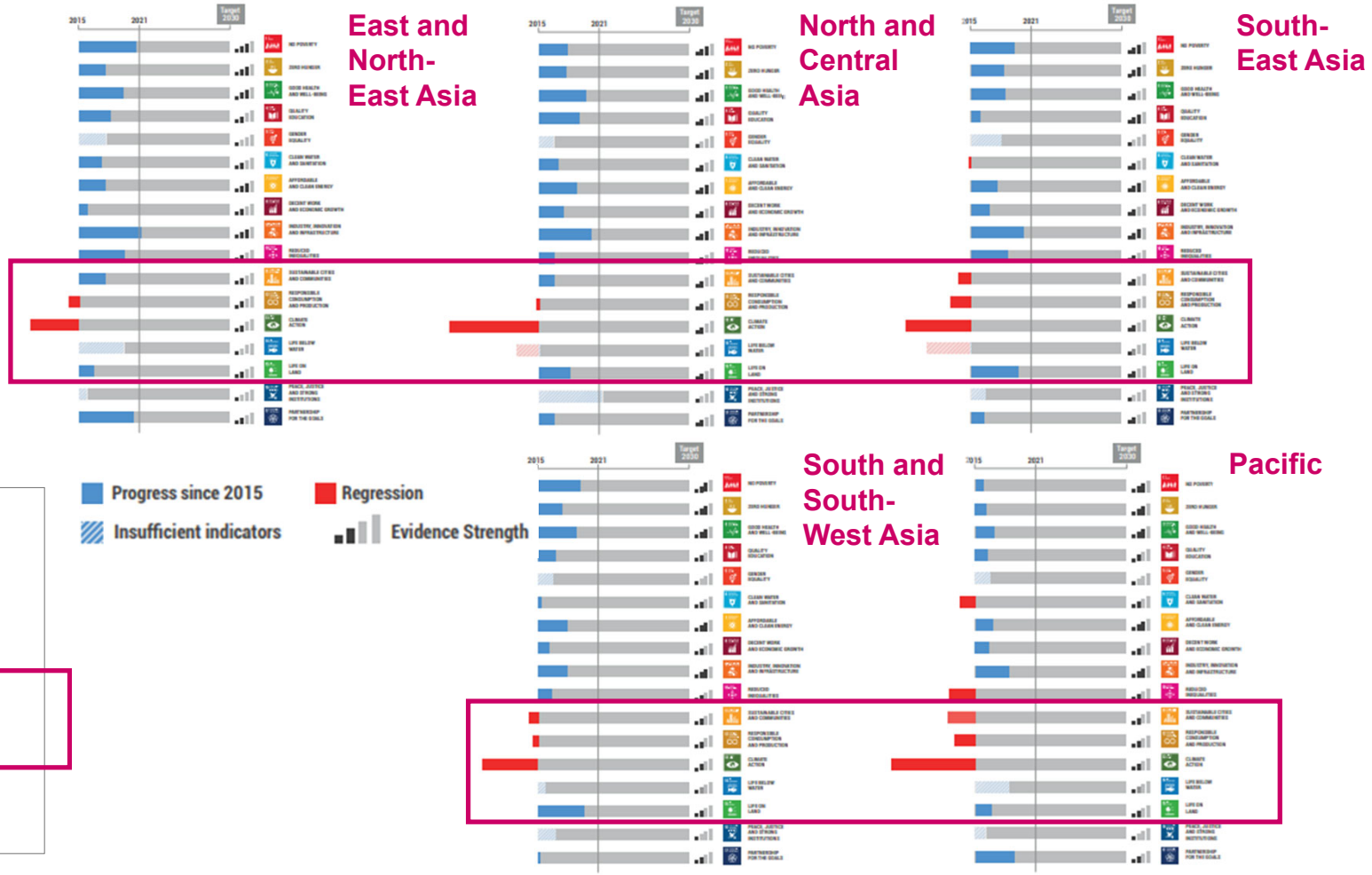


Source: Compiled by Zhou (2022) based on data from UNSD (https://unstats.un.org/sdgs/iaeg-sdgs/tier-classification/)

SDG progress and data constraints in Asia and the Pacific







Source: UNESCAP, 2022. https://www.unescap.org/sites/default/d8files/knowledge-products/ESCAP-2022-FG_SDG-Progress-Report.pdf#page=100

Future research agenda

- Two major technical challenges related to the SDG interlinkages analysis
  - Huge gaps in quality indicators and data for quantifying the SDG interlinkages
  - Lack of well-defined causations between SDG targets.
- Gaps in indicators and data: Proxy indicators, data imputation and use of big data;
- Combination of systematic review, statistical analysis, expert opinions and stakeholder consultation for identification of the causal links between SDG targets;
- Limitations of correlation analysis and application of other methods for the analysis of inferred causation based on advanced data science and techniques;
- Multidimensional and location-specific SDG interlinkages requires a move from a generic model to location-specific and context-based interlinkages analysis;
- Diagnostic function vs. policy assessment and projections

Further reading

- Baffoe, G., Zhou, X., Moinuddin, M., Somanje, A. N., Kuriyama, A., Mohan, G., Saito, O., & Takeuchi, K. (2021). Urban–rural linkages: effective solutions for achieving sustainable development in Ghana from an SDG interlinkage perspective. Sustainability Science, 1, 3. https://doi.org/10.1007/s11625-021-00929-8
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Thank you!

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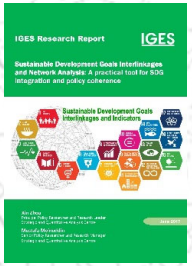
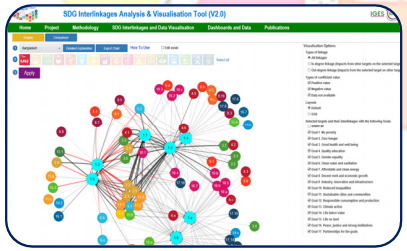


Zhou, X., Moinuddin, M., 2017. Sustainable Development Goals Interlinkages and Network Analysis: A practical tool for SDG integration and policy coherence. IGES Research Report. Hayama: IGES. Available at: https://sdginterlinkages.iges.jp/files/IGES_Research%20Report_SDG%20Interlinkages_Publication.pdf.



Zhou, X., Moinuddin, M., Li, Y., 2021. SDG Interlinkages Analysis & Visualisation Tool (V4.0). Hayama: IGES. Available at: https://sdginterlinkages.iges.jp/visualisationtool.html.

IGES SDGs Aspiration to Action