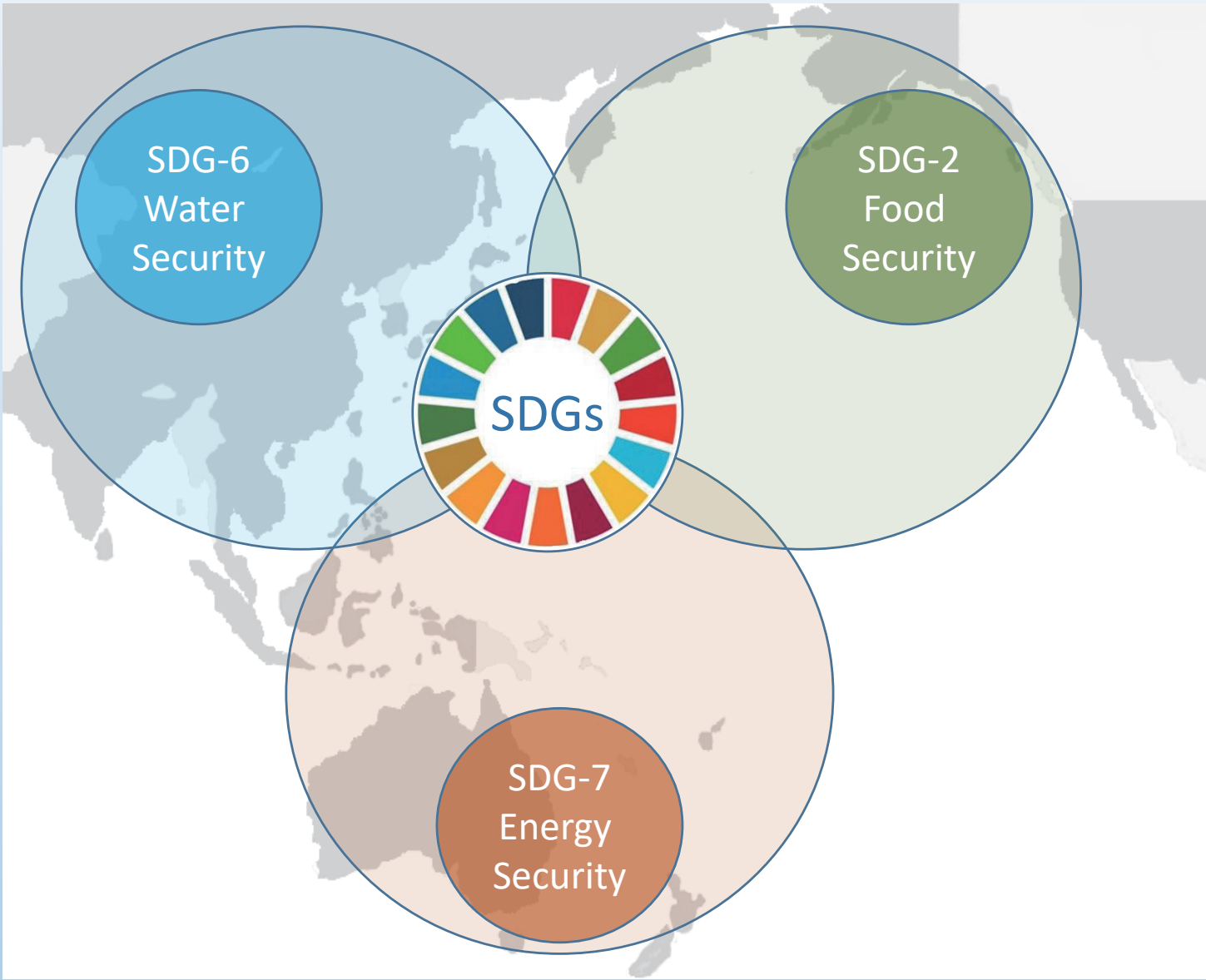
Final Technical Report



Water-Energy-Food Nexus Perspective: Path Making for Sustainable Development Goals (SDGs) to Country Actions in Asia

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ASIA-PACIFIC NETWORK FOR GLOBAL CHANGE RESEARCH

Final Technical Report (CRRP2016-8MY-Kuyama)

Water-Energy-Food Nexus Perspective: Path Making for Sustainable Development Goals (SDGs) to Country Actions in Asia

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Table of Contents

1. Introduction

In general, the unilateral sectoral approach in resource management that has been followed to date causes unintended trade-offs and conflicts among related sectors or areas. It has been widely acknowledged that the Millennium Development Goals (MDGs) had limited scope in addressing how the efforts to attain sectoral goals and targets would affect each other. General agreement has also been reached in the various international forums that incorporating an integrated approach to the Sustainable Development Goals (SDGs) is therefore critical, as if the post-2015 agenda fails to incorporate nexus aspects, sustainable development cannot be ensured.

Water, energy and food comprise the fundamental elements necessary for economic growth and development. These three elements have played and continue to play a vital role in all kinds of economic activities. Many commitments have been made towards achieving water, energy and food security for the poor, including the MDGs and related policy processes. However, despite significant progress the security of water, energy and food supplies each remain far from being achieved globally. In recent years, a growing number of scientists and policy analysts have drawn attention to the critical role of a nexus (i.e., integrated) approach in food, water and energy sectors for sustainable development – an approach which aims to facilitate integrated planning and decision making as well as support the agreed-on development pathways.

In the Asia and Pacific region, millions of people lack basic services (water, energy and food), and are deprived of their human rights and trapped in poverty. About 280 million people lack adequate access to safe water (World Bank, 2018), more than half of the population suffer food insecurity (FAO, IFAD, UNICEF, WFP and WHO, 2019) and 350 million lack access to electricity (IEA, 2018). It is projected that demand for these three resources will further increase in coming years and meeting such additional demand will be challenging under the conventional uni-sectorial approach. It is envisaged that by 2030, 30% of the world will be faced with water shortage (WWAP 2015), food demand will increase by 50% (FAO, IFAD, UNICEF, WFP and WHO, 2017) and energy consumption will increase by 30% (IEA 2017). With Asia and the Pacific region taking the foremost role in terms of economy and development, the continuing growth in population will place immense pressures on these resources, which will lead to increasing conflicts unless an integrated planning and decision making framework is incorporated in development pathways.

Global leaders formally approved the Sustainable Development Goals on the occasion of the UN Sustainable Development Summit, which is expected to offer major improvements in the development agenda of the SDGs forerunner – the MDGs. The roles of food, water and energy are justifiably accorded critical status in the approved goals as they are crucial for sustainable development, and specific goals and targets have been set for these three key sectors. Water, energy and food are not isolated but are inextricably linked, and concerns expressed in the literature emphasize the relevance of food water and energy linkages not only for poor people who have limited access to food, water and energy in sufficient quality but also for fast-developing regions with rapidly growing demand for these three elements (Bazilian et al., 2012; Hoff 2011; ICIMOD 2012; World Economic Forum 2011). Going forward, ignoring this interdependency will only create further contradictions and lead us away from the bedrock principle of sustainable development (Douglas Merrey, 2015).

Universality is the key principle of the SDGs. These goals should be relevant for all countries and combined efforts with different country target and actions will contribute to achieving them (Nilsson et al., 2013; Van der Heijden et al., 2014). The most important challenge is how the global ambition should be interpreted at the national level. Hence, the Open Working Group for the SDGs em-

phasized setting up national targets, taking in to account the national context such that these targets can be elaborated with indicators. The water-energy-food nexus approach is totally compatible with this principal and will help identify suitable sets of actions for specific countries or regions (Weitz et al., 2014). To date, much discussion has taken place at international and regional levels but has mostly dealt with the issue on a conceptual level. In most cases policy and development choices are made on a unilateral basis, and the lack of knowledge on water energy food nexus has often led to mismatches in prioritization and decision making, which will hinder sustainable development.

Since each country's efforts and actions are critical to achieving the universal goals, it is important to understand the different national realities, capacities, levels of development and national policies and priorities that exist prior to setting country targets. To our knowledge no research work focusing on the framework of translation of global level targets to national targets, particularly in Asian countries, exists. This study therefore attempts to develop a framework for translating the global ambitions to the national level.

To manage the three resources effectively and meet the related targets more swiftly, it is critical to understand the nature of linkages among food-water-energy goals and targets. This project therefore explores synergies and trade-offs among food-water-energy targets that will help both developed and developing Asian countries to develop policies and actions to manage these three resources effectively and meet the related targets more swiftly. Further, as consumption patterns and resource use intensity are strongly linked with a country's economy this project also performed analysis of readiness to implement SDGs by the three emerging economies of Bangladesh, India and Viet Nam.

The research outcome is intended to provide a practical guideline for translating global ambitions to country level targets and indicators in the country context, specifically in the areas of:

(i) Assessing quantitative and qualitative relationships among proposed targets and indicators for SDGs, particularly focusing on three major dimensions: food (SDG-2), water (SDG-6) and energy (SDG-7);
(ii) Evaluating readiness of the case study countries for implementation of the proposed goals and targets; and
(iii) Designing a shortlist of indicators (or composite index) to assist the case study countries in formulating policies and actions to meet related targets on water-food-energy effectively and more swiftly.

2. Methodology

To meet the objectives of this research, the study team followed a step-wise approach and relied on several key supporting tools, techniques and models such as literature review, networking analysis technique, local stakeholder consultations, stakeholder surveys, Analytic Hierarchy Process (AHP) model, and Regression Model.

Step 1: Stocktaking of water, energy and food security in the case study countries

Intensive literature review and stakeholder interviews was performed to evaluate the status of water, energy and food security, as well as the progress and country readiness for SDGs implementation in the case study countries (particularly focusing on SDG-2, SDG-6 and SDG-7 on food, water and energy, respectively). Through analysis of secondary data and local stakeholder consultation workshop and interviews, critical nexus issues related to water, food and energy security under the country specific context were identified.

Step 2: Stakeholder perception analysis

A questionnaire survey was conducted, targeting all relevant Ministries and governmental departments related to water, food and energy, to analyse stakeholder perception on the importance of nexus aspects for the country actions on SDG-2, SDG-6 and SDG-7.

A network analysis was performed to visualize relationships between SDG-2, SDG-6, SDG-7 and its relevant targets.

Step 3: Quantitative assessment of interlinkages among the approved targets

Under this step, quantitative aspects of the interlinkages were addressed by employing a useful statistical technique/model known as regression modelling to test hypotheses on possible associations or quantitative links among approved targets under water, food and energy goals. Results of the regression model can help determine whether and to what extent approved targets quantitatively correlate with each other.

By taking these correlations into account, it is expected that when designing and monitoring their work, policy- and decision makers concerned with specific sustainable development goals will have to consider targets or indicators that refer to the other Goals, which may provide stronger incentives for cross-sectoral, integrated work than in the past. Similarly, it is also suggested that for institutions concerned with monitoring and evaluation of progress in the SDGs, it will be necessary to look at multiple Goals, which may enable greater integration across the Goals.

Step 4: Prioritizing interlinkages for the country actions and policy planning

An intensive, detailed literature review including country policies and strategies, institutional arrangements, key actions to achieve SDGs and level of achievements was carried out.

National Stakeholder Consultation Workshops have been conducted in each country to collect feedback on the results of network analysis and regression analysis. Prioritization of country actions was then attempted based on the key stakeholders' (including government agencies, academic institutes, civil organizations, business organizations and international development agencies) perceptions/preferences and documented national priorities. Then, group discussion and the analytic hierarchy process (AHP) model were utilized

in order to incorporate key local stakeholders' preferences into the analysis results and final policy recommendations.

The resultant analysis provided a shortlist of prioritized targets, which are measurable as well as interdependent in nature among the approved water, food and energy goals. Consequently, this shortlist of targets can help the countries under study to manage their water, food, and energy more effectively and meet their respective SDG targets more swiftly.

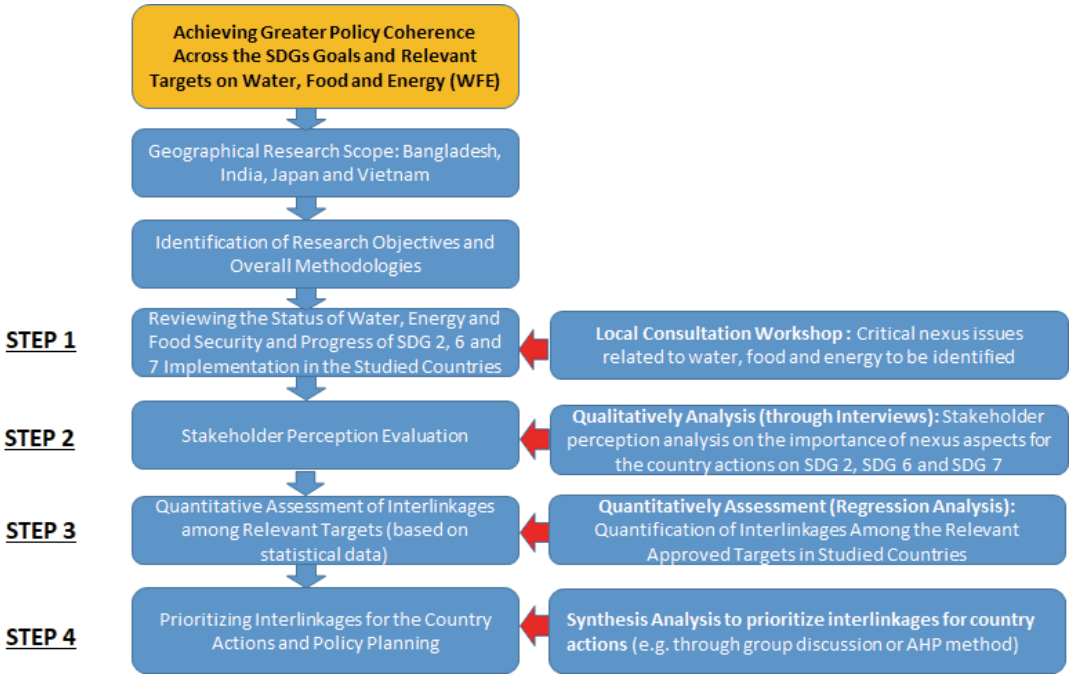
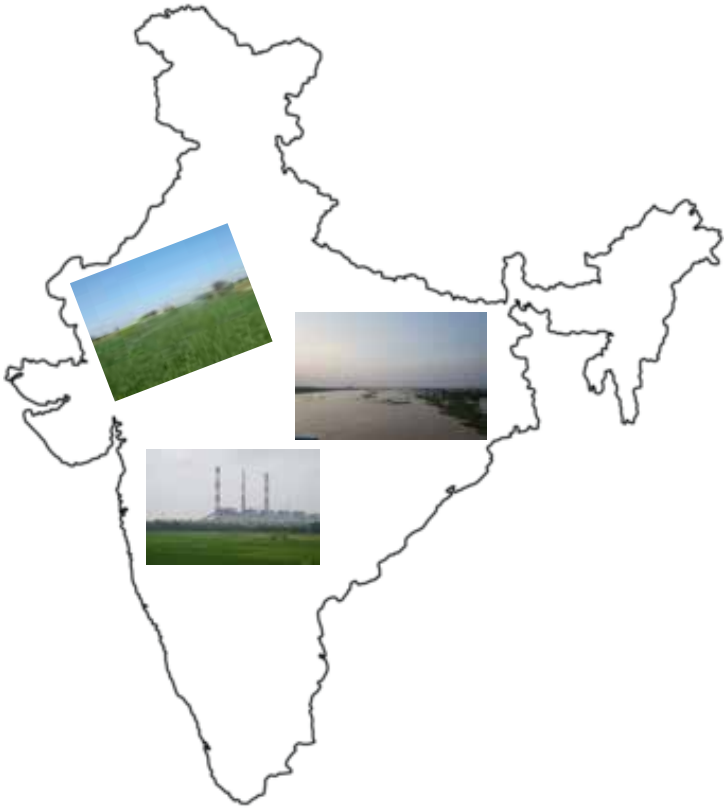


Figure 1: Overall Research Framework Using A Stepwise Approach

3. Results & Discussion

3.1 Case Study of India



3.1.1 Introduction

The UN General Assembly's Open Working Group (OWG) on Sustainable Development Goals has proposed a set of 17 Sustainable Development Goals (SDGs). This set of goals, targets and indicators are proposed to help frame agendas and policies over the next 13 years (by 2030). These Goals were developed resulting from the success of the Millennium Development Goals (MDGs) through inclusion of new areas such as climate change, economic inequality, innovation, sustainable consumption, peace and justice, and are designed to interlink – one goal is associated with others.

The focus of this study is mainly on three Sustainable Development Goals including SDG-2, SDG-6 and SDG-7. All three goals focus on the security of three basic essential components for the survival of human beings, economic growth and development, i.e., food, water and energy. Table 1 gives the themes of the three goals.

Table 1: Selected Sustainable Development Goals (SDG-2, SDG-6 & SDG-7)

SDG-2	**End hunger, achieve food security and improved nutrition and promote sustainable agriculture.**
SDG-6	Ensure availability and sustainable management of water and sanitation for all.
SDG-7	Ensure access to affordable, reliable, sustainable and modern energy for all.

Sources: - *Sustainable Development Goal, 2016*

The proportion of undernourished people (SDG-2) had declined from 15% (2000-2002) to about 11% (2014-16), with Southern Asia and sub-Saharan Africa accounting for 63% of total undernourished people worldwide in 2014-2016 (DESA, 2017). More than 27% of the global population live in countries with excess water stress (SDG-6), and some regions like Northern Africa, Western Asia, Central Asia and Southern Asia are experiencing water stress levels above 60%, which indicates strong water scarcity in the future.

The Government of India is strongly committed to the 2030 agenda and is also focused on the SDGs. India's national development goals with emphasis on *"development with all, and for all"* is a major theme for inclusive development. In the past few years, India has directed its development pathway to meet its priorities for employment, skills development, economic growth, food, water and energy security, disaster resilience and poverty alleviation. It is acknowledged that societal development is based on good health and well-being, which cannot be assured without food security, quality and availability of drinking water, and energy for socio-economic development. Table 2 covers the basics of the water-energy-food nexus.

It is very important to understand the interdependency of the three basic elements when designing future objectives for the country and region, as this is sure to improve the overall level of security. This review report summarizes the nexus among the three goals and current status of India in line to accomplish the Sustainable Development Goals (SDGs). The challenges of an interlinked and integrated agenda require governments and all stakeholders to develop a more concrete understanding of the interactions between these goals.

Table 2: Review of Water-Energy-Food (WEF) Security Nexus

Water security	**The elements of water security are: (1) *water access*; (2) *water safety*; and (3) *water affordability* so that every person can lead a clean, healthy and productive life, while ensuring that the natural environment is protected and enhanced (Global Water Partnership, 2000).**
Energy security	The elements of energy security are: (1) *continuity* of energy supplies relative to *demand*; (2) *physical availability of supplies*; and (3) *supply sufficient to satisfy demand at a given price* (Department of Energy & Climate Change (DECC), 2009; International Energy Agency (IEA), 2001).
Food security	The elements of food security are: (1) *food availability*: influenced by production, distribution and exchange of food; (2) *access to food*: including affordability, allocation and preference; (3) *utilization*: nutritional value, social value and food safety (4) *food stability* over time (Ericksen, 2008; Schmidhuber and Tubiello 2007).

Source: - *(Bizikova, 2013)*

The overall goal of the study is to provide a guideline for country indicators for SDGs by establishing scientific relationships among SDG goals and targets, particularly focusing on three major dimensions: food (SDG-2), water (SDG-6) and energy (SDG-7). It also provides a shortlist of interlinked targets to help in formulating policies and actions to meet related targets on water-food-energy effectively.

3.1.2 Methodology

To meet the objectives of this research, this study followed a step-wise approach and also used several tools and techniques including a literature review, networking analysis, stakeholder consultations, and regression analysis. The methodological framework for the present study is shown in fig. 2.

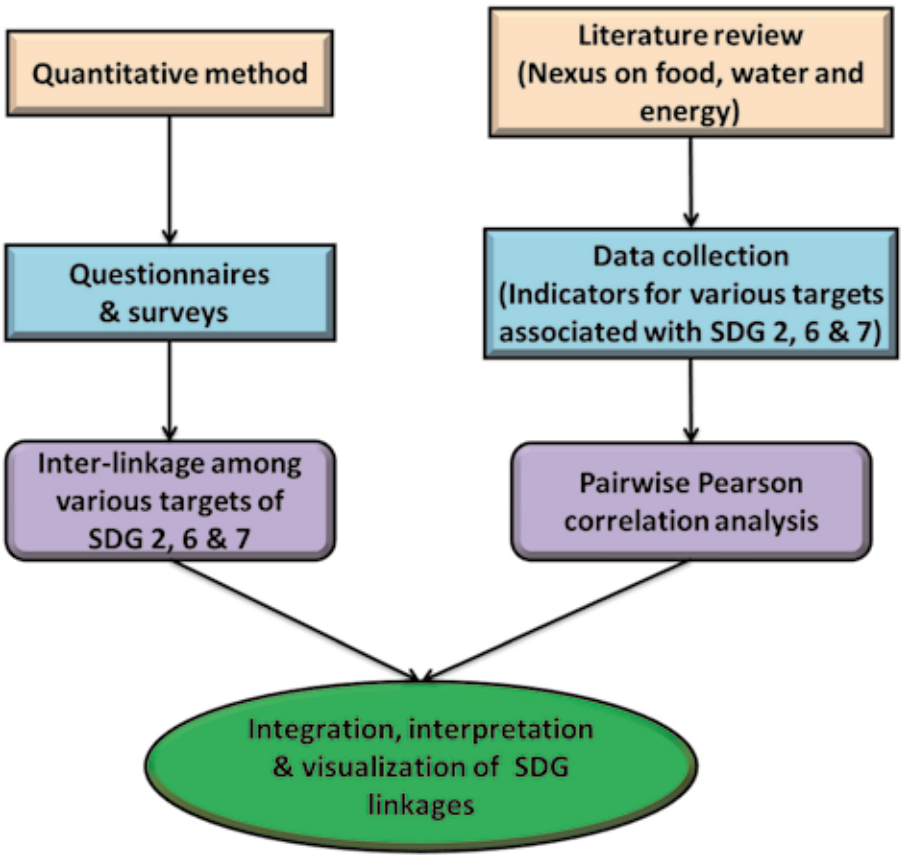


Figure 2: - Methodological framework of the Study

i. Readiness of countries to implement SDGs

A literature review and stakeholder interviews were performed to evaluate the situation surrounding water energy and food security of India. Through analysis of secondary data and local stakeholder consultations, critical nexus issues related to water, food and energy security were identified. The analysis also considers comments of stakeholders and civil societies on the proposed targets and indicators. The main focus of the questionnaire was to clarify the dependency of SDG-2, SDG-6 and SDG-7 on targets of other SDGs, and the questionnaires were filled in by government organizations, institutes and NGOs in the fields of food, water and energy.

ii. Quantitative assessment of relationships among proposed targets for SDGs

This methodology framework introduces the dependencies among the goals in terms of potential interactions, i.e. synergies (where progress in one goal favors progress in another) and trade-offs (where progress in one goal hinders progress in another). Various studies used different SDGs for evaluating the synergies, trade-offs and dependencies of their targets on other SDGs (Pradhan et al., 2017; Singh et al., 2018). The time series data for different targets of SDG-2, SDG-6 and SDG-7 was collected from different sources, then the identified linkages between the targets and SDGs were validated using the Pearson correlation coefficient.

iii. Identifying interactions within SDGs for water, energy and food

A network analysis was performed to scientifically show relationships within the proposed targets and indicators for food, water and energy goals. The purpose of this analysis was to establish and visualize the nature of interlinkages among the targets and indicators, which were examined through the network analysis of SDG-2, SDG-6 and SDG-7. The synergy and trade-off relationships among SDG-2, SDG-6 and SDG-7 targets or indicators revealed thereby can provide useful insights to relational analysis.

iv. Quantitative Assessment of interlinkages among the proposed indicators

Quantitative aspects of the interlinkages are addressed by using statistical techniques to test hypotheses on possible associations among indicators of water, food and energy goals. Results of this analysis are important in determining whether and to what extent one indicator quantitatively correlates with the others. The identified linkages between the indicators have been validated using Pearson correlation coefficients, and were obtained through pairwise comparison of those indicators with their statistical significance test for the period 2000 to 2015. The linkages among SDG-2, SDG-6 and SDG-7 were analysed through pairwise correlation among the indicators which measured these targets. This pairwise correlation describes the direction of linkages between the two variables. The targets associated with different goals and their respective measuring indicators are listed in Tables 3 to 5. Due to unavailability of data, not all desired sets of targets are included in the analysis.

Table 3: Targets, indicators and data sources of SDG-2 (Food Security)

Targets	Target Description	Measuring Indicator	Source
T- 2.1	By 2030, end hunger and ensure universal access to nutritious and sufficient food.	Population below minimum level of dietary energy consumption or Prevalence of undernourishment.	World Bank http://data.worldbank.org/data-catalog/world-development-indicators
T-2.2	By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age.	Prevalence of anemia among children	World Bank http://data.worldbank.org/data-catalog/world-development-indicators
T-2.3	By 2030, double the agricultural productivity and incomes of small-scale food producers.	Crop production	World Bank http://data.worldbank.org/data-catalog/world-development-indicators
T-2.4	By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production.	Per capita food supply variability	FAO http://www.fao.org/faostat/

Targets	Target Description	Measuring Indicator	Source
T-2.5	By 2020, maintain the genetic diversity of seeds, cultivated plants, farmed and domesticated animals, and their related wild species.	Proportion of local breeds classified as being at unknown level of risk of extinction	UNSD https://unstats.un.org/sdgs/indicators/database/)
T-2.a	Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research.	Total official flows (disbursements) for agriculture, by recipient countries	UNSD https://unstats.un.org/sdgs/indicators/database/)

Sources: World Bank. World Development Indicators. Washington, D.C.: The World Bank (producer and distributor). http://data.worldbank.org/data-catalog/world-development-indicators (accessed in year 2017-18)

United Nations Statistics Division, Sustainable Development Goals Indicators (https://unstats.un.org/sdgs/indicators/database/)

FAOSTAT (http://www.fao.org/faostat/)

Table 4: Targets, indicators and data sources of SDG 6 (Water Security)

Target	Target Description	Measuring Indicator	Source
T-6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all.	People using at least basic drinking water services	World Bank http://data.worldbank.org/data-catalog/world-development-indicators
T-6.2	By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.	Proportion of population practicing open defecation	UNSD https://unstats.un.org/sdgs/indicators/database/)
T-6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.	Wastewater treated	India water portal, Water India and others sources http://www.waterindia.com/aboutus.aspx; https://www.indiawaterportal.org/; https://sandrp.in/2016/03/17/smart-urban-water-options-recycle-waste-water/
T-6.6	By 2020 protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.	Water body extent (permanent and maybe permanent)	UNSD https://unstats.un.org/sdgs/indicators/database/)

Target	Target Description	Measuring Indicator	Source
T-6.a	By 2030, expand international cooperation and capacity-building support to developing countries in water and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies.	Total official development assistance (gross disbursement) for water supply and sanitation, by recipient countries	UNSD https://unstats.un.org/sdgs/indicators/database/)

Table 5: Targets, indicators and data sources of SDG 7

Target	Target Description	Measuring Indicator	Source
T-7.1	By 2030, ensure universal access to affordable, reliable, and modern energy services.	Proportion of population with access to electricity	UNSD https://unstats.un.org/sdgs/indicators/database/)
T-7.2	Increase substantially the share of renewable energy in the global energy mix by 2030.	Access to electricity	World Bank http://data.worldbank.org/data-catalog/world-development-indicators
T-7.3	Double the global rate of improvement in energy efficiency by 2030.	Energy intensity level of primary energy	UNSD https://unstats.un.org/sdgs/indicators/database/)

Pearson's correlation provides a measure to evaluate the strength of an association between two variables. Pearson's correlation analysis can capture nonlinear correlations between variables and is less sensitive to outliers (Hauke & Kossowski, 2011). In Pearson's correlation a p-value less than 0.05 was considered to mean that the data was statistically significant. The interaction between target pairs of SDGs fell into three categories: synergy, trade-off and non-classified. Statistical interaction among two independent variables is said to represent synergy. The positive and negative signs assigned to indicators express the desire to increase or decrease their respective impact in order to meet the SDGs. In Pearson's correlation, a p value greater than 0.6 is considered to indicate a synergy (positive association) between two indicators, a p value less than −0.6 is considered to indicate a trade-off (negative association) and p value between −0.6 and 0.6 is considered to indicate non-classified.

By taking into account such correlations, it is expected that when designing and monitoring their work, policy- and decision makers concerned with a specific sustainable development goal will have to consider targets or indicators that refer to the other Goals as well, which may provide stronger incentives for cross sectoral, integrated work than in the past. Similarly, it is also suggested that for institutions concerned with monitoring and evaluation of progress of the SDGs, it will be necessary to look at multiple Goals, and that this may enable greater integration across Goals.

v. Prioritization of interlinkages for actions

The proposed research involved a stakeholder survey to collect feedback on the results of network analysis and regression analysis. It also aimed at prioritizing country actions based on the key stakeholders' perceptions and preferences. For this, an international workshop was organized on 25-26 June 2019 at Central University of Rajasthan. This workshop aimed to bring together and engage a wide gamut of stakeholders – government agencies, academic and research communities, civil societies, NGOs, international organisations and young professionals – on a common platform. Participants were divided into three groups with respect to SDG-2, SDG-6 and SDG-7 to prioritize and rank the top three targets from each goal based on their importance, current status and national development strategies and priorities. After the group work, all three groups provided their final priorities and ranking of targets. At the end, a matrix was prepared for the prioritized targets and their correlation values (from the previous section) and further refined in priority based on the correlation values as given below:
High priority – greater than 0.9
Moderate – between 0.6 to 0.8
Low – Less than 0.6

The analysis provides a shortlist of indicators, which are measurable and fully reflect the proposed relevant targets as well as interdependent nature among the approved water, food and energy goals. Consequently, this list of indicators can help to manage water, food, and energy effectively and meet related SDG targets more rapidly.

3.1.3 Results and Discussions

3.1.3.1 Status, Challenges and Issues related to Water, Energy and Food Security

Water Security in India

According to the World Bank, India is the world's most important user of groundwater, and it estimates that 114 million Indians are facing domestic, agricultural and industrial water shortage, which threatens their long-term food security, livelihoods, and economic growth (World Bank, 2012). India faces a serious and persistent water crisis owing to a growing gap between demand and supply. Poor water resources management and climate change are other key challenges which are further stressing this precious natural resource (OECD, 2014).

According to the World Resources Institute (WRI), about half of India faces high to extremely high water stress, owing to insufficient supply to households, as well as agricultural and industrial requirements. WRI explains the twofold nature of India's domestic water security as follows. First, there is insufficient safe water to satisfy national demand and second, the management of existing water resources is poor and inefficient (World Resources Institute, 2015). In past decades, the government has enforced measurement and enhancement of the availability and quality of drinking water and exerted efforts to improve water resources plans to meet societal demand (Rivière, 2015). This increase in water demand is also increasing pressure on groundwater resources and further depleting aquifers. Lack of drinking water for people is an important factor that contributes to India's water security challenge (Asthana and Shukla, 2014).

Water is vital to India's food security, which hinges on its ability to increase agricultural output to meet the

demands of a growing population. The country has one of the world's largest irrigation systems, which is characterized by high levels of inefficient water use (OECD/FAO, 2014). The agriculture sector is the main consumer of water and freshwater withdrawal for irrigation comprises nearly 90% (Pomeranz, 2013). India's water resource for agriculture is also under stress, which will invariably affect national food security. Mckinsey (2009) suggested that water demand in India will grow to almost 1.5 trillion m^3 by 2010, mainly due to population growth and the water requirement of staple crops like rice, wheat and sugar.

India faces many challenges caused by the inefficient management of existing water resources. The industrial sector is the second highest user of water resources after agriculture, the water demand of which will increase in the future (Aggarwal and Kumar, 2011). TERI reported in a survey that 27 major Indian industrial sector companies were operating in already stressed areas, with 75% indicating difficulties in accessing enough water, which affected their business (TERI, 2014).

India's water resources are unevenly distributed in time and space. First, the monsoon season regularly leads to floods in some areas, such as the Brahmaputra, Barak and Ganga, and droughts in Rajasthan, Gujarat, Andhra Pradesh, Karnataka and Tamil Nadu. Second, poor water quality is a major environmental issue in India as most of its river networks, lakes and surface water are polluted (GoI, 2012). Third, the lack of proper technology means that up to 50% of piped water supply is wasted due to leakage (Svane and Jain, 2014).

A recent survey reported that the lack of holistic approach in policy and water management is found in the Indian Government (Price et al. 2014). While the Central Ground Water Authority in India is responsible for the control and protection of ground water, pollution and the environment, and water policies and environmental legislation are deemed to be comprehensive 'on paper', there is a blatant disparity between policy and implementation. Further, these policies are neither fully implementable nor enforceable (Price et al., 2014).

Water Resources in India

Rainfall is distributed over five to six months of the year. The total available fresh water is 4,000 BCM per annum. Out of the total usable water, 728 BCM comes from surface water and 395 BCM from replenishable ground water (Moni, 2004). The per capita water availability will decrease in the future; in 1951 it was 5,177 m^3/y, which declined to 1,820 m^3/y in 2001, and in future will further decrease to 1,140 m^3/y, as given in Table 6 (Government of India, 2009).

The consumption of water is crucial – it is equally important to provide water for irrigation to increase food production and livestock, and to ensure food security for the rising population. The population growth rate is a serious concern as it will create a burden on the per capita water availability in the future (Magrath, 2007).

Table 6: Per capita water availability in India

Year	Population (Million)	Per capita water availability (m^3/year)
1951	361	5177
1955	395	4732
1991	846	2209
2001	1027	1820
2025	1394	1341
2050	1640	1140

Source: *Government of India, 2009*

The demand for water in India is steeply rising and is expected to rise further for the following reasons (*Amarasinghe, et al., 2007*):

a) Primarily, India's population, which was 1.3 billion in 2005 and is expected to be 1.66 billion by 2050.
b) High development in urban areas. In 2007, 28.2% of the population lived in urban areas, which is expected to increase to 55.2% by 2050.
c) Increase in per capita income from 468 USD in 2007 to 6,735 USD in 2050
d) Increased industrialization (GDP will increase from 29.1% in 2000 to 40% by 2050). As a result, demand for water will increase from 30 billion cubic meter (BCM) in 2000 to 161 BCM by 2050.
e) Increased water demand in agriculture sector for food production (expected to increase to 80% of water demand by 2050).

Challenges for Water Security

Water supply in India is going to be a serious challenge for various reasons. The most serious concern is the growing population, which is likely to be 1.66 billion by 2050. With the increasing population, the annual food requirement in the country will exceed 250 million tonnes (Raj, 2010). India's GDP, if based on 6.8% per annum from 2000 to 2025 and 6.0% per annum during 2025 to 2050, means per capita income is bound to increase by 5.5% per annum, and this will in turn increase the requirement for water for livestock, from 2.3 BCM in 2000 to 2.8 BCM in 2025 and 3.2 billion m^3 in 2050 (Sharma, 2014). Table 7 shows the different sectoral challenges in India.

Table 7: Sector-wise water security challenges in India

Sector	Challenge
Agriculture	Improvement in water usage efficiency
	Adoption of rainwater harvesting and watershed management techniques
	Reduction of subsidies on power supply, particularly for pumping water
	Prevention of ground water exploitation by introducing differential pricing, rewards and punishments
	Implementation of National River Link project, which aims to connect 30 rivers and canals to generate 175 trillion litres of water
Industrial	Encourage recycling and treatment of industrial wastewater through regulations and subsidies
	Encourage the introduction of new technologies which consume less water
Domestic	Introduction of a policy for mandatory rainwater harvesting in cities
	Propagation of efficient water usage
	Creation of common awareness about water conservation among the public

In India, over-exploitation of ground water is a major concern. Presently, the Government of India provides 20-meter wells pumping water with free power supply, and as a result the groundwater table in the country is falling annually by 0.4 m. Nevertheless, there is lack of awareness among users as well as policymakers about the serious consequences of continued use of this unscientific practice.

Augmentation of Water Resources

The consumption of water in India will increase by over 50% while the supply will increase only by 5–10% during the next 12–15 years. This gap in supply and demand will affect food production, biodiversity and other environment components. In order to improve the availability of water resources, more emphasis should be given to the following activities:

- ***Increasing Water Storage Capacity*:** Activities such as farm ponds, percolation tanks, water reservoirs and construction of small and medium size dams and rivers can retain more surface water, while increasing the ground water recharge.
- ***Efficient Irrigation Practices*:** Effective and efficient use of water in irrigation is important and should be linked with weather forecasting and new technologies in irrigation.
- ***Watershed Development*:** Development of watersheds is an important programme to make best use of rainwater for agriculture. It is important to conduct water budgets at the watershed level for judicial use of available water. The Government is also giving priority for watershed development to provide assured water supply to agriculture in rain fed areas.
- ***Research and Development*:** There is a need for more investment in research related to ground water monitoring, weather forecasting, breeding, water-efficient and drought-resistant crops and varieties which can cope up with the changing climatic conditions.

It is, therefore, necessary to prevent water scarcity by making best use of the available technologies and resources to conserve existing water resources, convert them into a utilizable form and make efficient use of

such in different sectors for sustainable development. Imposing regulatory measures to prevent the misuse of water and introducing rewards and penalties to encourage judicious use of water will help in conserving water (Saravanan, 2016).

Key Issues Critical for Establishing Good Water Governance

The following key issues determine how well a country's water legislation and institutions respond to evolving socioeconomic and environmental conditions and how it will help to achieve related water security goals.

a) For water management, establishing a proper river basin and/or aquifer system, requiring coordination and cooperation between political units across national and international.
b) Groundwater aquifers do not overlap with river basins, thus special attention should be given to the coordination and cooperation over these aquifers.
c) Integration of security of water rights with risk, uncertainty of resource availability and supply, and sustainability, avoidance of monopolization.
d) Prioritizing the environment and vital human rights in water allocation policies, laws and decision making processes, including requirements to assess and manage environmental flows.
e) Integrating surface and underground water resources management with land and biological resource governance.
f) Permitting water users and other stakeholders to take on greater responsibility, access relevant information and administrative and judicial remedies, and participate in decision making processes regarding water management and allocation.
g) Accounting for customary water allocation systems, rights and practices at the local level, where these exist.
h) Strengthening risk management of water-related natural hazards like floods and landslides, as well as incorporating the use of early warning systems.
i) Protecting freshwater ecosystems and managing protected areas of high conservation value.

Energy Security in India

Energy is essential on an individual human development level and for overall growth of the economy. The energy scenario in India poses increasing challenges for its future energy policy (*Sasidhar, 2014*). According to the government's Integrated Energy Policy (GoI), India's requirement for primary commercial energy is projected to increase from 551 MTOE (million tonnes of oil equivalent) in FY12 to 1,823 MTOE in FY32. India ranked in 81st position (or at 66%) in overall energy self-sufficiency in 2014 and is the fourth largest consumer of energy in the world after USA, China and Russia. India's energy consumption stands at 3.5% of the world's global energy consumption and is likely to be 10% by 2031, but the country is not endowed with abundant energy resources (Planning Commission., 2017). India announced its National Action Plan on Climate Change in 2008, and during COP15 in Copenhagen in 2009, its environment minister reconfirmed India's goal to reduce carbon emissions per unit of GDP by 20–25% below 2005 levels by 2020 (Cutler, 2016). As fossil fuel energy becomes scarcer, India will face energy significant shortages due to increase in energy prices and energy insecurity within the next few decades. Increased use of fossil fuels also causes environmental problems both locally and globally (Gunatilake, 2014) such as frequent flooding and droughts, deforestation and desertification as well as possible glacial melting in the Himalayas. These impacts are focused on climate change and provide strong impetus towards transitioning to a low-carbon economy (MacDonald and Wimbush, 1999).

India's growing population and expanding economy with a shift in focus from agriculture to the manufacturing and services sectors have led to an increase in energy intensity, which has resulted in unprecedented demand for energy (Ahmed and Ghani, 2007). Energizing rural India is thus crucial to promoting the country's broader economic and social development (MNRE, 2012). The country is adopting government-supported micro-irrigation systems in regions with high water scarcity, primarily to increase the irrigation cover with limited water availability (Agrawal and Jain, 2016). To facilitate use of micro-irrigation through SPIS, adequate financial incentives, judicious system design, timely observation and management, and continuous awareness generation are required (Levidow et al., 2014).

India faces an enormous rural energy poverty challenge given that many of its citizens lack access to electricity networks and depend on solid fuel for cooking and heating. It has the largest rural population in the world and as of 2009, 289 million people were living without electricity (IEA, 2011). Energy poverty is further exacerbated by the lack of integrated policy framework, division of the energy sector across multiple agencies, overemphasis on serving urban customers through the national grid rather than rural ones (Srivastava et al., 2012), misdirected subsidy regimes, ineffective implementation, poor sectoral governance, resource constraints and other structural factors (Balachandra, 2011; Krishnaswamy, 2010). The pace of electrification in rural India has been somewhat sporadic and past efforts in terms of both policies and programmes have achieved only marginal success (Bhattacharyya, 2006). In 2001, the government took a major step towards eradicating energy poverty by creating the Rural Electricity Supply Technology (REST) mission, with the objective of realising "power for all by 2012". That same year, MNRE was tasked with implementing the Remote Village Electrification (RVE) programme. In April 2005, the Indian government intensified its efforts by launching the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), a large-scale programme designed to accelerate rural electrification and provide electricity access to all Indian households (IEA, 2015).

India's share of energy consumption stands at 3.5% of the world's global energy consumption and is likely to be 10% by 2031. With a total installed capacity of 3,29,231 MW and a per capita consumption of a mere 650 units of electricity per annum, India suffered from huge estimated shortages of nearly 10% in energy terms and almost 17% in terms of peak demand as of 2007–08 (*GoI, 2017*). According to the International Energy Agency, coal accounts for about 40% of India's total energy consumption, oil for about 24%, and natural gas for 6% (*FICCI, 2011*). In 2015–16, the per-capita energy consumption was 22.042 Gigajoules (0.527 Mtoe) excluding traditional biomass use, and the energy intensity of the economy was 0.271 Megajoules per INR (65 kcal/INR). Further, less than 30% of India's population is able to use liquefied petroleum gas (LPG) to meet its cooking energy needs, with over 50% still dependent on firewood, chips, animal dung, and agricultural residues (*TERI, 2010*).

Energy is a basic requirement for economic development in every sector of the economy. It is thus necessary that the country quickly looks towards new and emerging renewable energy and energy efficient technologies as well as implements energy conservation laws (*Ghosh and Steven, 2013*). In response, the Indian Government has formed comprehensive policy covering compulsory use of renewable energy resources through biomass, hydropower, wind, solar and municipal waste in the country, particularly for commercial establishments, as well as Government establishments (*IEA, 2006*). In addition, India has the potential to generate 35 MW per square kilometer using solar PV and solar thermal energy (*Srivastava and Mathur, 2007*).

Renewable Energy in India

India has the fifth largest power generation portfolio in the world and its current renewable energy contribution stands at 44.812 GW, which includes 27.441 GW of Wind power and 8.062 GW of Solar power installed capacity in the country. Economic growth, increasing prosperity, growing urbanization and rising per capita energy consumption have led to increased demand for energy in the country (Kumar et al., 2010). The target of National Solar Mission has been up-scaled to 100 GW from 20 GW of grid connected solar power by 2022, which creates a positive environment among investors keen to tap into India's renewable energy potential. The Government has revised its target of renewable energy capacity to 175 GW by end of 2022, making it the largest expansion in the world and providing plenty of opportunities for investors (NITI Aayog 2015).

India's government has a bold goal for deploying renewable energy, with 175 GW of electricity-generating capacity by 2022, including 100 GW of solar power. MNRE is working in conjunction with the Indian Renewable Energy Development Agency (IREDA) to promote the utilization of all forms of solar power as well as increase the share of renewable energy in the Indian market (*Bagchi, 2012*). According to the 11th new and renewable energy five-year plan proposed by the government, from 2008 to 2012 the renewable energy market in India was to reach an estimated 19 billion USD. Renewable energy is at the take-off stage and businesses, industry, government and customers have a large number of issues to address before these technologies can properly penetrate (*Ghosh, 2015*).

The Ministry of New and Renewable Energy (MNRE) is playing a proactive role in promoting the adoption of renewable energy resources by offering various incentives such as generation-based incentives (GBIs), capital and interest subsidies, viability gap funding (VGF), concessional finance and fiscal incentives (Energy, 2017). Consumers, especially the very large percentage who today lack access to electricity, are extremely price sensitive, meaning the Government will need to take into account not only the ability of such people to pay for energy services but also to its own ability to absorb the costs of energy subsidies. MNRE (GoI) has signed a MoU with NABARD to promote Solar Home Lighting Systems (SHLS) in rural areas. This programme is to be implemented under the Jawaharlal Nehru National Solar Mission. JNNSM aims to achieve 20,000 MW of solar power production by the year 2022. In March 2017, NABARD Subsidy Schemes for the above Solar Home Lighting Systems were discontinued (MNRE and NABARD, 2016). By 2022, India will surpass China with the world's largest population, and as the government expands electricity and other forms of commercial energy to people still lacking even rudimentary access to electricity, along with millions still dependent on biomass and other traditional energy sources for cooking, the country will see an unprecedented growth in energy demand over the next several decades (Ebinger, 2016). Of the 10 largest electricity systems in the world India is projected to have one of the fastest growing markets over the next decade (Buckley, 2015)

Foreign Direct Investment (FDI) of up to 100% is permitted under the automatic route for renewable energy generation and distribution projects, subject to provisions of The Electricity Act, 2003 (Kumar et al., 2014). The Ministry of New and Renewable Energy (MNRE) has launched a programme titled "Development of Solar Cities in India". The programme aims for a minimum 10% reduction in projected demand of conventional energy, which can be achieved through a combination of energy efficiency measures and enhancing supply from renewable energy sources.

Energy Accessibility in India

According to the Indian Energy Security Scenarios (IESS) energy scenario building tool, India's usage and demand in 2047 remains grim. In parallel with increased economic development there is expected to be an increase in mobility and demand for both inter-city and intra-city passenger transport over the next few decades (*Ministry of Power, 2010*). The installed capacity of utility power plants is 314.64 GW as on 31 January 2017 and the gross electricity generated by utilities during 2015–16 was 1,168.359 billion kWh which includes auxiliary power consumption of power generating stations. The per capita consumption of Electricity was nearly 1,181 kWh during the financial year 2018-19 (*Ministry of Power, 2019*).

Nearly one-quarter of the population lacks access to electricity. It is important to understand this peculiarity of India's energy situation where the majority of potential energy demand still remains unmet, unlike in most developed countries where energy demand has reached or is close to saturation stage. The government has recognized that economic development is being hindered as a consequence of energy poverty, thus providing energy access to its entire population has been a top priority of policymakers for a long time, making it equally or even more important than energy security. India's major rural electrification scheme is an example of the government's determination to expand access to electricity in rural villages (*Chandrasekaran, 2017*).

Challenges for Energy Security

To address the challenges facing India's energy sector, it is imperative for the government to develop and implement well defined, coherent energy policies, to ensure optimal utilization of domestic energy resources, development of adequate infrastructure both upstream and downstream, development and harnessing of renewable energy resources, increase in energy efficiency, and development of technology, all of which are essential steps to ensure the country's energy security (*Singh, 2010*). Table 8 lists challenges in the energy sector.

Table 8: List of energy security challenges in India

Challenge	Description
Increased fuel efficiency	Policies implemented by the government through a cut in state subsidies on all petroleum products
Shift to natural gas and LNG	Focusing on costlier LNG imports, especially from Oman and Qatar. This would require construction of LNG terminals which pose security risks
Increased domestic production	To promote investment in the exploration and production of domestic oil and gas
Increased utilization of clean coal technology	Coal provides 56% of India's commercial energy supply. Application of the coal gasification combined cycle process is an emerging technology for clean and efficient coal fuelled generation
Shift to next generation fuels and increased use of renewable sources of energy	The Indian government is promoting the use of ethanol made from sugar cane and bio-diesel extracted from trees that are common in many parts of India, such as the Jetropha, Karanja and Mahua

The World Energy Outlook, published by the International Energy Agency (IEA), projects that India's dependence on oil imports will grow to 91.6% by the year 2020. Only 500 energy managers are certified by BEE (Bureau of Energy Efficiency) annually. These were the major challenges that are obstructing India to deal with energy security (*Ahn & Graczyk, 2012*). Lack of experienced solar cell manufacturing, solar power generators, lack of trained manpower and availability of other solar equipment manufacturers is another reason for the high cost of solar power. Establishing cell manufacturing units within the country is therefore an urgent requirement for decreasing the cost of solar power (*Sharma, 2015*).

Initiative for Energy Security in India

According to a report by IEA (International Energy Agency), India needs to invest a total of 800 billion USD in various stages by 2030 to meet its energy demand. India accounts for around 2.4% of annual world energy production, but on the other hand consumes 3.3% of the annual world energy supply.

- Akshay Urja Shops were launched to cover all districts of the country to ensure easy availability of energy systems/devices;
- A 140% increase in solar power capacity (4.13 GW) during 2014-16 as compared to 1.72 GW during 2012-14;
- 34 solar parks of aggregate capacity of 20,000 MW have been sanctioned for 21 states. INR 356.63 crores has been released to Solar Energy Corporation of India for the projects; and,
- As on September, 2019, cumulative capacity of 82 GW grid interactive renewable energy capacities had been installed in the country (MNRE, 2019).

Energy Security in India is the dream of the nation for the 21st century. And after implementation, the various policies look set to move India a step closer to achieving this dream. Huge financial investment, especially in the energy sector is the need of the hour. The new era of renewable sources will play a vital role in the nation's target of energy security, and to meet the growing energy demand over the next few years, India will have to enhance its energy security by procuring energy supplies at affordable prices.

Food Security in Context of India

Food security continues to be high on its list of development priorities because the country's relatively high rates of economic growth have not led to a reduction in hunger and under-nutrition. India's gross domestic product at factor cost and per capita income grew at 7% and 5% per annum, respectively from 1990–91 to 2013–14 (RBI, 2015). Food security, along with poverty eradication and ecological conservation, is one of the most significant elements of the millennium development goals. India is the world's largest food security puzzle as the country has enormous presence in the global food and nutrition security equation (Kumar and Meena, 2017). Issues related to the WEF Nexus have been addressed through various policy measures and schemes across the domains of agriculture, conventional and non-conventional energy sources, water management, environment, and rural development.

According to Food and Agricultural Organization (FAO), food security means physical and economic access to basic foodstuffs for all people at all times according to need (Singh, 2014). Food security is a combination of three dimensions – physical availability (food stocks), economic access (price of food) and biological utilization (food consumption) (WFP & MSSRF, 2008). As per FAO, it is also important to maintain stability of the three mentioned dimensions over time.

Mittal (2008) has made a projection of India's food demand and supply. It was inferred that the increase in total food demand is mainly due to increase in population and rise in personal income, while production is likely to be severely affected by low yield. It may be hard to meet the long term food requirement with domestic production only. Based on production trends, Kumar et al. (2009) observed that it will be difficult to meet future food grain demand in India.

Indian agriculture is highly vulnerable to climate change due to its high dependency on the monsoon and its variability. Chakrabarty (2016) found that both wheat and rice crops are sensitive to climate change. Lobell et al. (2012) found that growth of wheat crop in northern India is highly sensitive to temperatures over 34°C.

Food security in India is thus a matter of great concern as one third of its population is estimated to be absolutely poor and over half of all children are malnourished (Jain, 2016). Several critical issues have been raised in the context of food security in India: (a) liberalization of economy in the 1990s and its impact on agriculture and food security, (b) establishment of WTO and agreement on agriculture, (c) climate change, (d) prevalence of hunger and poverty coexisting with high level of food stock, (e) 'Right to food' campaign, (f) public distribution system, and (g) national food security bill. These important challenges have posed severe challenges for food security in India (Ittyerah, 2013).

India's food security situation remains ranked as "alarming" (IFPRI, 2014). Based on affordability, availability and quality in the global food security index, India ranked 75 out of 113 nations and also cited affordability rather than availability as a key food security threat. According to a food security index (2015), India reached 68th position (EIU, 2016). From the 5th Plan period to the 9th Plan period, agricultural growth in India was high – highest being in the 6th Plan period at around 5.7% (Planning Commission, 2012).

Initiatives to ensure food security for citizens range from concerted efforts to boost agricultural production to far-ranging market interventions aimed at both income and price stabilisation. Further, measures have been introduced to improve access to food of the really poor through public distribution and income generating schemes (Mittal and Sethi, 2009). According to the National Family Health Survey 2015-16, the proportion of underweight children in India under five years is significantly high in states such as Bihar (43.9 percent), Madhya Pradesh (42.8 percent) and Andhra Pradesh (31.9 percent) (GoI, 2015).

Food Availability and Accessibility

Availability refers to physical availability of food stock in desired quantities. It can be asserted that increased availability of food is an essential condition for achieving food security in India. For about two decades after independence, India remained a food deficit country but later on became largely self-sufficient in food grain production at the macro level (*Chand, 2009*). In order to measure access to food in India, one of the key indicators used by many scholars and commentators is that of food grain consumption (*Jain, 2013*). Large-scale sample surveys carried out by the National Sample Survey Organization (NSSO) provide data on physical quantities of cereals, pulses and other key items of food consumed by a household over a definite time period at regular intervals of time (*Singh, 2014*).

According to an economic survey, as per the second advance estimates, the total food grain production in the country was estimated at 257.07 million tonnes during 2014-15. The survey cited the fourth advance estimates for 2013–14 which shows an increase of 1.3% in the production of rice, at 106.5 million tonnes.

The survey stated that to improve resilience of the agricultural sector and bolster food security, including availability and affordable access, the strategy for agriculture has to focus on improving yield and productivity (*Business-standard, 2015*).

The Government and its policies play a major role in ensuring Food security. India runs two of the world's biggest children's nutrition programmes, the Integrated Child Development Scheme (ICDS) for children under six years and the Mid-Day Meal programme (MDM) for school-age children up to the age of 14, but malnutrition continues to haunt India (Ittyerah, 2013). Besides these, GoI has started various schemes to increase food grain production, such as Rashtriya Krishi Vikas Yojna (RKVY), National Horticulture Mission (NHM) and Integrated Schemes of Oilseeds, Pulses, Oil palm and Maize (ISOPOM). The latest legal initiative is enforcement of National Food Security Act, 2013 which ensures food availability and accessibility to two-thirds of the poor population through PDS.

Reasons for Decline in Food Production Growth

The decline in the growth of food production can be understood by the performance of the overall agriculture sector and the factors that are responsible for the slowdown. Concern over deceleration in Indian agriculture growth and the resultant threat to food security has also been explained by the Planning commission. Availability and access to food depends on the performance of agriculture as more than 55% of people in the country are dependent on this sector (*Dev and Sharma, 2010*).

Table 9: Global Hunger Index of India

Year	1992	2000	2008	2016
Rank	76	83	102	97
Total Countries	96	115	118	118
India GHI Score	46.4	36.2	36	28.5

Sources: - *Global Hunger Index (http://ghi.ifpri.org/#)*

India experienced a bumper harvest in year 2010; however, owing to inadequate storage facilities almost one third of food grain has been destroyed. Thus the government is strongly determined to save rather than sell the stocks in the market. India's food security status remains in the "serious" rank according to the Global Hunger Index, 2016 (*IFPRI, 2016*).

Due to inflation the cost of food items is increasing day by day, leading to hardship by making them unaffordable for poverty traumatized people in India (*Varma, 2016*). It ranks 97th of 118 countries in the world in terms of degree of food poverty. This implies that, while hunger levels in India have diminished somewhat, the improvement has been outstripped by several other countries.

Issues and Challenges

A large proportion of India's population still lacks access to safe drinking water and primary health care; in 2011–12, 21.9% of the population was below the poverty line, and are exposed to conditions of adverse

hygienic environment according to a Planning Commission estimate. Access to food at the household level and nutrition are interrelated, and access to food depends on increase in purchasing power due to increase in employment and social protection programmes (*Dev and Sharma, 2010*). It has been found that India at present finds itself in the midst of a paradoxical situation: endemic mass hunger coexisting with mounting food grain stocks. The food grain stocks available with the Food Corporation of India (FCI) stand at an all-time high of 62 million tonnes against an annual requirement of around 20 million tonnes for ensuring food security, but on the other hand, there are certain issues related to food security. These are:

- *Urban Food Insecurity* - Due to better opportunities in industrial urban areas, there has been phenomenal expansion of national population growth, as well as rapid rural-urban migration. This has caused a large stress on the fragile socio-economic infrastructure in the cities.
- *Hunger, Malnutrition and Poverty* - Hunger relates to food deprivation and is caused by insufficient food energy consumption. Malnutrition results in deficiencies, excesses or imbalances in the consumption of macro- and micro-nutrients.
- *Rural Food Insecurity* - Despite rising food production and availability, the intake of nutritious food and minimum caloric intake in the rural population has declined. In studies of Singh (2000), Evidence shows that in average rural people suffer from a calorie deficiency of 175 Kcal. (Chand and Jumrani, 2013)
- *Failure of Public Distribution System (PDS)* - Dreze *and Khera* (2011) presented in her paper that the Public Distribution System of India is not without its defects. With coverage of around 40-crore BPL (Below Poverty Line) families, a review of the PDS has discovered the following structural shortcomings and disturbances:

The major problem in the PDS system has been the delivery of poor quality food grains in the ration shops. Unprincipled and unfair shop prices and use of illegal ration cards in the open market are other reasons. Table 10 presents a list of challenges in food security.

Table 10: List of food security challenges in India

Challenge	Description
Crop Diversification	Crop diversification in India is generally viewed as a shift from traditionally grown less remunerative crops to more remunerative crops.
Biofuel and Medicinal Plant Cultivation	Production of Biofuel and Medicinal Plants challenge in case of food security. In the southern Indian state of Tamilnadu the production of ethanol increased from 46 ha to 9,020 ha from year 2000 to 2010 (Dev and Sharma, 2010).
Climate Change	Changing climate is a challenge for food security due to the low/heavy rainfall, extreme high/low temperatures such as droughts (due to less moisture) and floods (due to high moisture).
Mismatch between Water Demand and Availability	For future agricultural growth and food security there is a negative relationship between demand and supply of water.
Agricultural Prices	The lack of agricultural price policy for the welfare of market communities to regulate and facilitate food security.

Challenge	Description
Production of High Yield Varieties	This challenge can be achieved by introducing plant breeding programmes, employing modern biotechnology techniques and also by availing farmers of information and utilizing new techniques of production.
New Trends in Globalization	Introduced new trends in globalization akin to technology of faster communication, transport, and high growth in the service sectors have led to challenges of inequity among various sections of society, unenthusiastic competition among entrepreneurs, which have indirectly amplified food insecurity in the country.
Capital Investment	The percentage share of capital investment in GDP has been increased for agriculture.
Infrastructure Requirements	The facilities of warehouses, roads, transport and the market should be a priority for the government.

3.1.3.2 Policy context for managing the nexus

For understanding and managing the nexus among the food, water, and energy sector, it is essential to formulate policies that will result in more resilient, adaptable societies and success in achieving the SDGs (*The Energy and Resource Institute, 2014*). In India, there are many policies, programmes and schemes that have been used to address the WEF nexus challenges. Several policies and schemes by the central and state governments like the National Policy on Biofuels (2009), National Action Plan on Climate Change (2008), National Water Policy (1987), Clean Ganga Fund, National Clean Energy Fund, Agriculture Demand Side Management, state renewable energy, and power subsidy policies have a direct or indirect impact on the Nexus areas. Details of the policies, scheme and programme for the WEF sector are shown in fig. 3.

Thus, understanding the symbiotic linkages among the WEF nexus and exploring them in cross sectoral policies are important to achieving the sustainable development goals. There are some other schemes which come under the Pradhan Mantri Krishi Sinchai Yojana (Government Agricultural Irrigation Scheme) i.e., *Har Khet Ko Pani, Per Drop More Crop, Integrated Watershed Development Programme and Accelerated Irrigation Benefit Programme*. The Government of India recently launched some policies which are nexus-based, as shown in Table 11.

Table 11: Nexus policy, schemes and programmes of WEF sector in India

Policy/Scheme Name	Ministry/Agency	Launch (Year)	Objective
Atal Bhujal Yojana	Ministry of Water Resources, River Development and Ganga Rejuvenation	2018	To recharge groundwater and create sufficient water storage for agricultural purposes.
Kisan Urja Suraksha Evam Utthaan Mahabhiyan	Ministry of New and Renewable Energy	2018	Solar water pumps to be installed in remote areas for irrigation needs. Farmers can supplement income by selling surplus solar power to DISCOMs.
Saur Sujala Yojana	Department of Agriculture Chhattisgarh	2018	To provide solar-powered irrigation pumps to farmers at a sponsored price. Chhattisgarh was the first state to implement the scheme.
GOBAR-Dhan Yojana	Ministry of Drinking Water & Sanitation	2018	Residuals and cattle dung can be converted into Bio-CNG and Bio-Gas, thus providing farmers with an alternative source of income.

Sources: *From different government websites*

FOOD AND AGRICULTURE SECTOR		
Policy/Scheme Name	**Ministry/Agency**	**Launch (Year)**
Public Distribution System (PDS)	Ministry of Consumer Affairs, Food, and Public Distribution	1947
Mid-Day Meal Scheme (MDM)	Ministry of Human Resource Development	1995
Antyodaya Anna Yojana	The Union Ministry of Food and Consumer Affairs	2000
Livestock Insurance Scheme	Ministry of Agriculture & Farmers Welfare	2005
Green Revolution-Krishonnati Yojana	Ministry of Agriculture & Farmers Welfare	2005
Gramin Bhandaran Yojana	Ministry of Food Processing Industries	2007
Rashtriya Krishi Vikas Yojana	Ministry of Agriculture and Farmers Welfare	2007
National Food Security Mission	Ministry of Agriculture and Farmers Welfare	2007
National Initiative on Climate Resilient Agriculture (NICRA)	Indian Council of Agricultural Research (ICAR)	2011
Rainfed Area Development Programme	Rashtriya Krishi Vikas Yojana	2011
National Food Security Act, 2013	Ministry of Consumer Affairs, Food, and Public Distribution	2013
Paramparagat Krishi Vikas Yojana	Ministry of Agriculture and Farmers Welfare	2015
Pradhan Mantri Fasal Bima Yojana	Ministry of Agriculture and Farmers Welfare	2016
National Nutrition Mission (POSHAN Abhiyan)	Ministry of Women and Child Development	2018

WATER AND SANITATION SECTOR		
Policy/Scheme Name	**Ministry/Agency**	**Launch (Year)**
National Water Policy (NWP)	Ministry of Water Resources, River Development and Ganga Rejuvenation	1987
National Watershed Development Programme for Rain fed Areas	Department of Agriculture & Cooperation	1991
National Rural Drinking Water Programme (NRDWP)	Ministry of Drinking Water and Sanitation	2009
National Rural Drinking Water Programme (NRDWP)	Ministry of Drinking Water and Sanitation	2009
National Water Mission	Ministry of Water Resources, River Development and Ganga Rejuvenation	2011
Pradhan Mantri Krishi Sinchai Yojana (PMKSY)	Ministry of Water Resources, River Development and Ganga Rejuvenation	2015
Jal Kranti Abhiyan	Ministry of Water Resources, River Development and Ganga Rejuvenation	2015
Atal Mission for Rejuvenation and Urban Transformation	Ministry of UrbanDevelopment	2015
Swachh Survekshan Grameen	Ministry of Drinking Water and Sanitation	2018
Swajal	Ministry of Drinking Water & Sanitation	2018

ENERGY AND POWER SECTOR		
Policy/Scheme Name	**Ministry/Agency**	**Launch (Year)**
The Electricity Act 2003	Ministry of Power, Government of India	2003
Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY)	Ministry of Power, Government of India	2005
National Electricity Policy, 2005	Ministry of Power, Government of India	2005
Jawaharlal Nehru National Solar Mission	Ministry of Power, Government of India	2010
National Mission for Enhanced Energy Efficiency	National Action Plan for Climate Change	2010
Integrated Power Development Scheme" (IPDS)	Ministry of Power, Government of India	2014
National Smart Grid Mission (NSGM)	Ministry of Power, Government of India	2015
Deen Dayal Upadhyaya Gram Jyoti Yojana	Ministry of Power, Government of India	2015
Solar Charkha Mission	Ministry of Micro Small and Medium Enterprise	2018

Sources: *Teja, 2015 and from different government websites*

Figure 3: Policy, schemes and programmes of WEF sector in India

3.1.3.3 Stakeholder Perception

Perception of stakeholders on the importance of nexus aspects for the country actions on Water (SDG6), Energy (SDG7) and Food (SDG2)

1) The majority of respondents (90%) think that the country's planning for SDG-2, SDG-6 and SDG-7 should coordinate well to achieve sustainable development considering their experience with MDGs or other existing scientific evidences.

2) *Level of dependency of SDG-2 achievement on targets of SDG-6*
Figure 4 presents the qualitative weight for level of dependency of SDG-2 achievement on targets of SDG-6 from the survey. Results showed that there is **strong dependency** of SDG-2 achievement on targets of SDG-6 except target 6.6 (Expand international cooperation and capacity-building for sustainable water management) where it has **moderate dependency**. All the respondents think that there is linkage between targets of SDG-6 with SDG-2 as nobody supports the **no link** option and few support the low linkage option, as shown in fig. 4.

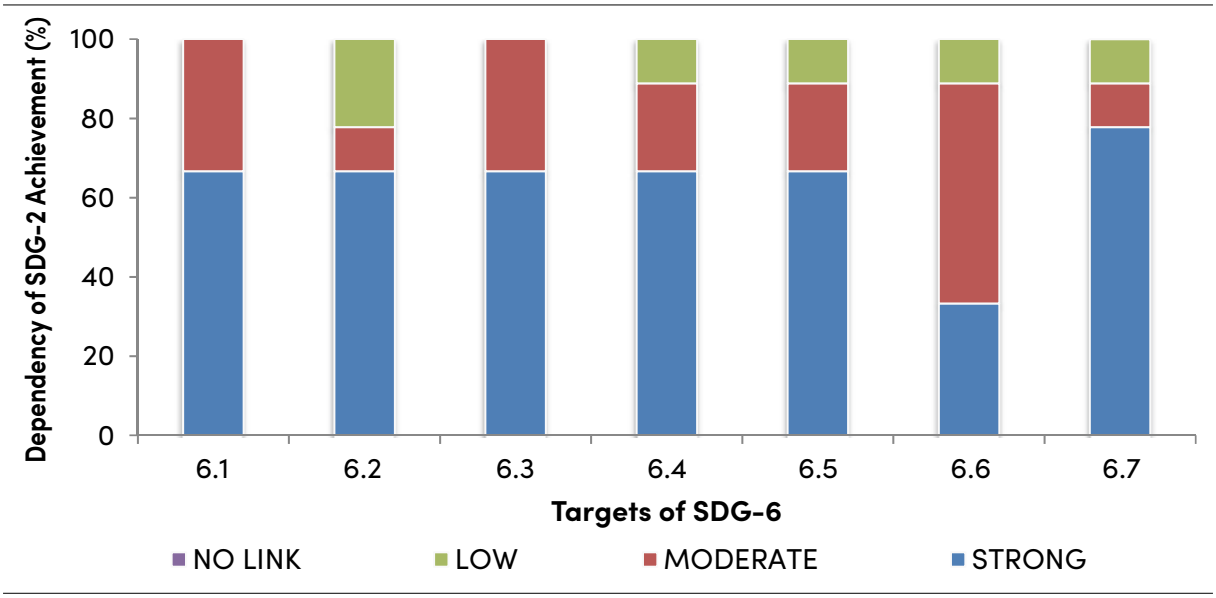


Figure 4: Level of dependency of SDG-2 achievement on targets of SDG-6

3) *Level of dependency of SDG-2 achievement on targets of SDG-7*
The level of dependency of SDG-2 achievement on targets of SDG-7 is mainly distributed into two categories, i.e., strong and moderate (fig. 5). But, dependency of SDG-2 is stronger with targets of SDG-6 as compared to targets of SDG-7. Only few respondents (10%) supported low and no link options.

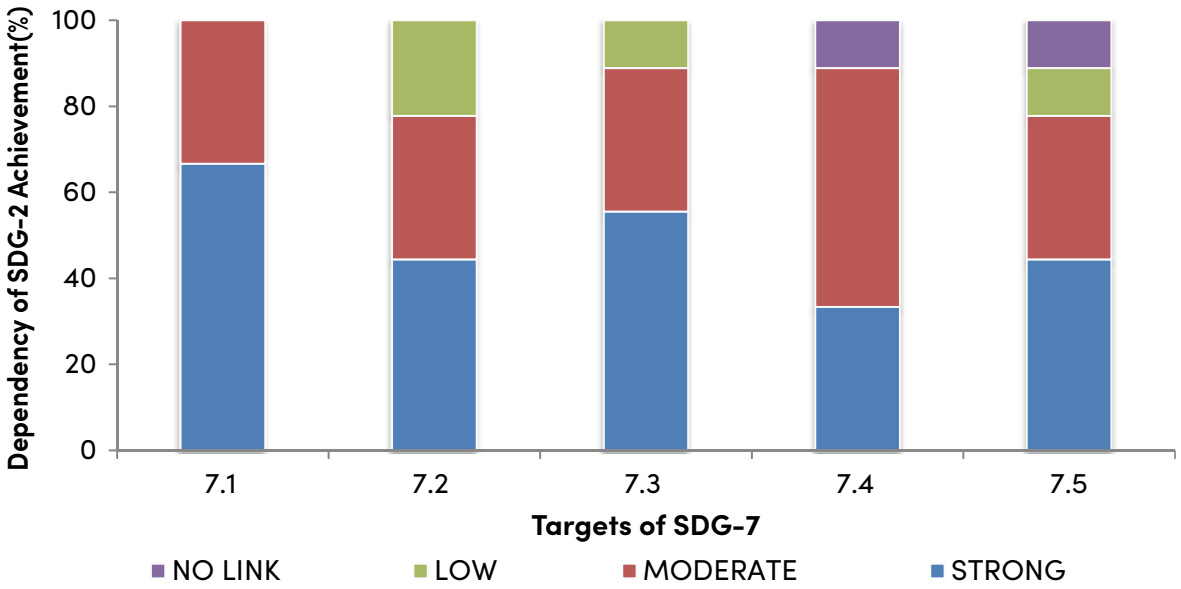


Figure 5: Level of dependency of SDG-2 achievement on targets of SDG-7

4) *Level of dependency of SDG-6 achievement on targets of SDG-2*

The survey results of the qualitative weight for the level of dependency of SDG-6 achievement of targets of SDG-2 shows that there is less strong dependency of SDG-6 achievement on targets of SDG-2 (fig. 6). The level of dependency of SDG-6 achievement on targets of SDG-7 is mainly distributed under strong and moderate categories. Dependency of SDG-6 is stronger for target 2.4 (Ensure sustainable food production systems and implement resilient agricultural practices).

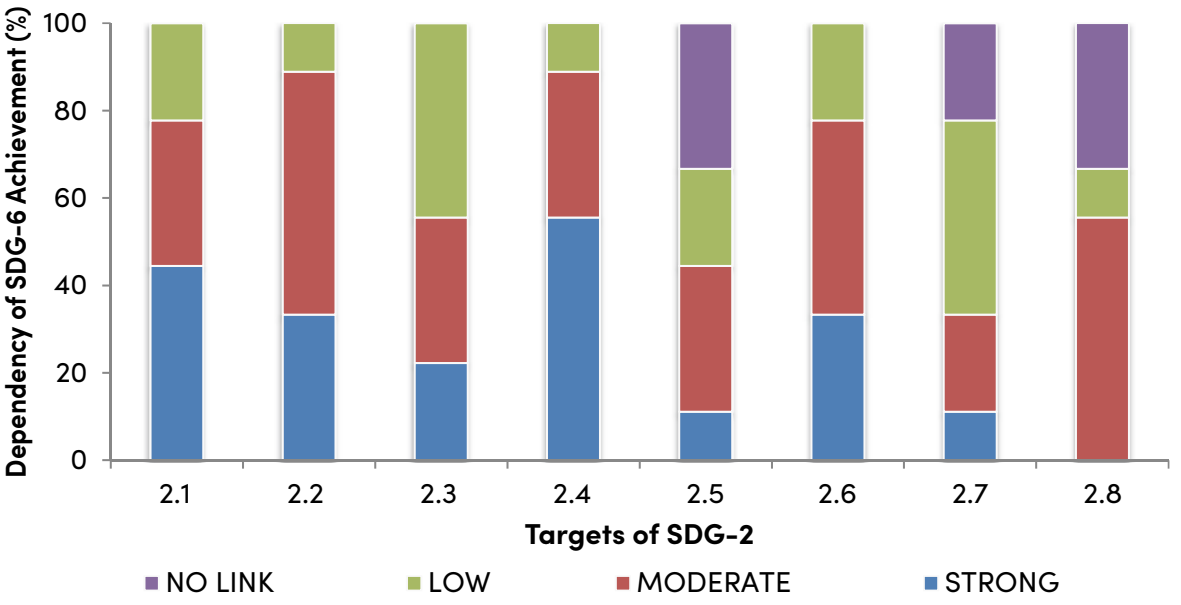


Figure 6: Level of dependency of SDG-6 achievement on targets of SDG-2

5) *Level of dependency of SDG-6 achievement on targets of SDG-7*

The survey results of the qualitative weight for the level of dependency of SDG-6 achievement of targets of SDG-7 shows that there is moderate level of dependency of SDG-6 achievement on targets of SDG-7 (fig. 7). The level of dependency of SDG-6 achievement on targets of SDG-7 is mainly distributed under a moderate link category followed by strong linkage. Dependency of SDG-6 is stronger for target 7.2 (Increase the share of renewable energy in the energy mix) followed by target 7.4 (Enhance international cooperation to facilitate access to clean energy research and technology) and target 7.5 (Expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries).

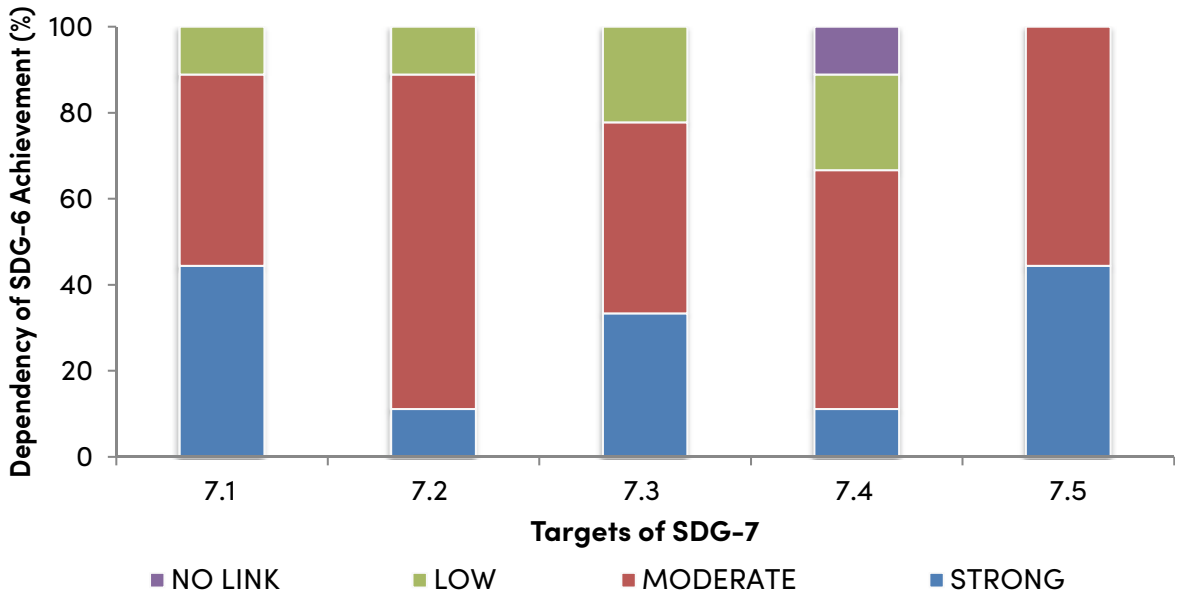


Figure 7: Level of dependency of SDG-6 achievement on targets of SDG-7

6) *Level of dependency of SDG-7 achievement on targets of SDG-2*

The survey results of the qualitative level of dependency of SDG-7 achievement on targets of SDG-2 shows that dependency of SDG-7 is mostly distributed in two categories (strong and moderate). Dependency of SDG-7 is stronger for targets 2.1, 2.2, 2.3, 2.4, 2.6 and 2.8 and poor for targets 2.5 (Maintain the genetic diversity of seeds) and 2.7 (Correct and prevent trade restrictions and distortions in world agricultural markets). Distribution of dependency is shown in fig. 8.

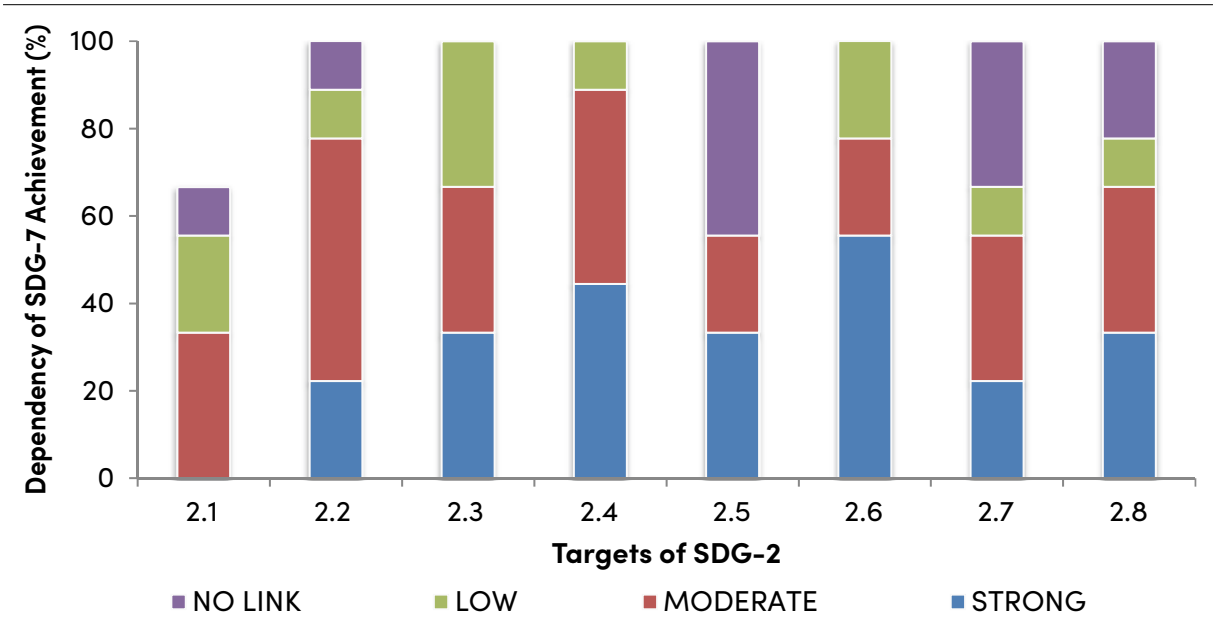


Figure 8: Level of dependency of SDG-7 achievement on targets of SDG-2

7) *Level of dependency of SDG-7 achievement on targets of SDG-6*

The survey results of the qualitative weight for the level of dependency of SDG-7 achievement of targets of SDG-6 reflect contribution in strong and moderate categories for almost all the targets (fig. 9). Dependency of SDG-7 is stronger for targets 6.1, 6.2, 6.3 and 6.4 and is poor for target 6.5 (Protect and restore water-related ecosystems).

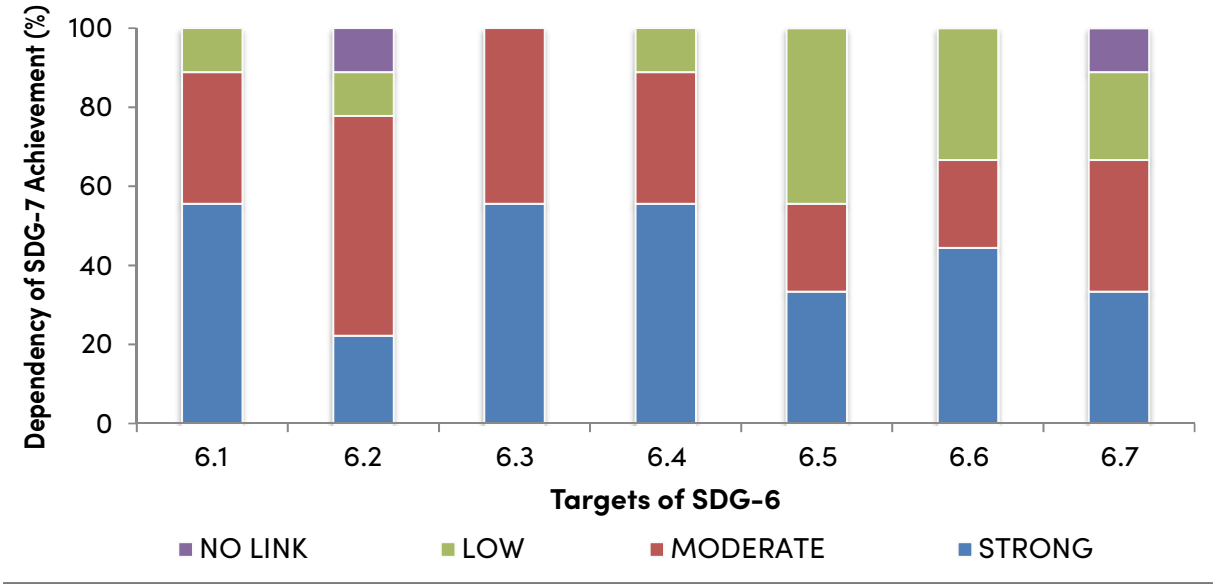


Figure 9: Level of dependency of SDG-7 achievement on targets of SDG-6

8) Based on experience with MDGs or other existing goals, the following key influences of SDG- 2, SDG-6 and SDG-7 for country planning are observed through the survey analysis. A high, strong contribution is observed in addressing interlinkages of water, energy and food security for balancing economic, social and environmental pillars in policymaking, followed by redefining relevant national policies (fig. 10).

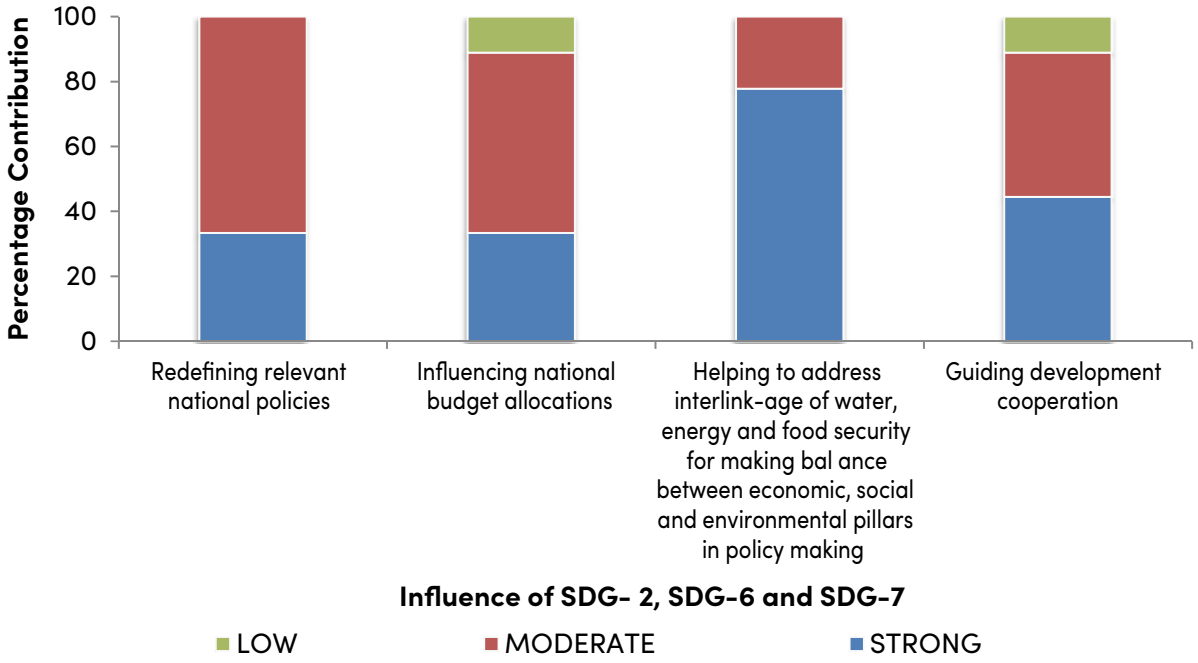


Figure 10: Key influences of SDG- 2, SDG-6 and SDG-7 for country planning

9) Based on expert views, the qualitative weighting for level of integration of water, energy, food nexus in country actions and policy was identified. It was found that there is definitely some sectoral integration which mostly falls in the moderate and low categories as shown in fig. 11. Moderate integration is observed in the following cases; i.e., energy development planning considers water as an essential input, energy use efficiency is considered important in water supply and wastewater management projects and water availability is recognized as important in agricultural crop production planning. Similarly, low integration is observed in two cases; i.e., energy project approval critically reviews impacts on water resources and energy use efficiency improvements are well addressed in irrigated agriculture practices.

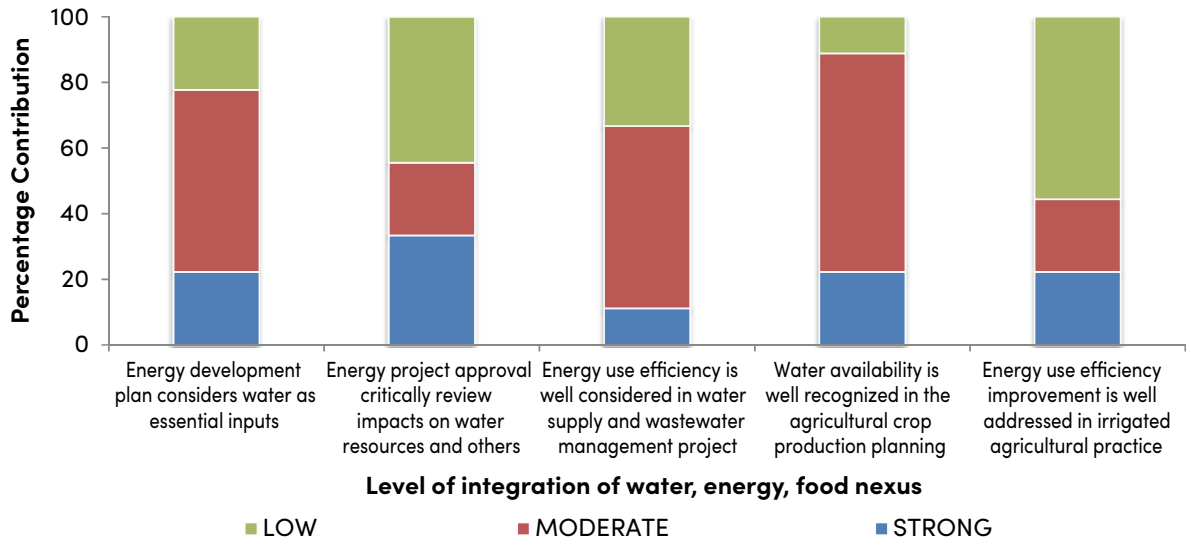


Figure 11: Qualitative weight for level of integration of water, energy, food nexus in country actions and policy

10) Opinions on the country's readiness level to implement SDG-2, SDG-6 and SDG-7 were sought via interviews, and the decisions of the majority of respondents are given in Table 12. In summary, the country is ready to implement globally adopted targets, since they are in line with national targets, and also ready to implement global targets, but there is a need to adjust national mid- to long-term policies for SDG-2, SDG-6 and SDG-7.

Table 12: Opinion on Country's readiness level to implement SDGs in India (opinion of majority of respondents)

	Food	Water	Energy
Country is ready to implement globally adopted target, since it is in line with national targets.	YES	YES	YES
Country is ready to implement global targets, but need to adjust national mid- and long-term policies.	YES	YES	YES
Country is not ready to achieve global target, but willing to achieve it if international supports are available.	NO	NO	NO
Country will not follow global target.	NO	NO	NO

11) Further, some questions were framed to understand the country's readiness level to integrate the nexus approach in the implementation plan of the three SDGs. It was observed that significant efforts are required to adopt a nexus approach at the country level and also some efforts are also required at the international level.

12) In order to achieve the target, some domestic efforts are required, which was checked through some questions in the questionnaire (fig. 12). To achieve this, there is a strong need for improvement

in institutional coordination, sectoral plans with cross-sector discussions and approval processes, coordination in financial allocation, awareness raising and capacity building of policy and decision makers.

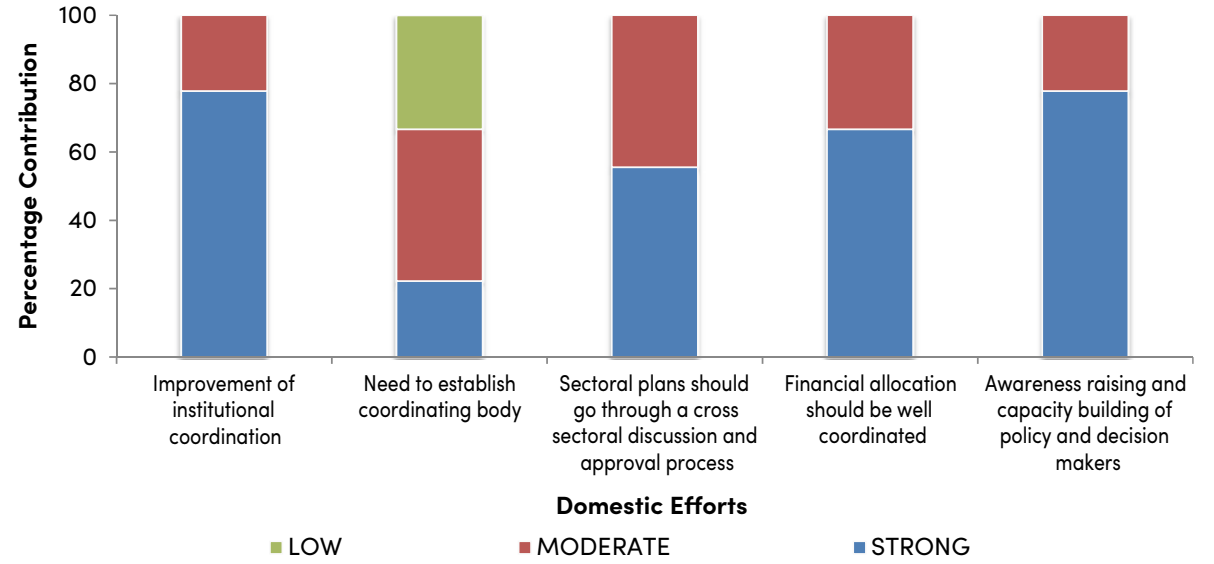


Figure 12: Response for various domestic efforts required for adopting nexus approach

Similarly, there is a moderate to strong requirement for international efforts by providing supports to countries to incorporate global targets in national plans and actions, knowledge development and sharing, facilitating technology transfer and addressing nexus aspects in international financial supports (fig. 13).

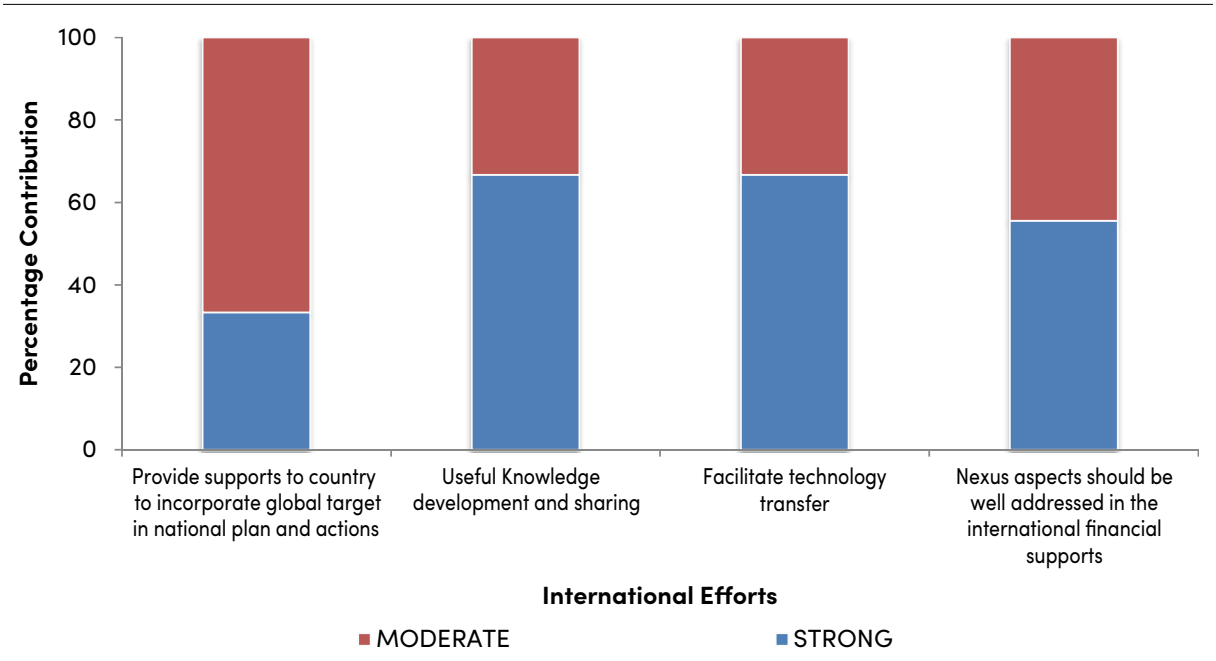


Figure 13: Response for various international efforts for adopting nexus approach

More than 75% of respondents mentioned that existing institutes can act as the coordinating body for SDG planning instead of opening new agencies, and that NITI Aayog has already been made the coordinating body for SDGs monitoring and related planning (NITI Aayog, 2016).

3.1.3.4 Regression Analysis

The linkages among targets have been examined through the network analysis associated with SDG 2, SDG 6 and SDG7. The synergy or trade-off relationship among SDG (2, 6 & 7) targets or indicators can provide useful insight to relational analysis. Linkages among SDG 2, 6 and 7 were analysed through pairwise correlation among the indicators measuring these targets. Pairwise correlation describes the direction of linkages between two variables. The interaction between target pairs of SDGs is split into three categories: synergy, trade-off and non-classified. For the Pearson correlation, a p value greater than 0.6 is considered to indicate a synergy (positive association) between two indicators, a p value less than −0.6 is considered to indicate a trade-off (negative association), and a p value between −0.6 and 0.6 is considered to indicate non-classified. The pairwise correlation coefficients with their statistical significance level are tabulated in Table 12. More of the indicators of SDGs 2 show a positive or strongly correlated p value (i.e., > 0.6), with the only exception of SDG-T 2.4, which has a negative correlation with SDGs T 2.1, T 2.3, T 6.1, T 6.6 and T 6, and comes under the trade-off category. Some other indicators (T 2.2, T 2.5, T 2.a, T 6.2 and all indicators of SDG 7) with SDG-T 2.4 come under the non-classified category because the p value of indicators lies between -0.6 to 0.6. For SDG 6, the indicator T 6.1 shows negative correlation with most of the other indicators. All the indicators of SDG 7 (T 7.1, T 7.2 and T 7.3) show a positive or strongly correlated p value (i.e., > 0.6) with other indicators and no negative correlation was observed in SDG 7, with other indicators as shown in Table 13.

Table 13: Pairwise Pearson Correlation among various targets (2000-2015)

	T2.1	T2.2	T2.3	T2.4	T2.5	T2.a	T6.1	T6.2	T6.3	T6.6	T6.a	T7.1	T7.2	T7.3
T2.1	1.000	.785**	.740**	-0.137	.879**	.698**	.787**	.790**	.974**	.944**	.713**	.730**	.730**	.719**
T2.2	.785**	1.000	.720**	0.094	.899**	.863**	-0.239	.996**	.958**	.936**	.856**	.940**	.940**	.713**
T2.3	.740**	.720**	1.000	-0.250	.799**	.606**	-0.342	.679**	-0.184	.736**	.662**	.636**	.636**	.594*
T2.4	-0.137	0.094	-0.250	1.000	0.125	0.223	-0.018	0.062	0.777	-0.149	-0.092	0.152	0.152	0.067
T2.5	.879**	.899**	.799**	0.125	1.000	.850**	-0.158	.889**	0.000	.922**	.783**	.826**	.826**	.569*
T2.a	.698**	.863**	.606**	0.223	.850**	1.000	-0.268	.864**	0.767	.830**	.740**	.869**	.869**	.642**
T6.1	.787**	-0.239	-0.342	-0.018	-0.158	-0.268	1.000	1.000**	-0.697	-0.313	-0.339	-0.272	-0.272	-.847**
T6.2	.790**	.996**	.679**	0.062	.889**	.864**	1.000**	1.000	.969**	.896**	.842**	.943**	.943**	.977**
T6.3	.974**	.958**	-0.184	0.777	0.000	0.767	-0.697	.969**	1.000	0.583	0.708	0.807	0.807	0.769
T6.6	.944**	.936**	.736**	-0.149	.922**	.830**	-0.313	.896**	0.583	1.000	.688*	.776**	.776**	0.524
T6.a	.713**	.856**	.662**	-0.092	.783**	.740**	-0.339	.842**	0.708	.688*	1.000	.750**	.750**	.710**
T7.1	.730**	.940**	.636**	0.152	.826**	.869**	-0.272	.943**	0.807	.776**	.750**	1.000	1.000**	.704**
T7.2	.730**	.940**	.636**	0.152	.826**	.869**	-0.272	.943**	0.807	.776**	.750**	1.000**	1.000	.704**
T7.3	.719**	.713**	.594*	0.067	.569*	.642**	-.847**	.977**	0.769	0.524	.710**	.704**	.704**	1.000

Note: *Statistical significance levels of correlation coefficients are presented with stars:*

p > 0.6 (Synergies in yellow); p < -0.6 (trade-off in red) and p of -0.6 to 0.6 (non-classified in blue).

***: Correlation is significant at the 0.01 level (2-tailed)*

**: Correlation is significant at the 0.05 level (2-tailed)*

3.1.3.5 Network Analysis

In this section, quantitative analyses of SDG linkages were evaluated, which indicates the interaction or dependency of SDGs on the basis of the weighted average among the various targets for comparative purposes. Responses of the questionnaire analysis were quantified by changing the response in terms of number. The following quantification was used for various responses to prepare network maps. The value assigned to the Strong option is 3, for the Moderate option, 2, for the Low option, 1, and for No Link, it is 0. Then, the weighted average is taken to link each SDG with targets of the remaining two SDGs.

Dependency of SDG 2 on targets of SDG 6 and 7

Figure 14 shows the dependency of SDG 2 on targets of SDG 6 and SDG 7. This dependency or interaction depends upon the weightage factor. According to the questionnaire results, it was found that the three targets (T6.1, T6.3 and T6.4) are strongly correlated with SDG 2 because of the high weighting of 2.63. Similarly, target T6.6 is likely linked with SDG 2 because of the low weighting of 2.32.

Similarly, target T7.1 of SDG 7 was strongly correlated with SDG 2 with a high weighting, 2.42, whereas target T7.4 and T7.5 were likely linked with SDG 2 because of the low weighting, 2.16.

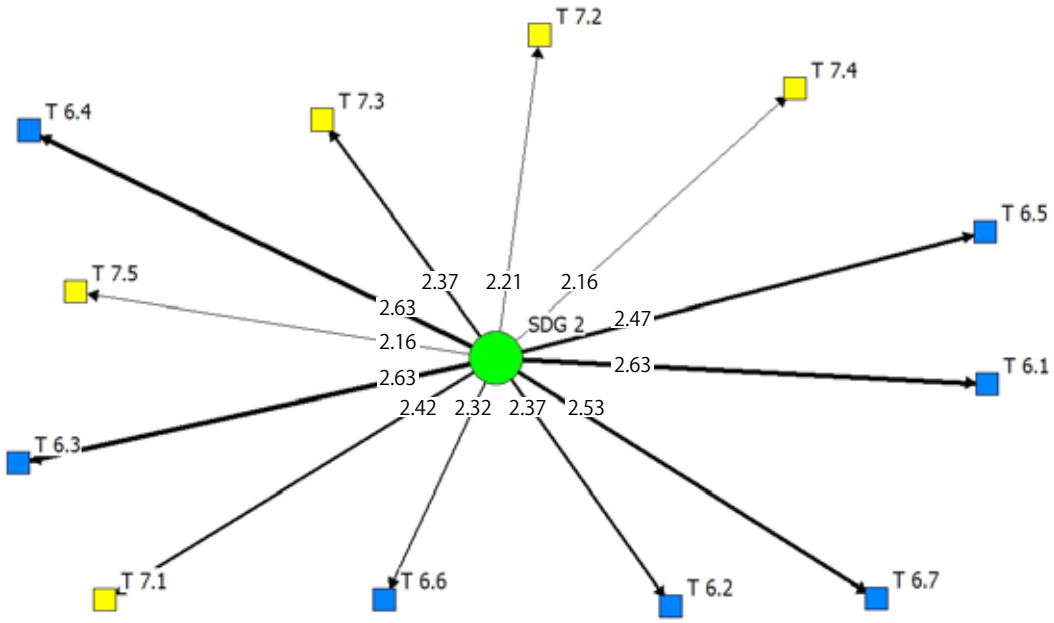


Figure 14: Dependency of SDG 2 on targets of SDG 6 and 7

Dependency of SDG 6 on targets of SDG 2 and 7

Figure 15 shows the dependency of SDG 6 on targets of SDG 2 and SDG 7. For SDG 2, a strong correlation was observed with target T2.1 and T2.4 because of the highest weightings of 2.37 and 2.32 respectively, whereas the targets T2.5 and T2.8 show they are likely linked with SDG 6 because of the low weightings of 1.42 and 1.47 respectively.

Similarly, target T7.1 of SDG 7 strongly correlated with SDG 2 because of the high weighting, 2.26, whereas target T7.4 is likely linked with SDG 6 due to the low weighting of 1.79.

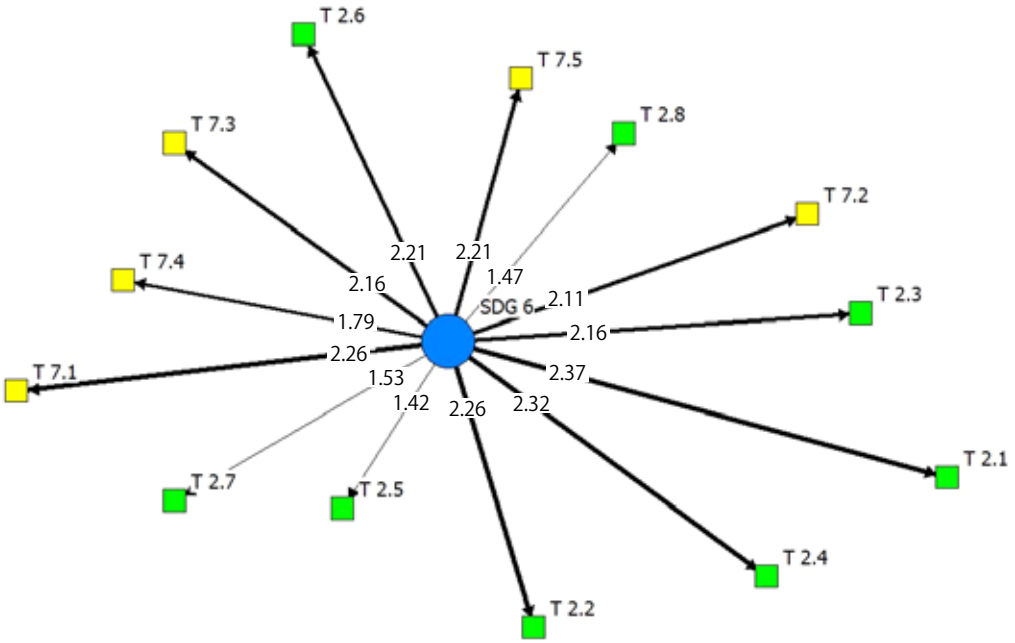


Figure 15: Dependency of SDG 6 on targets of SDG 2 and 7

Dependency of SDG 7 on targets of SDG 2 and 6

The dependency of SDG 7 on targets of SDG 2 and 6 is shown in fig. 16, in which target T2.4 strongly correlated with SDG 7 because of the high weighting of 2.26, whereas target T2.5 shows a low weighting in relation with SDG 2, 1.47. Similarly, for SDG 6, targets T6.3 and T6.4 show strong correlation with SDG 7 because of the high weightings of 2.42 and 2.32 respectively, whereas target T6.1 shows low correlation with SDG 6.

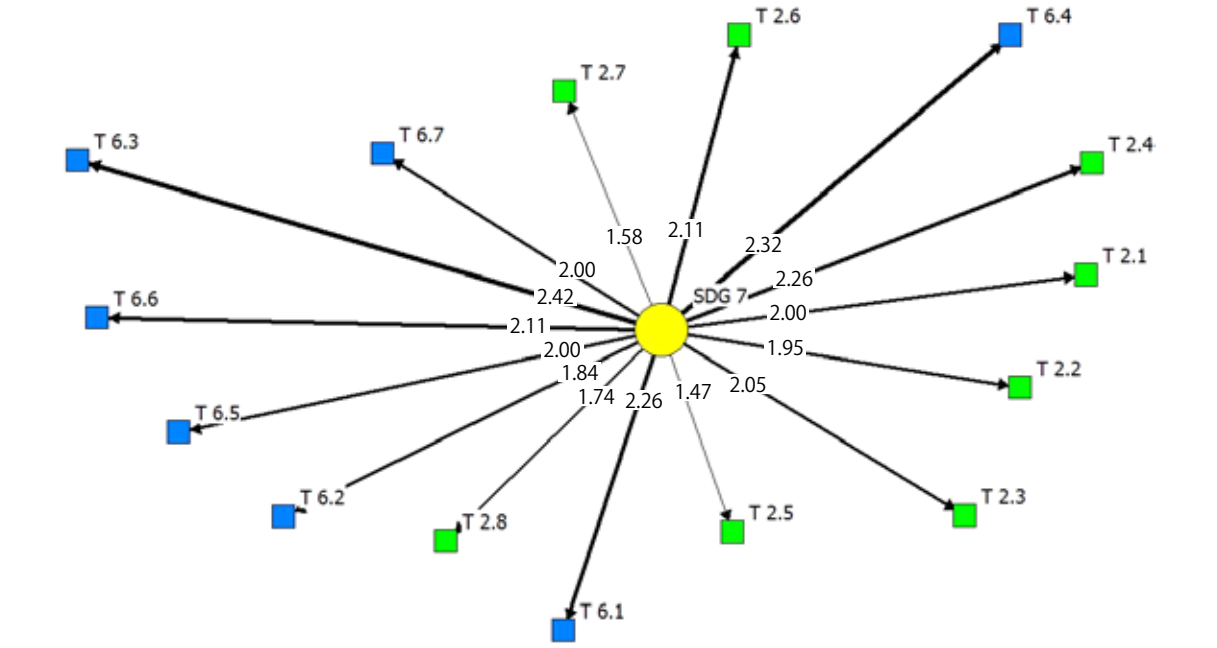


Figure 16: Dependency of SDG 7 on targets of SDG 2 and SDG 6

3.1.3.5 Prioritization of interlinkages for actions

After the group discussion, targets of each SDG were prioritized based on certain criteria. Table 14 presents the prioritized targets of each SDG with their possible justification. Some other linkages were also revealed among the targets of each SDG, awareness of which is important in order to properly implement the plans and actions necessary to achieve the targets and goals.

Table 14: List of prioritized targets with their justification (from group discussion)

Target	Target Description	Remark
SDG-2		
T-2.4	By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production.	If production is not ensured what should we make available to eat? Identify food crops which are adapted to the local climatic conditions and can also grow in case of limited water or other resources. Conserve the environment & natural resources.
T-2.1	By 2030, end hunger and ensure universal access to nutritious and sufficient food.	Food is essential for ensuring labour productivity.

Target	Target Description	Remark
T-2.2	By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age.	For ensuring a healthy population and future generations.
SDG-6		
T-6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all.	Consider main priority to provide equitable access to safe and affordable water for society's well-being and good health.
T-6.2	By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.	For ensuring healthy population and future generations and reducing vulnerabilities of society.
T-6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.	Improved water quality is a concern as it will help in protection of freshwater resources and use of treated wastewater.
SDG-7		
T-7.2	Increase substantially the share of renewable energy in the global energy mix by 2030.	To improve the status of other targets, it is important to have more sources of renewable energy.
T-7.1	By 2030, ensure universal access to affordable, reliable, and modern energy services.	For ensuring overall development of society.
T-7.3	Double the global rate of improvement in energy efficiency by 2030.	Ensure proper use and saving of energy with reduced wastage.

After identification of the prioritized items, a correlation matrix was prepared to classify the interlinked targets into different classes, i.e., high, moderate and low priority (as shown in Table 15). Interlinked targets with high priority are more important as there is high synergy which can help in achieving goals more quickly and also help in judicious use of financial and natural resources. High priority interlinked targets are shown in red (highly correlated targets), whereas grey boxes represent poorly correlated targets.

Table 15: Pairwise Pearson Correlation among prioritized targets (2000–2015)

	T 2.4	T 2.1	T 2.2	T 6.1	T 6.2	T 6.3	T 7.2	T 7.1	T 7.3
T 2.4				-0.081	0.062	0.77	0.15	0.15	0.07
T 2.1				0.79	0.79	0.97	0.73	0.73	0.71
T 2.2				-0.23	0.99	0.96	0.94	0.94	0.71
T 6.1							-0.27	-0.27	-0.84
T 6.2							0.94	0.94	0.97
T 6.3							0.80	0.80	0.76
T 7.2									
T 7.1									
T 7.3									

High priority (>0.9) Moderate priority (0.6-0.8) Low priority <0.6)

Target T 2.1 is strongly correlated with other SDG targets like T 6.2, T 6.3, T 7.2, T 7.1. Similarly, target T 6.2 is strongly correlated with all three energy targets. This means there is a need to focus on red box interlinked targets to accelerate the cumulative impact on WEF security of the country.

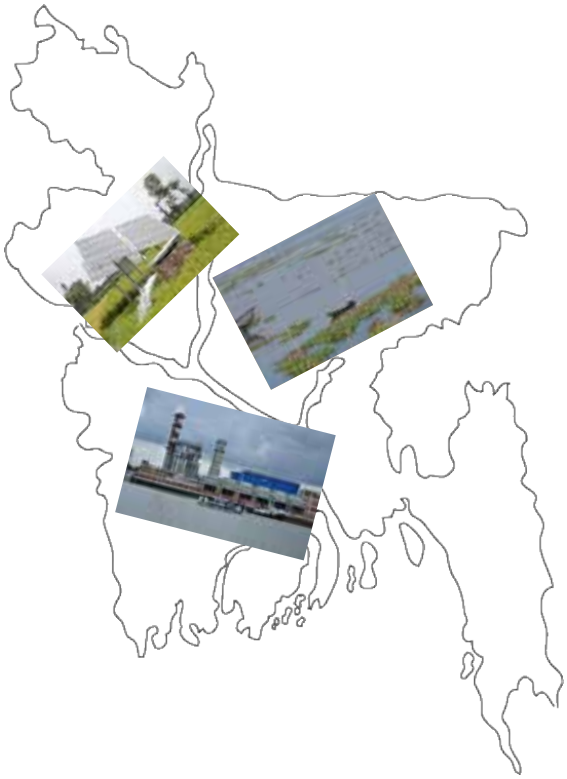
3.1.4 Conclusions

In this study, the interlinkages and dependencies among the SDG-2, SDG-6 and SDG-7) targets were evaluated through qualitative and quantitative approaches. Strong linkages among the various targets have been found through network analysis. This study analysed sustainability in terms of synergy and trade-off among the SDGs (2, 6 and 7) for the period 2000 to 2015 over India using the Pearson correlation coefficient. The *p* value for synergy and trade-off corresponds to positive and negative correlations. The aim of this correlation is to provide a systematic overview on the SDGs target interactions. The results of the quantitative analyses indicate the linkages or dependency of SDGs among the various targets. SDG 2 addresses food insecurity, malnutrition and promoting sustainable agriculture to achieve zero hunger and sustainable development. Food production is strongly dependent on quality and availability of water because the growth of agricultural production can increase water withdrawals and water degradation, hence SDG 2 highly correlated with the targets of SDG-6. Energy and modern energy also play a significant role in sustainable agriculture development and food security, as agricultural food production and consumption are strongly dependent on energy services because agriculture biomass and agricultural waste are potential sources of renewable energy. Therefore, some targets of SDG-7 (T 7.1 and T 7.3) highly correlated with SDG-2. SDG-6 focuses on the availability and sustainable management of water and sanitation for all. Under SDG 2, the increase in agriculture productivity (T 2.3) and sustainable food production practices (T2.4) can help to meet water efficiency in agriculture (T6.4), and vice-versa. Furthermore, clean water and sanitation are also required for achieving the nutrition targets. Similarly, water is also essential for most forms of energy; thermal cooling and resource extraction require substantial amounts of water, hence SDG 6 highly correlated with the targets of SDG-2 (T 2.1) and SDG-7 (T 7.1), whereas SDG-7 aims at ensuring access to affordable, reliable, sustainable, and modern energy for all. The agriculture sector can play an

important role in meeting the energy goal, especially through biofuels, and an expansion in use of biofuels or hydropower could increase the pressure on the water resources sector. The conventional forms of power generation have substantial water requirements, therefore SDG-7 strongly correlated with the targets of SDG-2 (T 2.4) and SDG-6 (T 6.1, T 6.3 and T 6.4).

Besides interlinking SDGs and targets of other SDGs, this study also highlighted the key interlinked targets which have high relevance for planning and investment purposes in order to comprehend the cumulative impact on multiple SDGs together.

3.2 Case study of Bangladesh



3.2.1 Introduction

The Water-Energy-Food Nexus has emerged as a useful concept to comprehend the complex and interrelated nature of our global resource systems that is indispensable to achieving the various social, economic and environmental goals (FAO 2014). The nexus approach expounds the interdependencies of water, energy, and food production and aims to systemize the interconnections to erect a framework for assessing the use of all resources and to manage trade-offs and synergies (Hellegers et al., 2008; Bazilian et al., 2011; Scott et al., 2011; Hermann et al., 2012; Hussey and Pittock, 2012; Sharma and Bazaz, 2012). This holistic approach will not only provide a significant contribution towards attaining national and regional sustainable development targets, but will also be effective for espousing equity amongst individuals and communities in local and global development agendas (Biggs et al., 2015).

Bangladesh has established a new development paradigm through outstanding progress in MDG achievement. Its remarkable achievement of consistent average economic growth rate has led to an ambition of being a middle income country by 2021. Its thriving development has embraced the Sustainable Development Goals as a priority issue and the country has strived to achieve greater success than the MDGs. The water-energy-food nexus perspective can be useful as a policy and management instrument in dealing with the challenges to implementation of the SDGs.

Implementation of Water-Energy-Food (WEF) nexus is critical to overcome natural resource complexity for achieving the ambition of championing SDGs in the contest of Bangladesh. Bangladesh contains total land area of 150,000 km^2 with its massive population over 150 million leading to 10^{th} position among the most densely populated countries. Despite rapid economic growth in recent years, livelihood of more than 70% of total population involved in agricultural activities is threatened by declining arable land issue that accounts falling from 0.11 to 0.05 hectares between 1980 to 2010 (Kumar et al., 2012; Gain et al., 2015). Moreover, depletion of groundwater jeopardizes food production for groundwater's contribution in irrigation is 79% (FAO, 2012). Despite being self-sufficient in food grain production, 40% of the population is undernourished and 20% is severely malnourished (FTF, 2011).

Bangladesh is located at the downstream of Ganges-Brahmaputra-Meghna river system comprising about 405 rivers of which 57 are trans-boundary. While total amount of annual renewable freshwater resources is 1,210,644 million m^3, 91.3% (1,105,644 million m^3) comes from trans-boundary Rivers of upstream China, India, Nepal and Bhutan making supply of water resources of the deltaic country highly dependent of upstream government strategies (Gain et al., 2015). Key issues like arsenic pollution, saline intrusion and chemical toxication remain threats to safeguarding of potable water. Bangladesh has already exceeded water scarcity threshold defined by Falkenmark, Lundqvist and Widstrand (1989) and likely to approach absolute water scarcity threshold by 2025 and would fall far below that threshold by 2025 (Gain et al., 2015).

Facilitating power supply to burgeoning population with accelerating economical progress has always been a key challenge to Bangladesh. Besides only 62% population has access to electricity, the per capita electricity consumption is 170 kWh in Bangladesh (Bala, Alam, & Debnath, 2014) against 321 kWh per capita electricity generations depicting poor scenario of power sector (Lipu & Bhuiyan, 2014). Electricity demand has increased significantly illustrated as in 2011 demand was 6765 MW against generation capacity of 4890 MW leading to severe load shedding up to 1335 MW ((Islam et al. 2014). Power generation process has to encounter challenges of provisioning great quantity of cooling and air emission

control water, providing fuel against its accelerating cost and facilitating large amount of land for setting up plants.

The project 'Water energy food-nexus perspective: Path making for Sustainable Development Goals (SDGs) to country actions in Asia' intends to explore synergies and trade-offs among food-water-energy targets of the UN Sustainable Development Goals and thus guide countries to integrate the nexus approach into national planning, thus facilitating efficient management of resources and achievement of the SDGs. In this regard, reviews of plans, policies and strategies of Bangladesh to evaluate gaps and provisions within national sectoral planning documentations to incorporate the WEF nexus has been a key activity of the project. Stakeholder perception of concerned sectors collected through questionnaires has assisted in analyzing expert views on facilitating the nexus approach in the SDG planning process. This report aims to describe the current national context of Bangladesh regarding the WEF nexus with the intention of integrating the nexus concept into the country's policy and action plans.

3.2.2 Methodology

i. Readiness of countries to implement SDGs

The readiness of countries to implement SDGs has been assessed by reviewing the relevant policies, plans, programs and strategies of the Government of Bangladesh and stakeholder consultation. A total of 45 policies, plans, programs and strategies (Table 16) have been critically reviewed in the context of exploring the readiness of the country to implement SDGs as far as water-energy-food nexus is concerned. In addition to reviewing the policies, stakeholder consultation and questionnaire survey were conducted to explore the readiness of the country to implement SDGs. The stakeholder questionnaire survey respondent comprised key professionals from water, energy and food sector as well as professionals from planning agencies and international organizations working in Bangladesh. Part 2 of the questionnaire survey (Annex 1) is used to assess the readiness of the country to implement SDGs.

Table 16: Water-Food-Energy related policies, plans, strategies and programs

Sl. No.	Name of the Policy, Plans, Strategies and Programs	Organization	Year
1	Bangladesh Delta Plan 2100	General Economics Division (GED), Bangladesh Planning Commission, Ministry of Planning	October, 2018
2	Bangladesh Climate Change Strategy and Action Plan	Ministry of Environment and Forest	September, 2009
3	Bangladesh Country Water Resources Assistance Strategy	World Bank	2005
4	Coastal Development Strategy	Water Resources Planning Organization, Ministry of Water Resources	February, 2006

Sl. No.	Name of the Policy, Plans, Strategies and Programs	Organization	Year
5	Flood Response Preparedness Plan of Bangladesh	Department of Disaster Management Ministry of Disaster Management and Relief	June, 2014
6	Master Plan of Haor Area	Bangladesh Haor and Wetland Development Board, Ministry of Water Resources	April, 2012
7	National Plan for Disaster Management 2010-2015	Disaster Management Bureau, Disaster Management & Relief Division	April, 2010
8	National Action Programme (NAP) for Combating Desertification	Department of Environment, Ministry of Environment and Forest	August, 2005
9	National Adaptation Programme of Action (NAPA)	Ministry of Environment and Forest	November, 2005
10	National Strategy for Water Supply and Sanitation 2014	Local Government Division, Ministry of Local Government, Rural Development and Cooperatives	December, 2014
11	National Biodiversity Strategy and Action Plan for Bangladesh	Ministry of Environment and Forest	August, 2004
12	National Water Management Plan Development Strategy	Water Resources Planning Organization, Ministry of Water Resources	2001
13	National Water Management Plan	Water Resources Planning Organization, Ministry of Water Resources	2004
14	Rio + 20: National Report on Sustainable Development	Ministry of Environment and Forests	May, 2012
15	Standing Orders On Disaster	Disaster Management Bureau, Ministry of Food and Disaster Management	April, 2010
16	Coastal Zone Policy	Ministry of Water Resources	2005
17	Cyclone Shelter Construction, Maintenance and Management Policy 2011	Ministry of Disaster Management and Relief	February, 2012
19	Government Jalmahal Management Policy	Ministry of Land	2009
20	National Agriculture Policy	Ministry of Agriculture	April, 1999
21	National Agricultural Extension Policy	Ministry of Agriculture	2012
22	National Fisheries Policy	Ministry of Fisheries and Livestock	1998

Sl. No.	Name of the Policy, Plans, Strategies and Programs	Organization	Year
23	National Forestry Policy	Ministry of Environment and Forests	1994
24	National Land Use Policy	Ministry of Land	2001
25	National Policy for Safe Water Supply & Sanitation	Local Government Division, Ministry of Local Government, Rural Development and Cooperatives	1998
26	National Water Policy	Ministry of Water Resources	1999
27	National Food Policy Plan of Action (2008-2015)	Food Planning and Monitoring Unit (FPMU), Ministry of Food and Disaster Management	August, 2008
28	National Food Policy Plan of Action and Country Investment Plan	Food Planning and Monitoring Unit (FPMU) Ministry of Food	June, 2015
29	Master Plan for Agricultural Development in the Southern Region of Bangladesh	Ministry of Agriculture	March, 2013
30	Bangladesh Country Investment Plan	Government of the People's Republic of Bangladesh	June, 2011
31	Perspective Plan of Bangladesh 2010-2021	General Economics Division, Planning Commission, Ministry of Planning	April, 2012
32	Coastal Development Strategy	Water Resources Planning Organization, Ministry of Water Resources	February, 2006
33	National Environment Management Action Plan (NEMAP)	Ministry of Environment and Forests	1995
34	National Food Policy	Ministry of Food and Disaster Management	August, 2006
35	Bangladesh National Nutrition Policy	Ministry of Health and Family Welfare	2015
36	Bangladesh National Plan of Action for Nutrition	Ministry of Health and Family Welfare	1997
37	New Agricultural Extension Policy (NAEP)	Ministry of Agriculture	1996
38	Power System Master Plan	Power Division, Ministry of Power, Energy and Mineral Resources	September, 2016
39	Energy Efficiency and Conservation Master Plan up to 2030	Power Division, Ministry of Power, Energy and Mineral Resources	March, 2015

Sl. No.	Name of the Policy, Plans, Strategies and Programs	Organization	Year
40	Seventh Five Year Plan FY2016 – FY2020	General Economics Division (GED), Bangladesh Planning Commission, Ministry of Planning	November, 2015
41	Perspective Plan of Bangladesh 2010-2021	General Economics Division (GED), Bangladesh Planning Commission, Ministry of Planning	April, 2012
42	Renewable Energy Policy of Bangladesh	Power Division, Ministry of Power, Energy and Mineral Resources	December, 2008
43	National Energy Policy	Ministry of Power, Energy and Mineral Resources	November, 2005
44	Integrated Small Scale Irrigation Policy	Ministry of Agriculture	December, 2014
45	National Agriculrure Policy	Ministry of Agriculture	2013

ii. 2.2 Quantitative assessment of relationships among proposed targets for SDGs, particularly focusing on three major dimensions: Food (G2), Water (G6) and Energy (G7)

1. Stakeholder survey

Stakeholder's perception on water-energy-food nexus perspective was evaluated by analyzing questionnaire responding of key personnel from concerned sectors. The purpose of the questionnaire survey was to see stakeholder's level of understanding of Food (SDG-2), Water (SDG-6) and Energy (SDG-7) and to evaluate country readiness to incorporate nexus aspects in the action plans towards SDGs. A total of 43 people responded to the questionnaire comprising of 18 respondents from agriculture sector, 13 from water sector, 4 from energy sector and others are from government planning and statistical agencies and international research organizations. All of the questionnaire responding were collected by personal interview prosecuted by interactive discussion. The sample of the questionnaire survey is given in Annex 1.

2. Network analysis

Network analysis can inform institutional and interagency guidelines for developing practical ways to ensure effective flow of information and resources (Maldonado, 2017). Network analysis has been carried out using Social Network Analysis Software by developed by Borgatti et al. (2002). In the current study, network analysis has been conducted to assess (i) the perception of stakeholders on the importance of nexus aspects for the country cctions on SDG-2 (Food), SDG-6 (Water) and SDG-7 (Energy), (ii) the expert view on kind of efforts necessary to adopt WEF nexus approach in the process of SDG implementation, and (iii) dependency of targets of SDG-2, 6 & 7 on each other.

3. Regression analysis

Quantitative interdependencies among SDG-2: zero hunger, SDG-6: clean water & sanitation & SDG-7: affordable & renewable energy have been done using SDG indicators datasets. The data for regression analysis has been extracted from various sources (Table 17). Pearson Correlation Coefficient has been determined by dividing the covariance of two variables by the product of their standard deviations and Significance Level has been determined by comparing p-value calculating through regression analysis. Statistical Significance Levels of Pearson Correlation Coefficients has been attributed as: not significant when $p > 0.05$; * for $p < 0.05$; ** for $p < 0.01$ and *** for $p < 0.001$ i.e. highly significant.

Interaction among different actors leading to an impact greater or less than the sum of individual effects is called synergy (if the result is positive) or trade-off (if the result is negative) (Mainali et al., 2018). Advanced Sustainability Analysis (ASA) developed by European Framework Programmes can provide synergy and trade-off of SDGs specifying potential causality between SDG targets. The Advanced Sustainability Analysis (ASA) is a mathematical information system that can analyze indicator data for the different point of view decomposing factors affecting changes that offers decision makers a tool for policy development for dimensions of sustainable development (Luukkanen, 2004).

In this study, synergy or trade-off is measured by primarily normalizing indicator datasets for SDG-2, SDG-6 and SDG-7 to the base or previous year and then calculating relative changes between two normalized indicator data by their ratio. If the resultant of the ratio is greater than 1, then the quotient has been inverted to keep the index between -1 to +1. Synergy and trade-off analysis have been done for relative changes of corresponding indicator data for each year difference. Primarily indicator datasets of SDG-2, SDG-6, and SDG-7 have been normalized to the base or previous year and then determining relative changes between two normalized indicator data by their ratio. If the resultant has been found greater than 1, then the quotient was inverted to keep the index between -1 to +1.

Table 17: Sources of data for regression analysis

Sl. No.	SDG Goal no.	Sources of data (accessed on 3 February 2018)
1	SDG 2	https://data.worldbank.org/indicator/SN.ITK.DEFC.ZS?view=chart https://unstats.un.org/sdgs/indicators/database/ https://data.worldbank.org/indicator/AG.LND.AGRI.K2 https://data.worldbank.org/indicator/AG.LND.IRIG.AG.ZS http://www.fao.org/faostat/en/#country/100 https://unstats.un.org/sdgs/indicators/database/
2	SDG 6	https://data.worldbank.org/indicator/AG.LND.IRIG.AG.ZS http://www.fao.org/faostat/en/#country/100 https://unstats.un.org/sdgs/indicators/database/
3	SDG 7	https://unstats.un.org/sdgs/indicators/database/ https://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC?view=chart https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?view=chart https://data.worldbank.org/indicator/EG.FEC.RNEW.ZS?view=chart

iii. 2.3 Prioritization of interlinkages for actions

The prioritization of the interlinkages among food, water and energy has been assessed through stakeholder consultation. A stakeholder workshop was organized involving professionals from water, food, energy and planning sectors. The participants were grouped into two groups, one for the water sector and one the food and agriculture sector, which then discussed how to prioritize the goals and allot related points. This enabled them to prioritize the different targets of SDG-2, SDG-6 and SDG-7.

3. 2.3 Results and discussions

3.2.3.1. Readiness of countries to implement SDGs

i. Institutional

It was found in the study that a group of twelve members in the Prime Minister's office chaired by the Principal Secretary is responsible for SDG monitoring, followed by the Ministry of Planning as the coordinating body, with Bangladesh Bureau of Statistics (BBS) being responsible for SDG-related field data management. Bangladesh's government has emphasized existing policies, strategies and regulations as being instrumental for implementation of the SDG targets. It was found in a study by the Center for Policy Dialogue (CPD) that around 80% of SDG targets reflect national priorities, and that SDG-2, SDG-6 and SDG-7 have been integrated well into the existing national prioritization process. During the formulation of the 7th Five Year Plan (7FYP), SDGs were emphasized in setting up priority areas of resulting goals 2, 6 & 7 aligning around 82% of the 7FYP.

ii. Policy

The obligation of plans and policies of the Government of Bangladesh to address the dynamic synergies between the sustainable development goals to implement the SDGs is quoted in the preamble of Data Gap Analysis of Sustainable Development Goals (SDGs) (GED, 2017). The National Sustainable Development Strategy (GED, 2013) of Bangladesh identifies Agriculture, Industry, Energy, Transport and Human Resource Development as five priority development sectors. The five year plan for the period 2016–2020 is found to thematically fully aligned with food, water and energy issues of the SDGs (MoP, 2016), although it fails to adequately express concern over their nexus approach. The Perspective Plan of Bangladesh (2010–2021) (GED, 2012), however, draws weak attention to electricity management for agriculture, while strongly emphasizes the integration of water resources management for achieving self-sufficiency in food production. The perspective plan presents a skeptical view on the attainment of hydropower contribution to the national grid for its dependency on co-operation from neighboring countries. Except for planning to economize natural gas consumption to power production by utilizing the released gas as fertilizer, there is scant indication of synergy between power and agriculture in the plan.

The National Water Policy (NWPo) (MoWR, 1999) adequately acknowledges the synergy between water and agriculture by focusing on irrigation water use efficiency through water recycling, crop diversification, conjunctive water use and rotational irrigation, along with ensuring safeguarding against environmental pollution. The NWPo emphasizes sustaining ecosystem balance for development of hydropower systems. The National Energy Policy (MoPEMR, 2004) underlines environmentally sound energy development programmes incorporating renewable energy to enable rural development. However, apart from hydro-

power, any detailed mention of linkage between energy with water and food is absent in the document. The National Food Policy (MoFDM, 2006) envisions establishing dependable and sustained food security by recognizing the interconnection between food and water while does not point to synergy between energy and food. The National Agriculture Policy (NAP) (MoA, 1999) encompasses the development of food security through increasing production of all crops, underlining the SDG agenda of ending hunger. However, the NAP emphasizes achieving irrigation water management efficiency in light of the National Water Policy and Water Resources Development Plan, with little enlightenment on power supply issues. Proper integration of the WEF nexus perspective into the country's policy and action plans is key to the success of sustainable development.

Table 18: Policy Coherence with WEF nexus for Bangladesh

Plan & Policy	Water & Food	Water & Energy	Food & Energy	Water-Energy-Food
7th 5 Year Plan	High	Very Low	Very Low	Very Low
Perspective Plan	Moderate	Low	Very Low	Very Low
National Water Policy	High	Low	Very Low	Very Low
National Food Policy	High	Very Low	Very Low	Very Low
National Energy Policy	Very Low	Low	Low	Very Low
National Agriculture Policy	High	Very Low	Very Low	Very Low

3.2.3.2. Stakeholder Perception

Based on the experience with MDGs or other existing goals, from the food and agriculture sector, as shown in fig. 17, 56% strongly argued that redefining relevant national policies is the key to country planning whereas 31% only moderately claim this action will play a role. In the water sector, as shown in fig. 18, 46% of the stakeholders strongly, and another 46% moderately think that redefining relevant national policies is key to country planning. In the energy sector shown in fig. 19, 75% of stakeholders strongly recommend redefining relevant national policies, and 25% moderately agree with this action. In the planning agencies, as shown in fig. 20, 50% strongly agree with this action, while others equally agree slightlyor moderately.

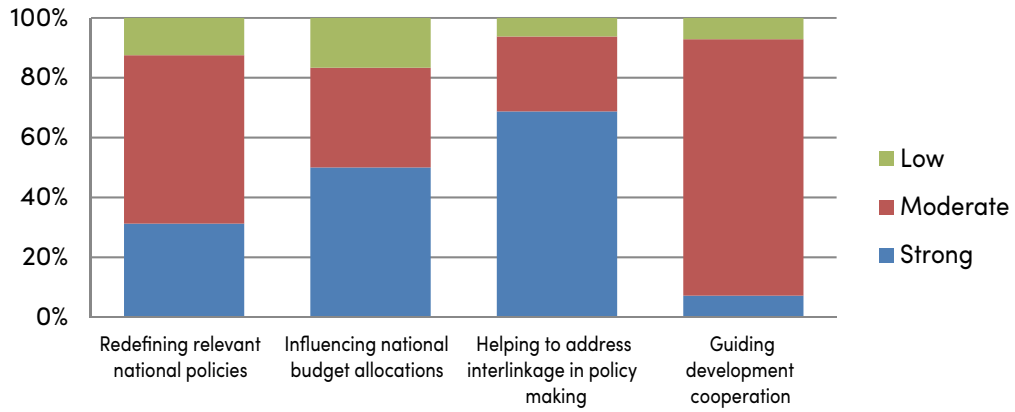


Figure 17: Key influences of SDG- 2, SDG-6 and SDG-7 for country planning according to food and agricultural sector

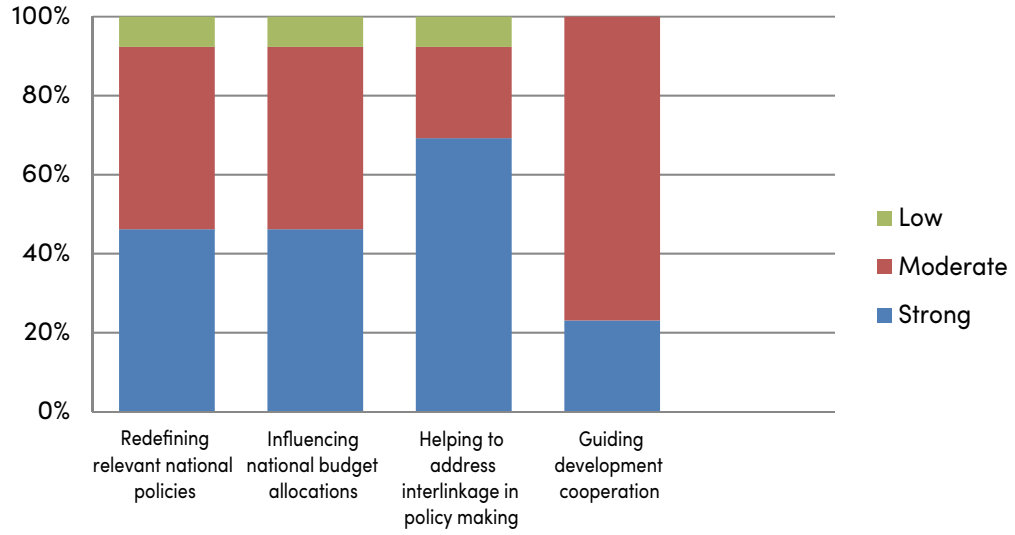


Figure 18: Key influences of SDG- 2, SDG-6 and SDG-7 for country planning according to water sector

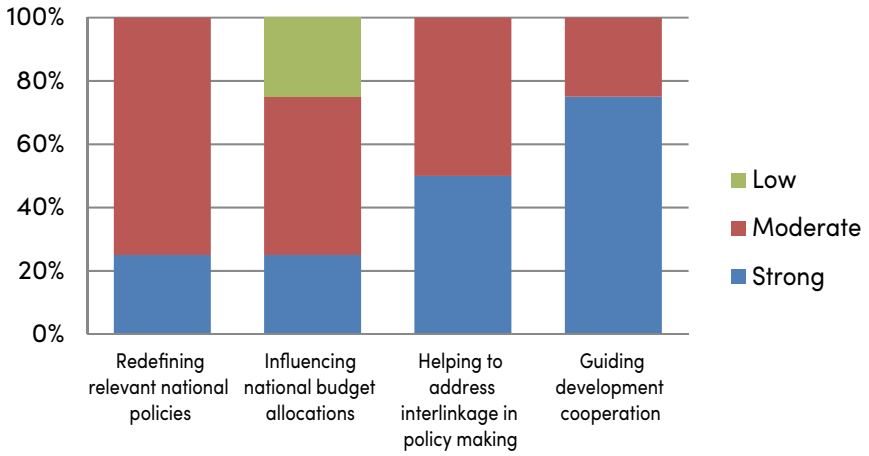


Figure 19: Key influences of SDG- 2, SDG-6 and SDG-7 for country planning according to energy sector

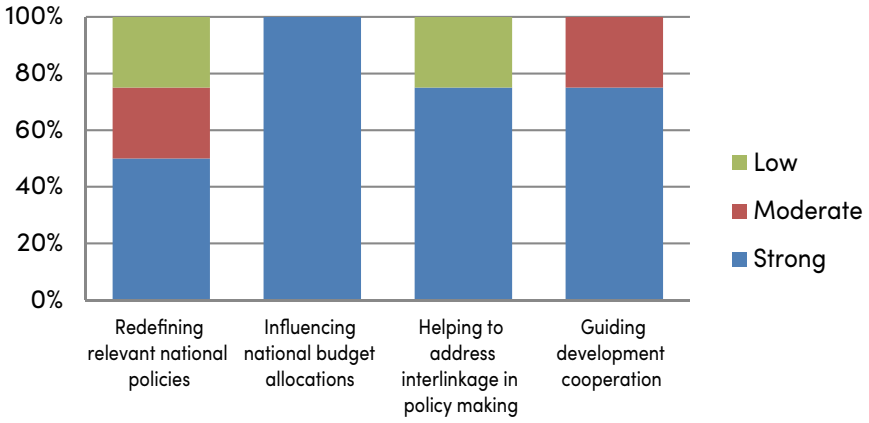


Figure 20: Key influences of SDG- 2, SDG-6 and SDG-7 for country planning according to planning sector

In the food and agriculture sector, 50% strongly agree that influencing national budget allocations is the key to country planning, whereas 33% moderately agree it will play a role. In the water sector, 46% of stakeholders strongly agree and another 46% moderately agree on the same issue, and only 8% slightly agree; in the energy sector, 50% of stakeholders strongly agree and others moderately or slightly agree with this assertion. All stakeholders in the planning sector strongly believe that influencing national budget allocations is key to country planning.

In the food and agriculture sector, 69% strongly agree that helping to address interlinkages of water, energy and food security to balance economic, social and environmental pillars in policymaking is the key to country planning, whereas 25% moderately agree. Similarly, in the water sector, 69% of the stakeholders strongly agree and 23% moderately agree on this issue. In the energy sector, half of the stakeholders strongly agree and half agree moderately, and in the planning sector, 75% strongly agree, and the remaining quarter agree moderately.

In the food and agriculture sector, 86% strongly agree that guiding development cooperation is the key to country planning. For the water sector, the figures were 77% strongly agreeing and 23% moderately agreeing. In the energy and planning sectors, 75% strongly agree and others moderately agree on this assertion.

Stakeholder's perception results on level of integration of water, energy, food nexus in country actions and policy are shown in fig 21, fig 22, fig 23 and fig 24.

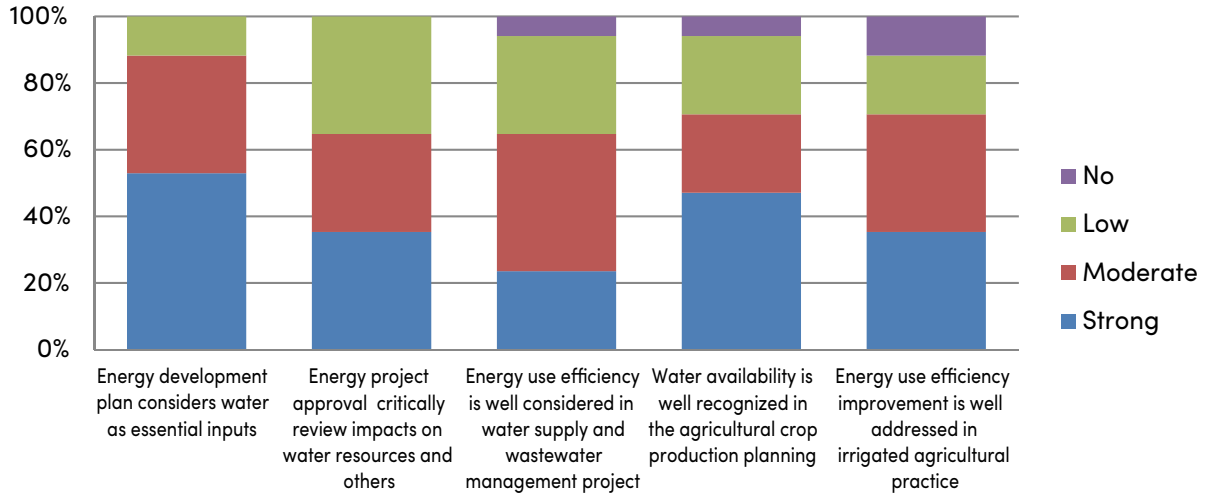


Figure 21: Level of integration of water, energy, food nexus in your country actions and policy according to food and agricultural sector

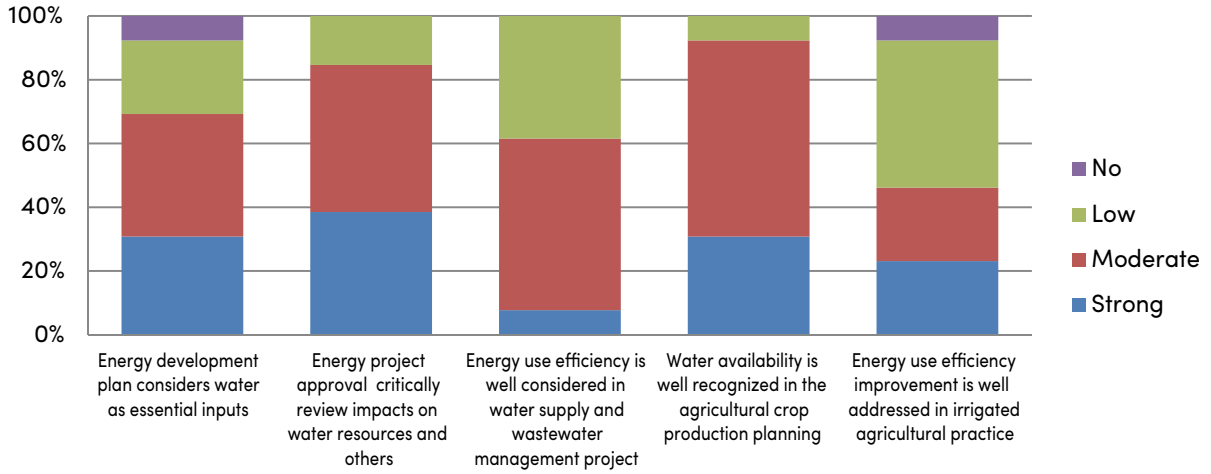


Figure 22: Level of integration of water, energy, food nexus in your country actions and policy according to water sector

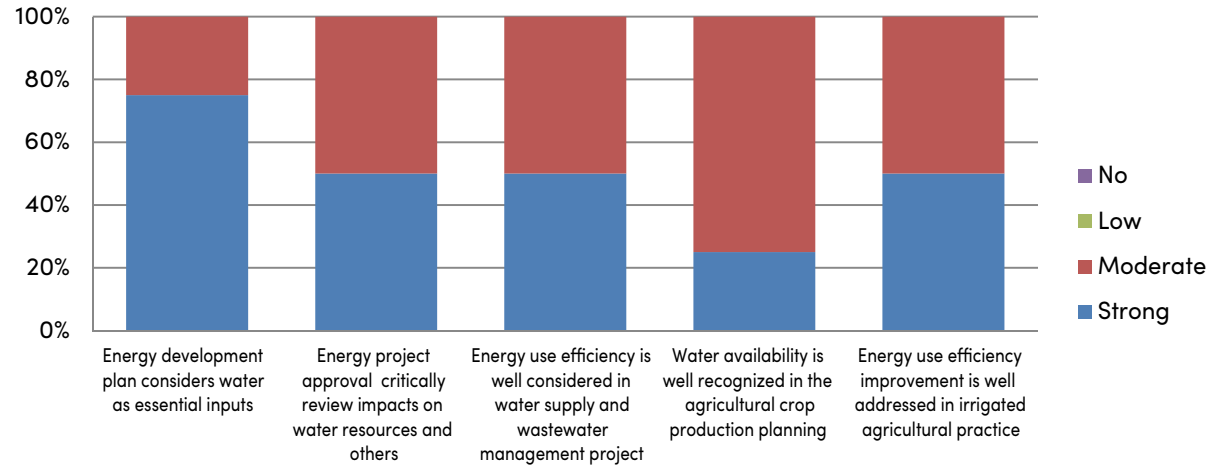


Figure 23: Level of integration of water, energy, food nexus in your country actions and policy according to energy sector

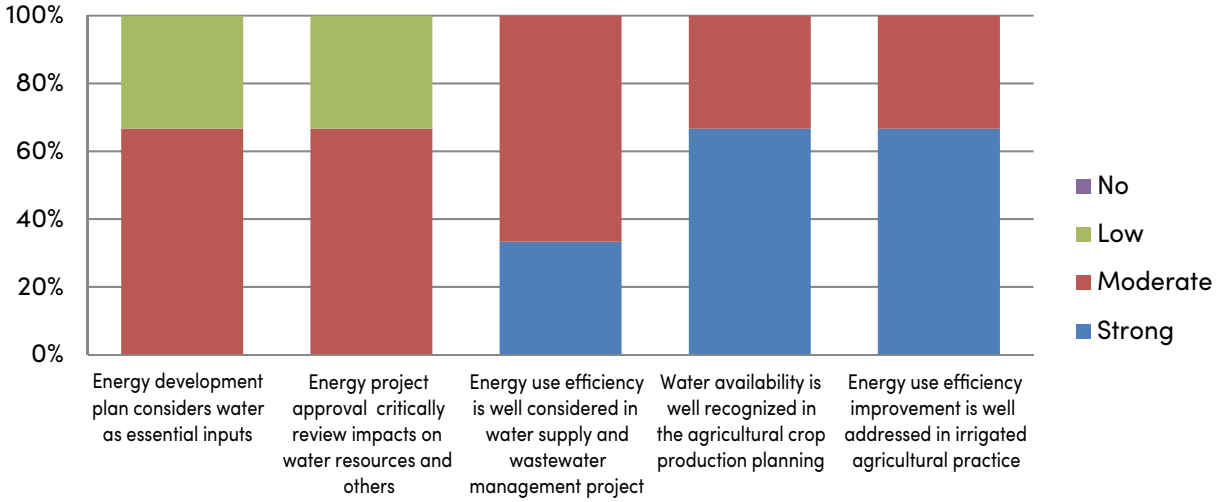


Figure 24: Level of integration of water, energy, food nexus in your country actions and policy according to planning sector

In the food and agriculture sector, as shown in fig. 21, 53% strongly agree and 35% moderately agree that the energy development plan considers water as an essential input while only 12% slightly agree (i.e., agrees to a Low extent). In the water sector, as shown in fig. 22, 33% strongly agree and 42% moderately agree on the same, while 25% slightly agree on this. As shown in fig. 23, 75% of stakeholders in the energy sector strongly agree and 25% moderately agree on the same. From the planning sector, as shown in fig. 24, 67% moderately agree and 33% slightly agree.

In the food and agriculture sector, 35% strongly agree and another 35% moderately agree that energy project approval critically reviews impacts on water resources and others while 30% slightly agree. In the water sector, 39% strongly agree and 46% moderately agree while 15% slightly agree. In the energy sector, 50% strongly agree and 50% moderately agree. From the planning sector, 67% moderately agree and 33%

slightly agree on this issue.

In the food and agriculture sector, 24% strongly agree and 41% moderately agree that energy use efficiency is well considered in water supply and wastewater management projects whereas 29% slightly agree. In the water sector, 54% moderately agree and 38% slightly agree, whereas only 8% strongly agree. In the energy sector, 50% of stakeholders strongly agree and 50% moderately agree, and in the planning sector, 67% moderately agree and 33% slightly agree on this issue.

In the food and agriculture sector, 47% strongly agree, 24% moderately agree and another 23% slightly agree that water availability is well recognized in agricultural crop production planning; in the water sector, 61% moderately agree and 31% strongly agree on this issue; 25% of stakeholders in the energy sector strongly agree and 75% moderately agree on this issue; and in the planning sector, 67% strongly agree and 33% moderately agree on this issue.

In the food and agriculture sector, 35% strongly agree and another 35% moderately agree that energy use efficiency improvement is well addressed in irrigation agricultural practice whereas 18% slightly agree; in the water sector, 23% strongly agree, 23% moderately agree and 46% slightly agree on this issue; 50% of stakeholders in the energy sector strongly agree and 50% moderately agree; and in the planning sector, 67% moderately agree and 33% slightly agree on this issue.

Expert view on country's readiness level to implement SDG-2, SDG-6 and SDG-7 is shown in 25, fig 26 and fig 27,

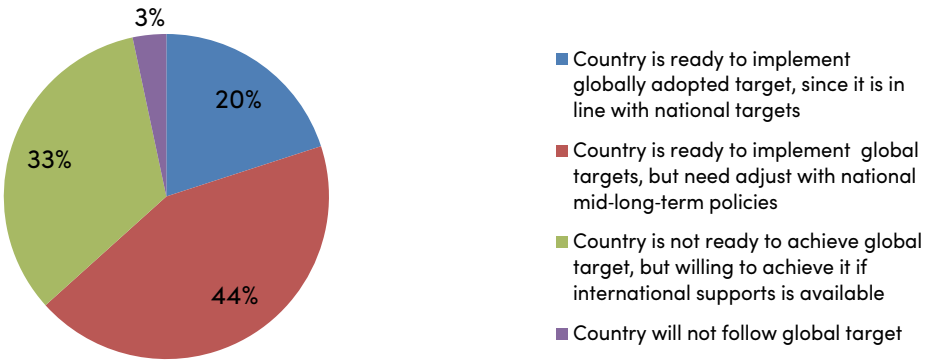


Figure 25: Expert view on country's readiness level to implement SDG-2, SDG-6 and SDG-7 according to food and agriculture sector

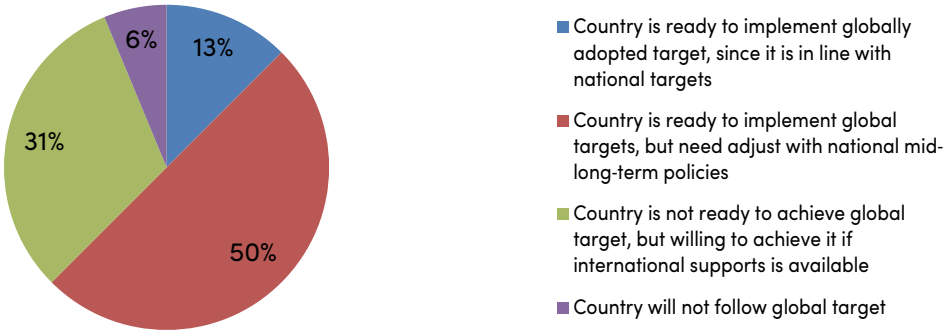


Figure 26: Expert view on country's readiness level to implement SDG-2, SDG-6 and SDG-7 according to water sector

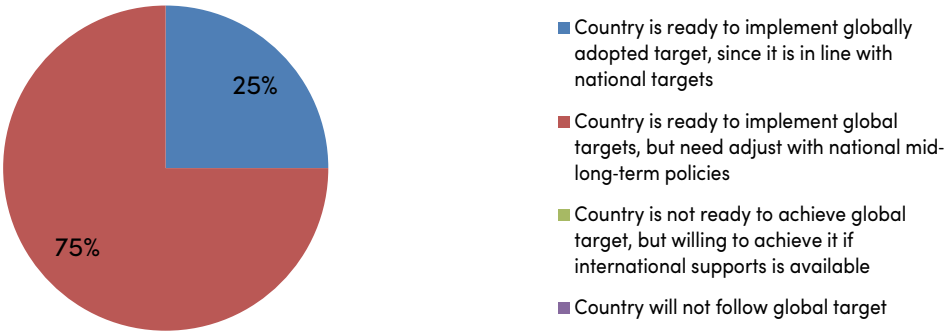


Figure 27: Expert view on country's readiness level to implement SDG-2, SDG-6 and SDG-7 according to energy sector

In the food and agriculture sector, as shown in fig. 25, the majority (44%) claim that the country is ready to implement global targets but needs to adjust its national mid- to long-term policies, whereas the second majority (33%) believe it will achieve global targets only if international supports are available. The remaining 20% thinks that the country is ready to implement the globally adopted target since it is in line with national targets.

In the water sector, as shown in fig. 26, half of all stakeholders claim that the country is ready to implement global targets but needs to adjust its national mid- to long-term policies whereas 31% argue that it will achieve global targets only if international supports are available. Only 13% of the stakeholders think that the country is ready to implement the globally adopted target since it is in line with national targets.
In the energy sector, as shown in fig. 27, a majority of 75% think that the country is ready to implement global targets but needs to adjust its national mid- to long-term policies, whereas 25% believe the country is ready to implement the globally adopted target since it is in line with national targets.

Very few stakeholders from any sector think the country will not follow the global target.

Expert opinions on the country's readiness level to integrate nexus approach in implementation plan of SDG-2, SDG-6 and SDG-7 are shown in fig 28, fig 29, fig 30 and fig 31.

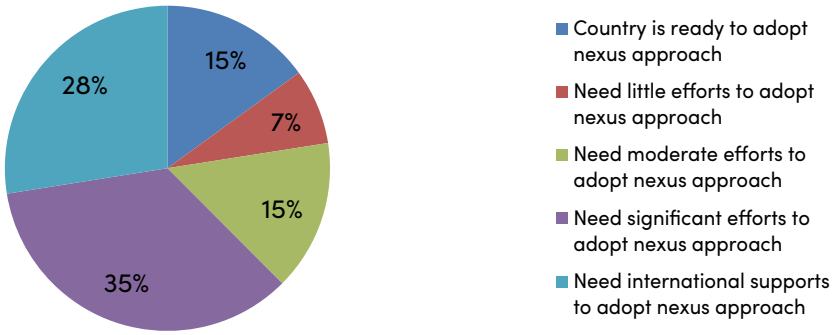


Figure 28: Expert opinion on the country's readiness level to integrate nexus approach in implementation plan of SDG-2, SDG-6 and SDG-7 according to food and agriculture sector

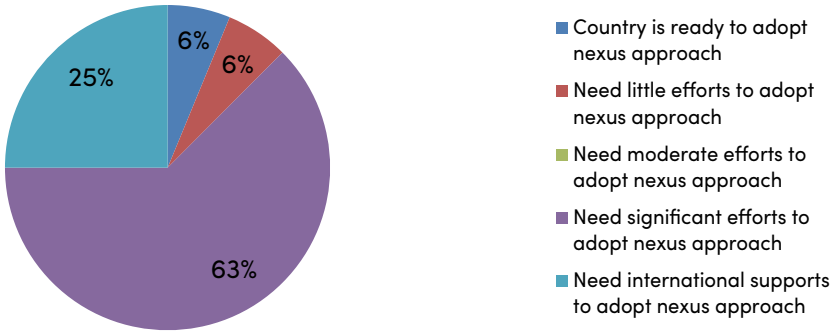


Figure 29: Expert opinion on the country's readiness level to integrate nexus approach in implementation plan of SDG-2, SDG-6 and SDG-7 according to water sector

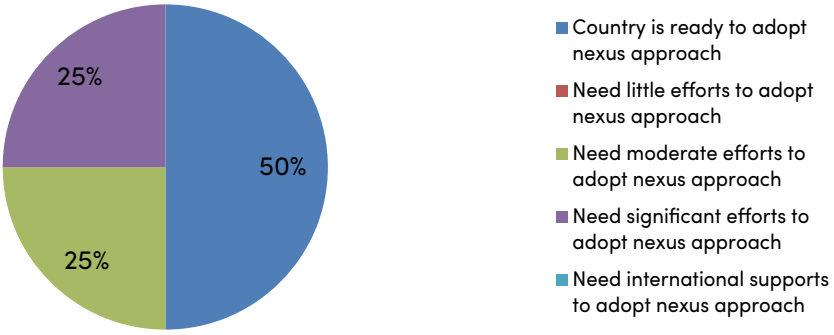


Figure 30: Expert opinion on the country's readiness level to integrate nexus approach in implementation plan of SDG-2, SDG-6 and SDG-7 according to energy sector

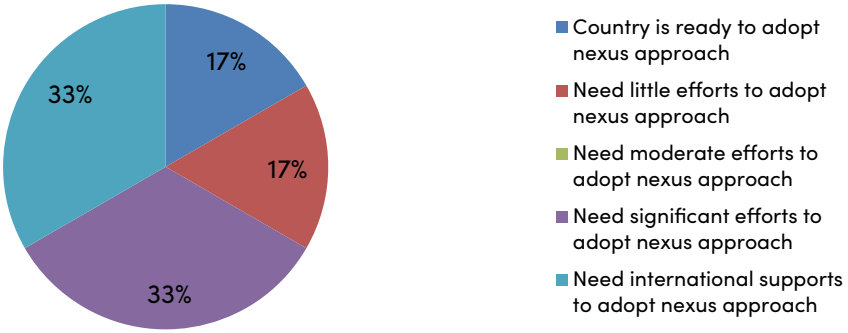


Figure 31: Expert opinion on the country's readiness level to integrate nexus approach in implementation plan of SDG-2, SDG-6 and SDG-7 according to planning sector

The majority of all stakeholders in food, water and planning agencies, as shown in figs. 28, 29, 31, argued that significant efforts are needed to adopt a nexus approach, whereas the requirement of international supports to adopt a nexus approach is consented to by the second largest majorities from these sectors. The majority of stakeholders from the energy sector, as shown in fig. 30, claim that the country is ready to adopt a nexus approach whereas the remainder from the sector equally believe that significant effort and international support is necessary to integrate the nexus approach in the implementation plan of SDG-2, SDG-6 and SDG-7.

Expert view on kind of domestic efforts necessary to adopt nexus approach in the process of translating global goals to the country actions are shown in fig 32, 33, 34 and 35.

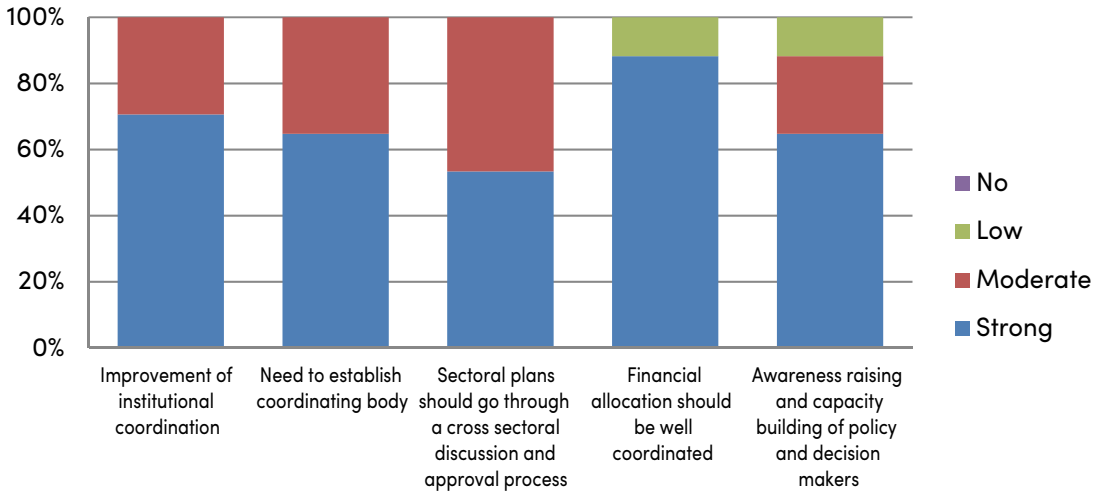


Figure 32: Domestic efforts necessary to adopt nexus approach according to food and agriculture sector

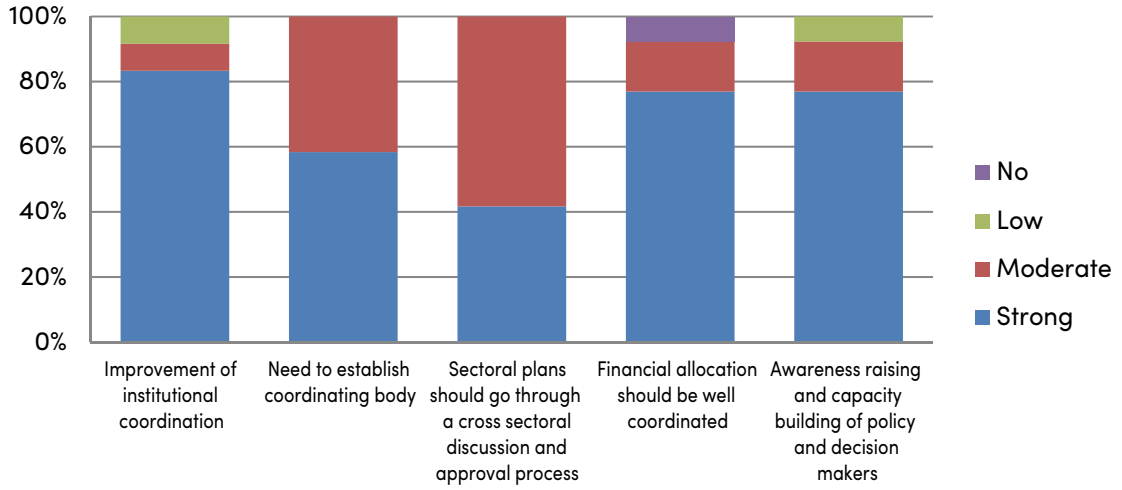


Figure 33: Domestic efforts necessary to adopt nexus approach according to water sector

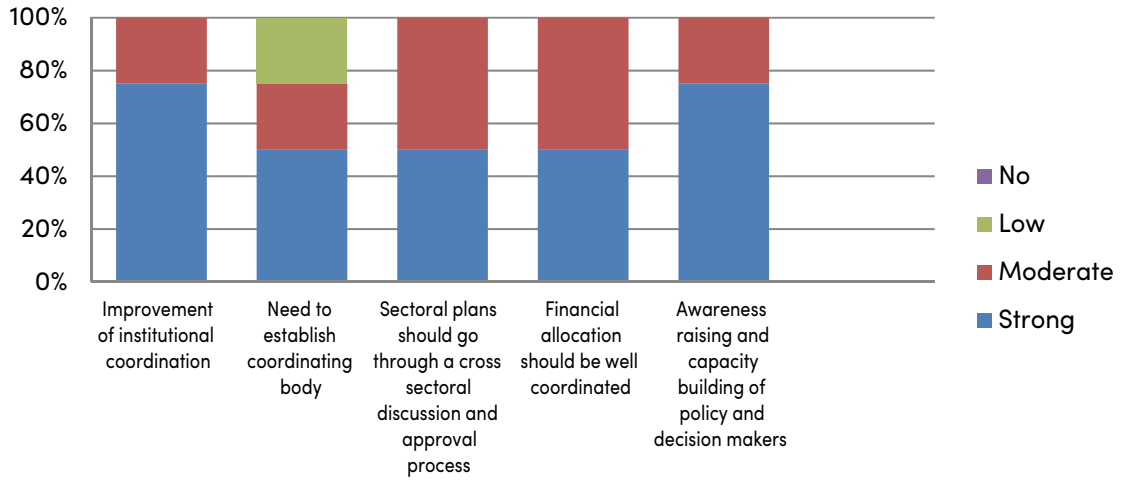


Figure 34: Domestic efforts necessary to adopt nexus approach according to energy sector

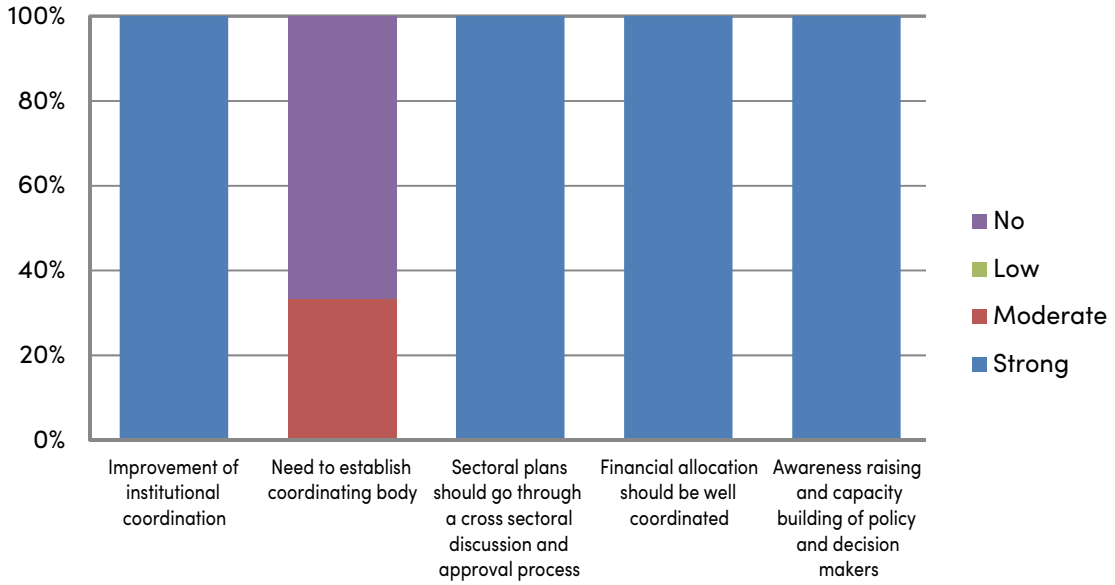


Figure 35: Domestic efforts necessary to adopt nexus approach according to planning sector

In the food and agriculture sector, as shown in fig. 32, 71% strongly agreed and another 29% moderately agreed that improvement of institutional coordination is necessary to adopt a nexus approach in the process of translating global goals to country actions. In the water sector, as shown in fig. 33, 81% agreed on this issue; 75% of stakeholders in the energy sector, as shown in fig. 34, strongly agreed and 25% moderately agreed on this issue. From the planning sector, as shown in fig. 35, all strongly agreed on this issue.

In the food and agriculture sector, 65% strongly agreed and another 35% moderately agreed that establishing a coordinating body is necessary to adopt a nexus approach in the process of translating global goals to country actions; in the water sector, 58% strongly agreed and 42% moderately agreed on this issue.; in the energy sector, 50% of stakeholders strongly agreed, and others equally moderately or slightly agree on this issue. From the planning sector only 33% moderately agree against 67% arguing that there is no need to establish a coordinating body.

In the food and agriculture sector, 53% strongly agree and another 47% moderately agree sectoral plans should go through a cross-sectoral discussion and approval process. In the water sector, 42% strongly agree and 58% moderately agree on this issue; in the energy sector, 50% of stakeholders strongly agree, and others equally moderately agree or slightly agree on this issue, whereas in the planning sector all strongly agreed on this issue.

In the food and agriculture sector, 88% strongly agree and only 12% moderately agree that financial allocation should be well coordinated; in the water sector, 77% strongly agree and 15% moderately agree; in the energy sector, 50% of stakeholders strongly agree, and others equally moderately agree or slightly agree on this issue. From the planning sector all strongly agreed on this issue.

In the food and agriculture sector, 65% strongly agree and only 23% moderately agree that awareness raising and capacity building of policy and decision makers is necessary to adopt a nexus approach in the process of translating global goals to the country actions; in the water sector, 77% strongly agree and 15%

moderately agree on this issue; in the energy sector, 75% of stakeholders strongly agree and the other 25% moderately agree on this issue. From the planning sector all strongly agree on this issue.

Expert view on kind of international efforts necessary to adopt nexus approach in the process of translating global goals to country actions are shown in fig 36, 37, 38, 39.

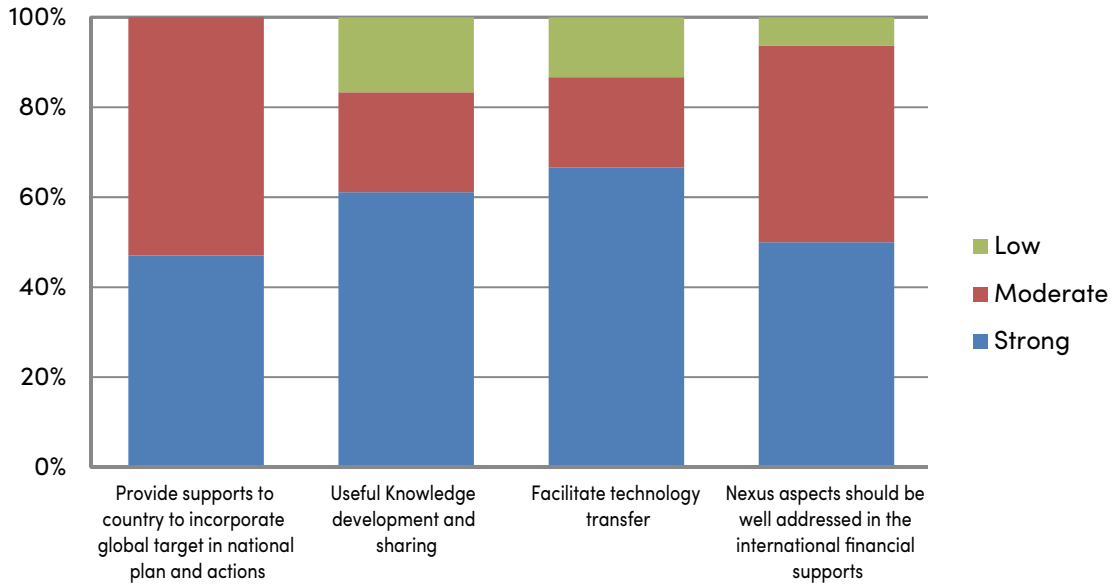


Figure 36: International efforts necessary to adopt nexus approach according to food and agriculture sector

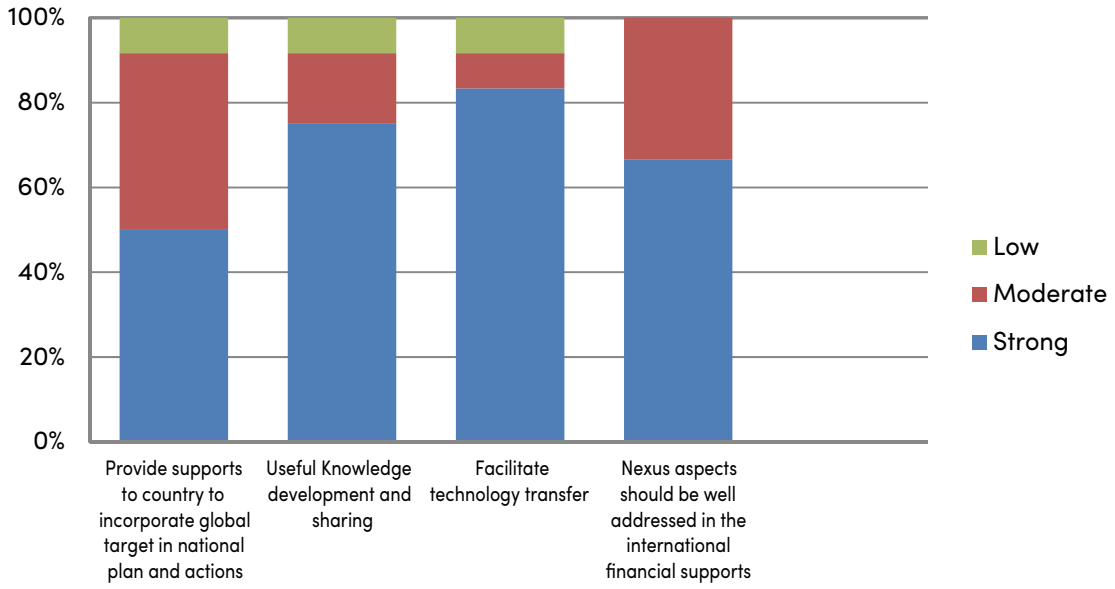


Figure 37: International efforts necessary to adopt nexus approach according to water sector

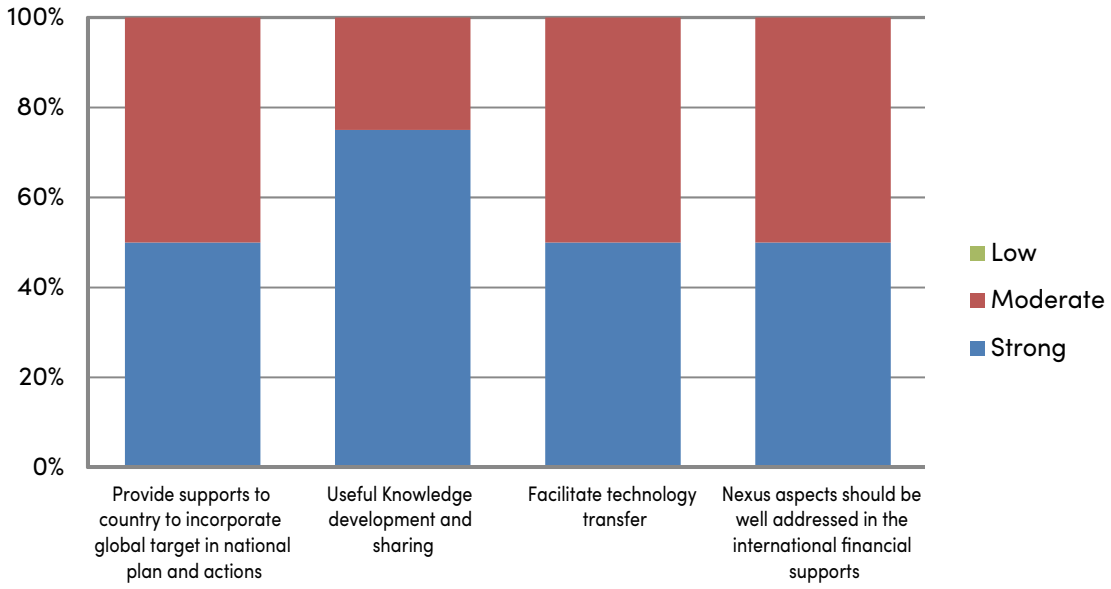


Figure 38: International efforts necessary to adopt nexus approach according to energy sector

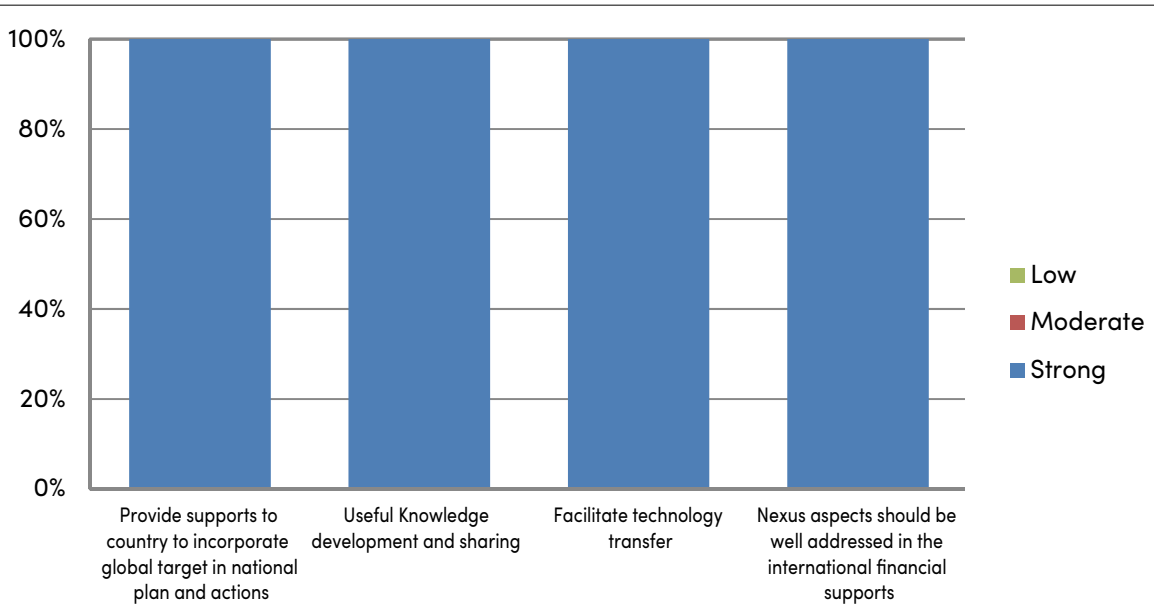


Figure 39: International efforts necessary to adopt nexus approach according to planning sector

In the food and agriculture sector, as shown in figure 36, 47% strongly agree and only 53% moderately agree that providing supports to the country to incorporate global targets in national plans and actions is necessary to adopt a nexus approach in the process of translating global goals to country actions. In the water sector, as shown in fig. 37, 50% strongly agree and 42% moderately agree on this issue; in the energy sector, 50% of stakeholders strongly agree and the other 50% moderately agree on this issue as shown in fig. 38. In the planning sector all strongly agreed on this issue as shown in fig. 39.

In the food and agriculture sector, 61% strongly agree and only 22% moderately agree that useful knowl-

edge development and sharing is necessary to adopt a nexus approach in the process of translating global goals to country actions, whereas 17% slightly agree. In the water sector, 75% strongly and 17% moderately agree on this issue. In the energy sector, 75% of stakeholders strongly agree and the other 25% moderately agree on this issue. From the planning sector all strongly agree on this issue.

In the food and agriculture sector, 67% strongly agree and only 20% moderately agree that facilitating technology transfer is necessary to adopt a nexus approach in the process of translating global goals to country actions, whereas 13% slightly agree. In the water sector, 83% strongly agree on this issue. In the energy sector, 50% of stakeholders strongly agree and the other 50% moderately agree on this issue. From the planning sector all strongly agree on this issue.

In the food and agriculture sector, 50% strongly agree and 44% moderately agree that nexus aspects should be well addressed in international financial supports, whereas 6% slightly agree. In the water sector, 67% strongly agree and 33% moderately agree on this issue. In the energy sector, 50% of stakeholders strongly agree and the other 50% moderately agree on this issue. From the planning sector all strongly agree on this issue.

Expert view on coordinating body for SDGs planning is shown in fig 40. The majority of stakeholders from food, water and energy sectors, as shown in fig. 40, agree that existing institutions are sufficient to coordinate SDG planning whereas a substantial remaining portion suggested incorporating sectoral technical agencies in the SDG coordinating process. All stakeholders from planning agencies believe that existing institutions are sufficient and there is no need to develop new agencies to coordinate SDG planning.

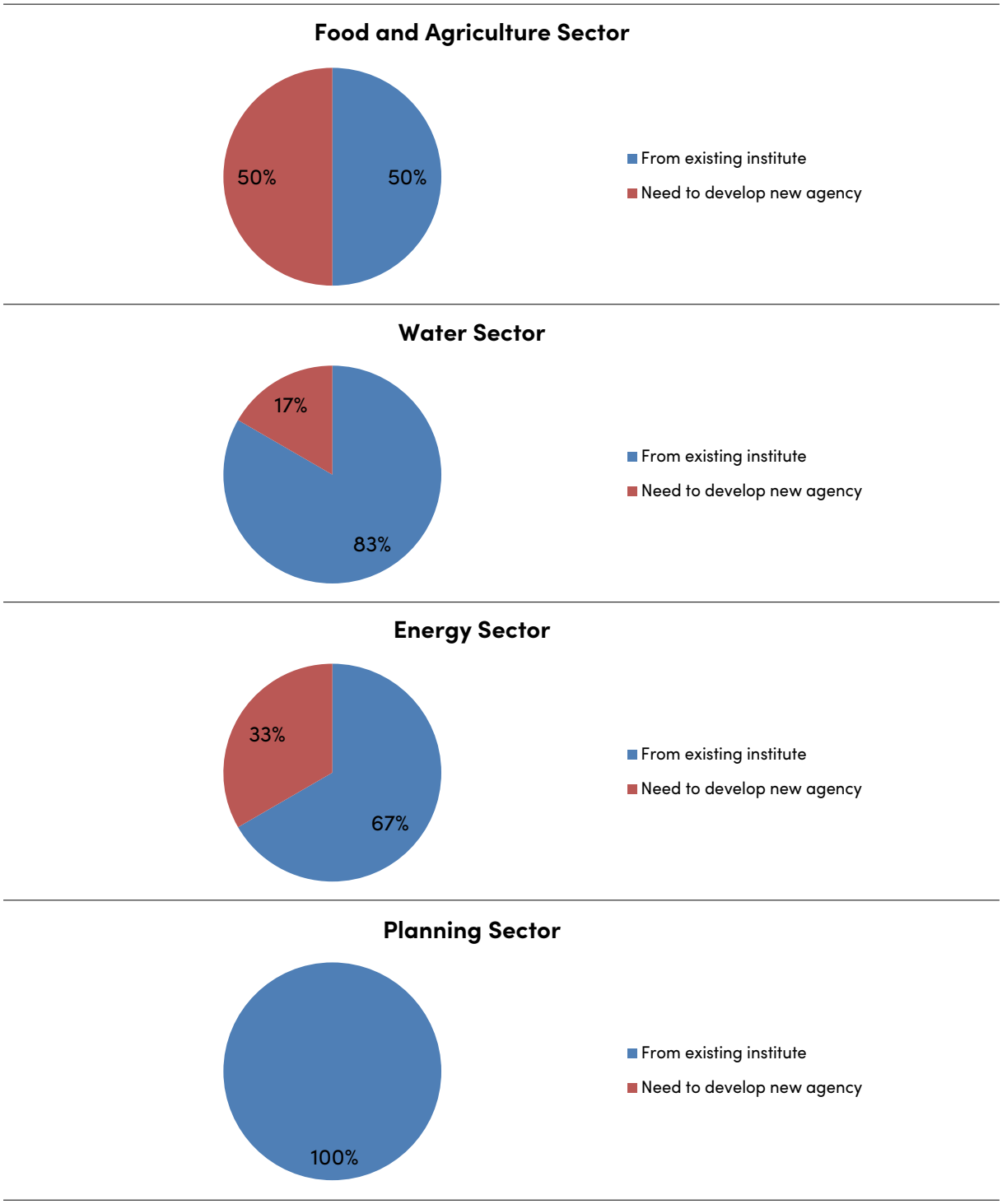


Figure 40: Expert view on coordinating body for SDGs planning

3.2.3.3. Regression analysis

Synergy and trade-off evaluation among SDG-2, SDG-6 and SDG-7

Evaluation of quantitative interdependencies among SDG-2: zero hunger, SDG-6: clean water and sanitation and SDG-7: affordable & renewable energy can contribute in the integration of WEF nexus scenarios in national policymaking, the establishment of cross-sectoral cooperation among government agencies and reflection of synergetic responses in action plans and programmes. Sets of indicators with available authentic well-defined datasets have been used to assess the correlation between targets of SDG-2, SDG-6, and SDG-7, as shown in Table 19. The data of the other targets of SDG-2, SDG-6, and SDG-7 are not available. The pair-wise Pearson correlation coefficient and statistical significance level of SDG targets calculated using indicator data are illustrated in Table 18, and were calculated by dividing the covariance of two variables by the product of their standard deviations and evaluated by comparing p-value calculation through regression analysis. Statistical significance levels of Pearson correlation coefficients were attributed as: not significant when $p > 0.05$; * for $p < 0.05$; ** for $p < 0.01$ and *** for $p < 0.001$, i.e., highly significant.

Table 19: SDG indicator values for different targets (United Nations Statistics Division, 2015; World Bank Data)

Year	SDG T2.1 (Free from undernourished)	SDG T6.2 (Improved sanitary facility)	SDG T6.1 (Basic drinking water services)	SDG T7.1 (Access to electricity)	SDG T7.2 (Renewable energy use)
2000	79.2	45	94.65	32.00	59.01
2001	81.3	47	94.84	35.00	55.79
2002	81.8	48	95.03	37.31	54.32
2003	82.5	49	95.23	39.61	52.64
2004	82.9	50	95.42	40.60	52.12
2005	83.4	51	95.60	44.23	50.78
2006	83.7	52	95.79	50.53	48.90
2007	83.7	53	95.97	46.50	47.48
2008	83.6	54	96.15	51.25	45.58
2009	83.4	55	96.33	53.63	43.69
2010	83.1	56	96.50	55.26	41.05
2011	83.1	57	96.67	59.60	39.44
2012	83.2	58	96.84	60.88	38.61
2013	83.6	59	97.01	61.50	38.76
2014	84	60	97.17	62.40	37.63
2015	84.9	61	97.33	68.20	34.75

Values of indicators for SDG-2, SDG-6 and SDG-7 as shown in Table 20 tabulated from the year 2000 to 2015 have been assessed to evaluate synergy and trade-off among them.

Table 20: Pair-wise Pearson coefficient and significance level of SDG targets

	SDG_T2.1 (Free from undernourished)	SDG_T6.1a (Improved sanitary facility)	SDG_T6.1b (Basic drinking water services)	SDG_T6.2b (Open defecation)	SDG_T7.2 a (Access to electricity)	SDG_T7.2 b (Renewable energy use)
SDG_T2.1 (Free from undernourished)	1	0.80***	0.79***	-0.79***	0.79***	-0.77***
SDG_T6.1a (Improved sanitary facility)	0.80***	1	1.00***	-1.00***	0.99***	-0.99***
SDG_T6.1b (Basic drinking water services)	0.79***	1.00***	1	-1.00***	0.99***	-0.99***
SDG_T6.2b (Open defecation)	-0.79***	-1.00***	-1.00***	1	-0.99***	0.99***
SDG_T7.2 a (Access to electricity)	0.79***	0.99***	0.99***	-0.99***	1	-0.99***
SDG_T7.2 b (Renewable energy use)	-0.77***	-0.99***	-0.99***	0.99***	-0.99***	1

(Not significant when $p > 0.05$; * for $p < 0.05$; ** for $p < 0.01$ and *** for $p < 0.001$, i.e. highly significant)

It is found from Table 20 that the majority of correlation coefficients are positive, implying that an increase or decrease in one target achievement will consecutively affect positively or negatively the achievement of the other. Most of the values are found to be higher and all of them are highly significant, resulting in the fact of high linear linkage among different SDG targets.

Synergy and trade-off between SDG-2 and SDG-6

Synergy and trade-off between SDG-2: zero hunger and SDG-6: clean water & sanitation has been measured against their indicators T-2.1: population free from undernourishment and T-6.1: population with improved sanitary facility. The relative change between the two indicators is shown in fig. 41. Bars above axis line represent synergy and bars below axis line represent a trade-off.

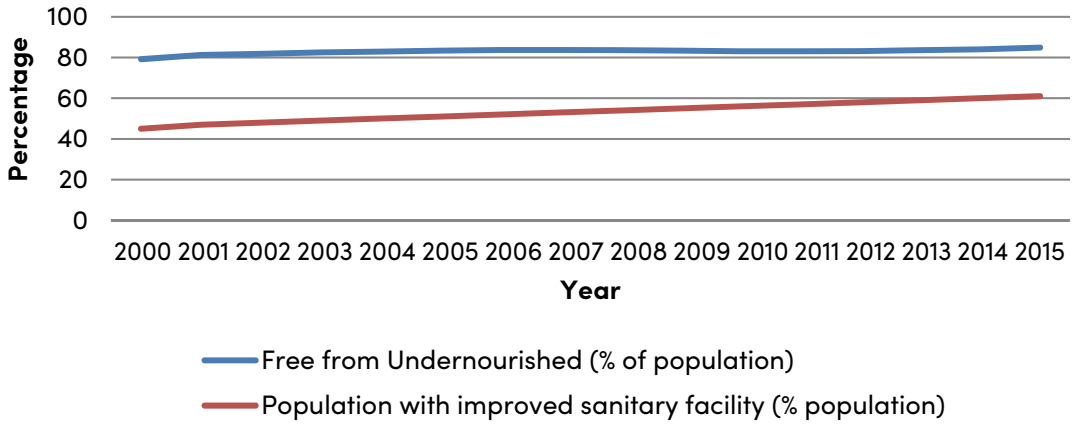


Figure 41: Relative Change between SDG-2 and SDG-6 (population free from undernourishment and with improved sanitary facility)

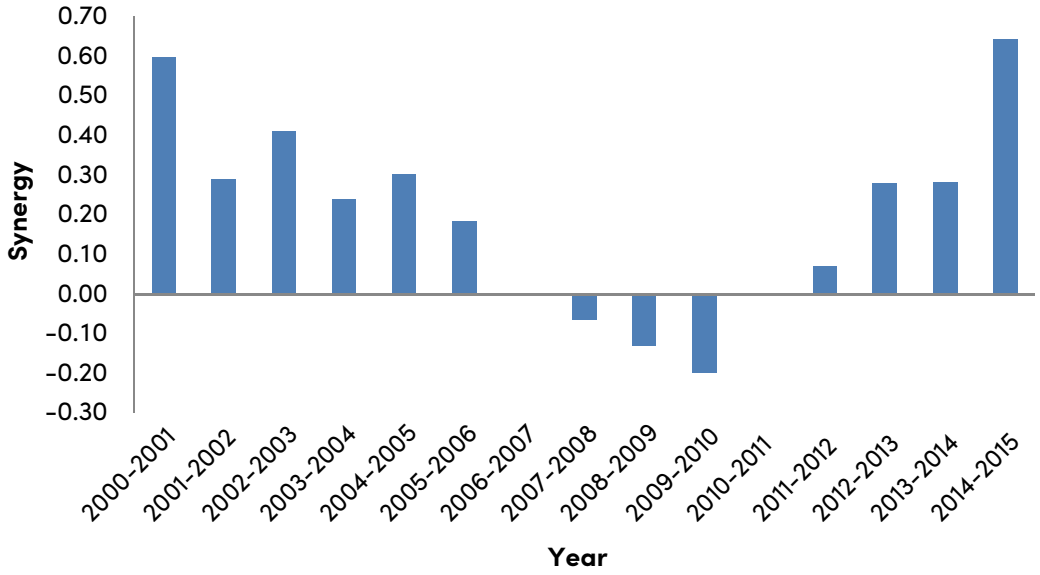


Figure 42: Synergy for SDG-2 and SDG-6 (population free from undernourishment and with improved sanitary facility)

Synergy and trade-off analysis results shown graphically in fig. 42 reveal that there exists mostly positive synergy except for a small trade-off situation during 2006 to 2011 between T-2.1: population free from undernourishment and T-6.1: population with improved sanitary facility. Though from 2000 to 2006 their synergy is irregular, from 2011 onwards, a gradual positive synergy was found, resulting possibly from the constant and stable economic growth of Bangladesh supported by Government projects. As achieving both – undernourishment and improved sanitary status – is driven by the same factors such as economic growth, infrastructural development, government concerns, positive synergy is most general in this case. The trade-off during 2008 to 2011 presumably resulted from a small drop in freeing the country from undernourishment though provision of constantly increasing sanitary facilities. Aiming to maximize potential synergy between SDG-2 and SDG-6, it is evident that any increment in efforts to achieve the targets of one will result in strengthening the other.

Synergy and trade-off between SDG-6 and SDG-7

Synergy and trade-off between SDG-6: clean water & sanitation and SDG-7: affordable & renewable energy has been measured against their indicators T-7.2: population with access to electricity and T-6.1: population using at least basic drinking water services. Relative change between the two indicators is shown in fig. 43.

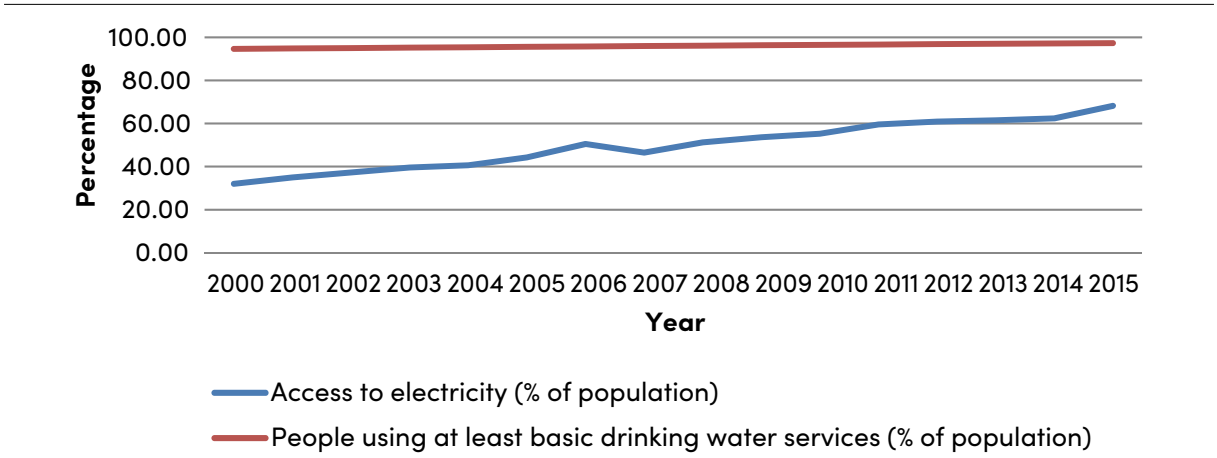


Figure 43: Relative change between SDG-6 and SDG-7 (population with access to electricity and using at least basic drinking water services)

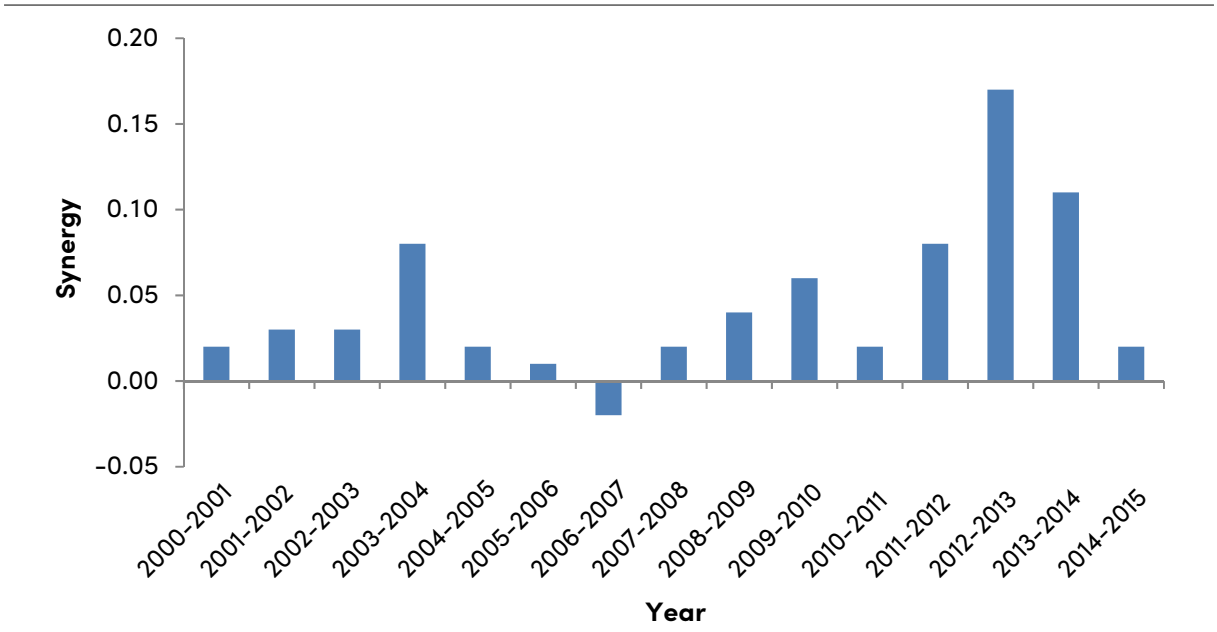


Figure 44: Synergy for SDG-6 and SDG-7 (population with access to electricity and using at least basic drinking water services)

The synergy and trade-off analysis results shown graphically in fig. 44 reveal that there exists mostly positive synergy except for a small trade-off situation during 2006 to 2007 between T-7.2: population with access to electricity and T-6.1: population using at least basic drinking water services. An interruption in electrification from 2006 to 2007 against a constant increase in strengthening drinking water services has resulted in a trade-off for that period. From 2007 and onwards, positive synergy between the two targets has grown gradually, resulting possibly from the constant and stable economic growth of Bangladesh supported by Government projects. It also implies that electrification, in general, enables provision of drinking water services. Aiming to maximize potential synergy between SDG-6 and SDG-7, it is evident that any increment in efforts to achieve the targets of one will result in strengthening the other.

Synergy and trade-off between SDG-2 and SDG-7

Synergy and trade-off between SDG-2: zero hunger and SDG-7: affordable & renewable energy has been measured against their indicators T-2.1: population free from undernourishment and T-7.2: population with access to electricity. Relative change between the two indicators is shown in fig. 45.

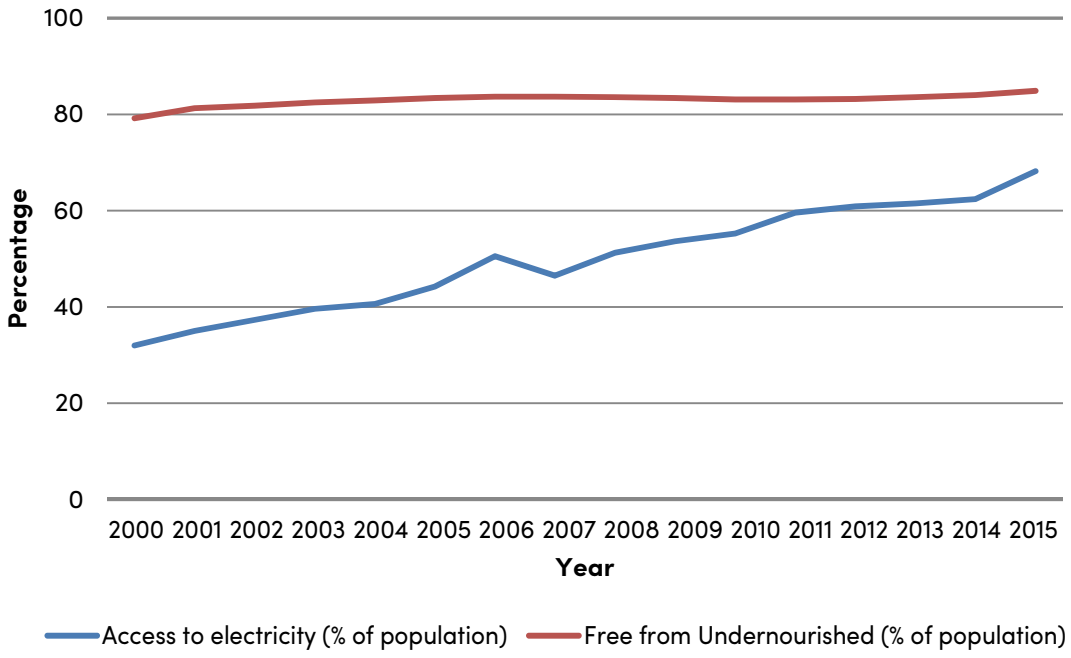


Figure 45: Relative change between SDG-2 and SDG-7 (population free from undernourishment and with access to electricity)

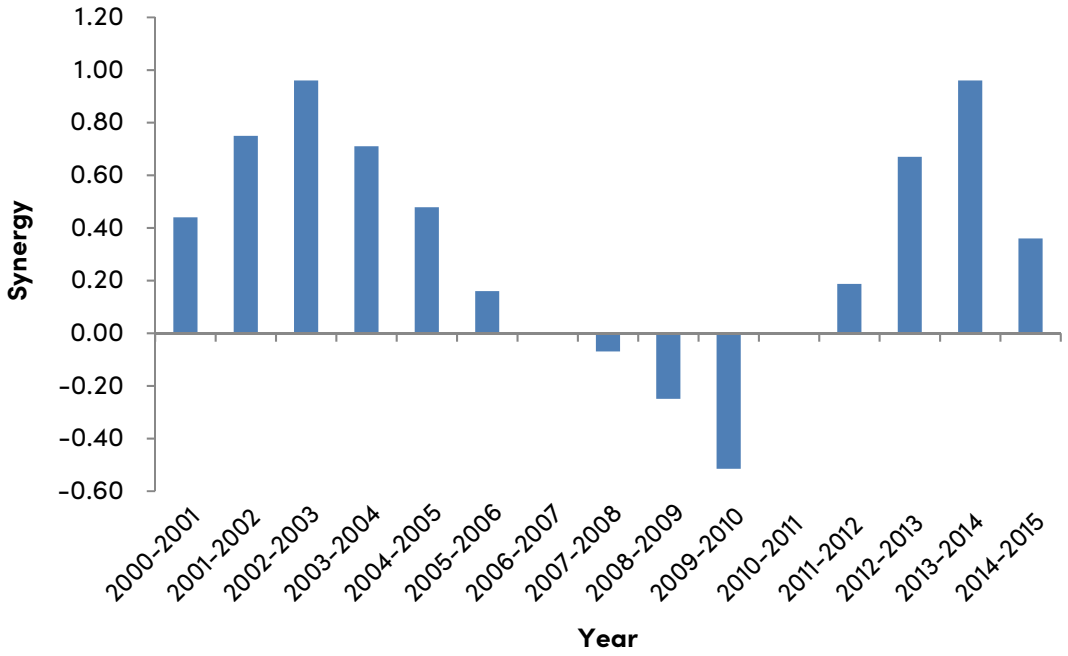


Figure 46: Synergy for SDG-2 and SDG-7 (population free from undernourishment and with access to electricity)

Synergy and trade-off analysis results shown graphically in fig. 46 reveal that there exists mostly positive synergy over time, except for a small trade-off situation during 2006 to 2011 between T-2.1: population free from undernourishment and T-7.2: population with access to electricity. Though from 2000 to 2006 the synergy was irregular, from 2012 onwards, positive synergy grew gradually, resulting possibly from the constant and stable economic growth of Bangladesh supported by Government projects. As achieving both – undernourishment and access to electricity – is driven by the same factors such as economic growth, infrastructural development, government concerns, positive synergy is most general in this case. The trade-off during 2006 to 2011 presumably resulted from a small drop in progress towards freeing the country from undernourishment coupled with interruption in electrification from 2006 to 2007. Aiming to maximize potential synergy between SDG-2 and SDG-7, it is evident that any increment in efforts to achieve one target will result in strengthening the other.

The analysis has shown strong synergy differing over time among SDG-2, SDG-6 and SDG-7 evaluated by assessment of their target datasets. SDG-2, SDG-6 and SDG-7 showed higher synergy during periods of simultaneous positive increment of target data resulting from economic growth, infrastructural development, government concerns, and so on. A lack of indicator data has constrained efforts to evaluate the synergy and trade-off in a broader sense.

3.2.3.4 Network Analysis

Perception of Stakeholders on the Importance of Nexus Aspects for the Country Actions on SDG 2 (Food), SDG 6 (Water) and SDG 7 (Energy)

- Dependency of SDG-2, 6 and 7 on targets of one another is analyzed using SNA utilizing stakeholder perception survey data that determined how SDG-2 is dependent on targets of SDG-6 and 7 and vice-versa for the other two cases.
- As stakeholders attributed level of dependency by strong, moderate, low or no consent, these four levels are attributed with weights: 3 for strong, 2 for moderate, 1 for low and 0 for no consent.
- Standardized weights are determined for each dependency and they are attributed as the weight of the relationship between the two targets indicating dependency of the SDG on other SDG targets.
- Different types of colored and shaped nodes are used to express SDG goals and targets.
- A circular layout was adopted by using the degree prestige index in order to visualize the network to illustrate dependency of SDG-2, SDG-6 and SDG-7 on one another.

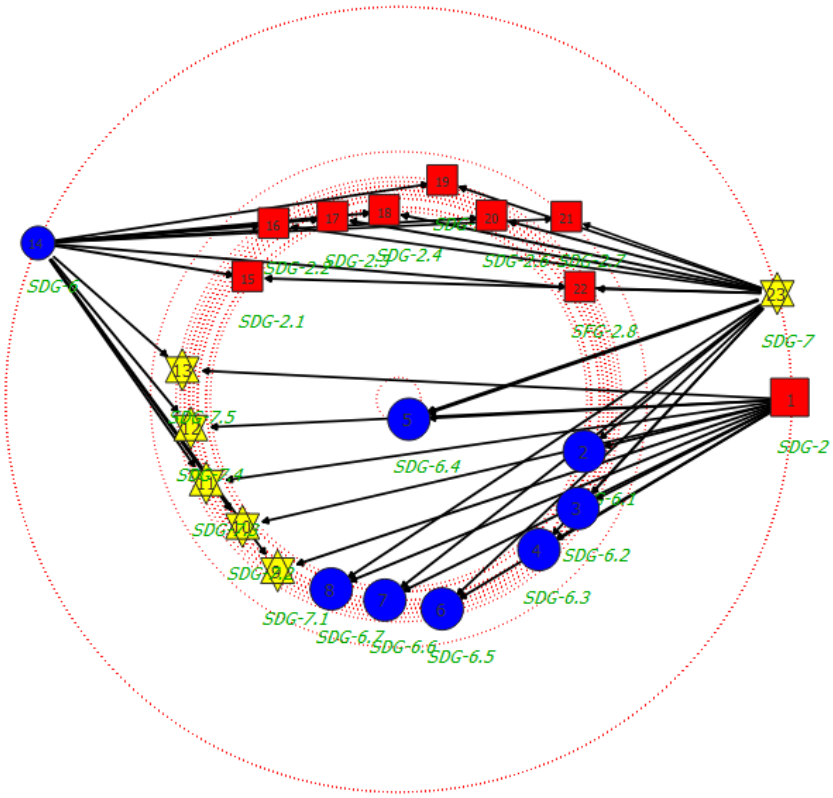


Figure 47: Social network analysis (SNA) diagram of dependency of SDG-2, 6 and 7 on targets of one another

- As shown in fig. 47, SDG-2, SDG-6 and SD-7 are situated on the outer most periphery of the SNA and targets on which they dependent are situated on inner circles.
- As shown in the figure, SDG target-6.4 (Implement integrated water resources management at all levels) has the core influence on achievement of SDG-2 and 7 whereas SDG target-2.7 (Correct and

prevent trade restrictions and distortions in world agricultural markets) is in the most outer circle just inside the peripheral circle, showing lowest influence in achieving SDG-6 and SDG-7.

- Most of the other targets are situated in circles very close to each other, illustrating their similar level of influence on achievement of SDG-2, SDG-6 and SDG-7.

Expert view on kind of efforts necessary to adopt WEF nexus approach in the process of SDG implementation

- Domestic and international effort options are presented in fig. 48 through nodes of different colour.
- As stakeholders attributed importance of the efforts by strong, moderate, low or no consent, these four levels are attributed with weights: 3 for strong, 2 for moderate, 1 for low and 0 for no consent.
- The following fig. 48 illustrates domestic and international efforts necessary to adopt a WEF nexus approach in the process of SDG implementation, and was developed by using the degree centrality index in a circular layout.

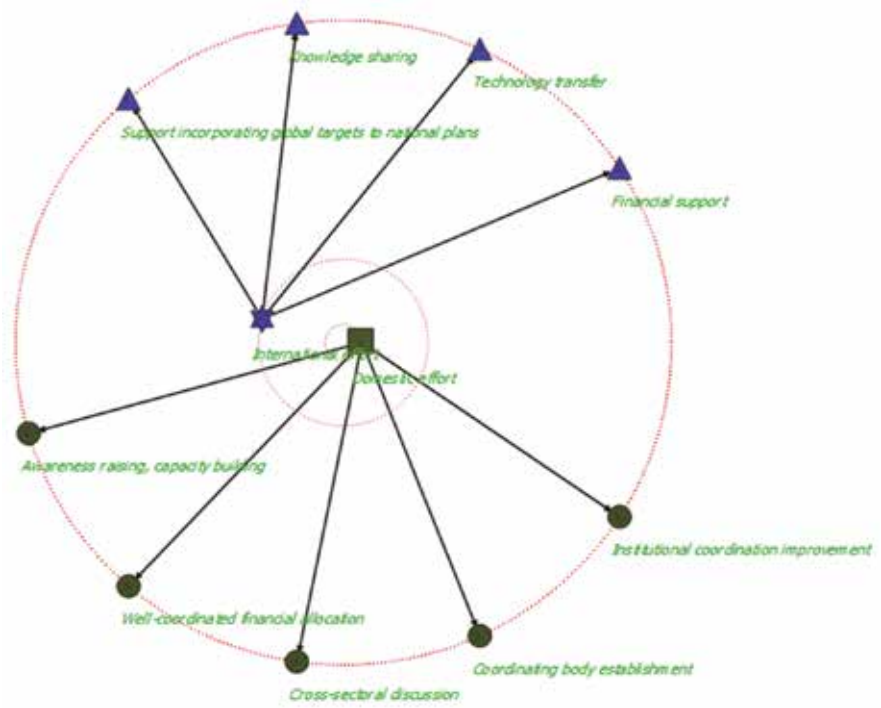


Figure 48: Domestic and international effort options presented through Social Network Analysis tool

Dependency of Targets of SDG-2, SDG-6 and SDG-7 on each other

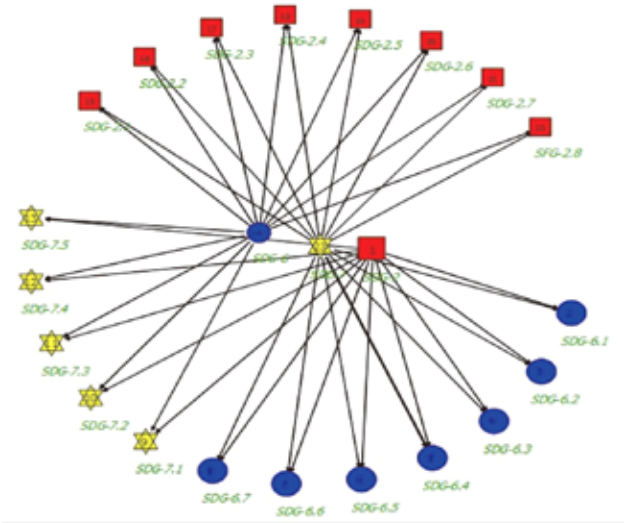


Figure 49: Dependency of Targets of SDG-2, SDG-6 and SDG-7 presented through Social Network Analysis tool

3.2.3.5. Prioritization of interlinkages for actions

As mentioned earlier, the prioritization of the interlinkages among food, water and energy has been assessed through stakeholder consultation. The participants were grouped into two groups, one for the water sector, and the other for the food and agriculture sector. After discussions over how to prioritize the goals they ranked them with different points. At the end the stakeholders came up with a prioritization of different targets of SDG-2 and SDG-6. The consultation came up with the following ranks in the context of prioritization among the targets of SDG-2, SDG-6, and SDG-7 as shown in Table 21

Table 21: Prioritization of targets of SDG 2, SDG-6 and SDG-7

SDGs	1st priority	2nd priority	3rd priority
SDG-2	T 2.4	T 2.2	T 2.3
SDG-6	T 6.5	T 6.4	T 6.3
SDG-7	T 7.1	T 7.2	T 7.3

Priority interlinkages are shown in Table 22. Data are not available for the identified three priority targets of SDG-6. Therefore, strength of interlinkages between targets of SDG-6 and targets of other two SDGs cannot be measured. According to r2 value in Table 22, four interlinkages can be identified as moderate priority. However, r2 value also shown strong negative relationships in several cases, which indicates possible trade-off relationships. Therefore, it is also important to take actions interlinkages of highly negative r2 value to minimize trade-off relationships.

Table 22: Pairwise Pearson Correlation among prioritized targets, Bangladesh

	T 2.4	T 2.1	T 2.2	T 6.3	T 6.4	T 6.5	T 7.2	T 7.1	T 7.3
T 2.4	-	-	-	DNA	DNA	DNA	-0.81	-0.82	0.53
T 2.1	-	-	-	DNA	DNA	DNA	0.79	0.69	-0.58
T 2.2	-	-	-	DNA	DNA	DNA	-0.98	-0.99	0.4
T 6.3	DNA	DNA	DNA	DNA	DNA	DNA	DNA	DNA	DNA
T 6.4	DNA	DNA	DNA	DNA	DNA	DNA	DNA	DNA	DNA
T 6.5	DNA	DNA	DNA	DNA	DNA	DNA	DNA	DNA	DNA
T 7.2	-0.81	0.79	-0.98	DNA	DNA	DNA	-	-	-
T 7.1	-0.82	0.69	-0.99	DNA	DNA	DNA	-	-	-
T 7.3	0.53	-0.58	0.40	DNA	DNA	DNA	-	-	-

3.2.4 Conclusion

The water-energy-food nexus perspective is an effective policy and management instrument to facilitate conservation of ecosystem in achieving sustainable development goals involving the interconnecting issues of natural resources into the planning and implementation strategy. In this regard, reviewing of plans, policies and strategies of Bangladesh to evaluate gaps and provisions within national planning to incorporate the WEF nexus perspective has been a key initiative of the project. Stakeholders cognition derived through scrutinizing the perception survey revealed important aspects and country readiness to incorporate nexus aspects in the action plans towards the SDGs. Evaluation of quantitative interdependency in this study among SDG-2, SDG-6 and SDG-7 showed higher synergy during periods of simultaneous positive increments of target data, which in turn implies nexus existed, leading to the importance of WEF nexus in SDG implementation. Given the growing criticality in resource management in the water, energy and food sectors, harnessing the WEF nexus in policymaking is of utmost importance for achieving success in SDG implementation.

3.3 Case study of Viet Nam

3.3.1 Introduction

Vietnam, after 20 years of "Doi Moi" (or renovation), has gained an enormous achievements in hunger eradication and poverty reduction. However, its development has not been considered sustainable. After 15 years of the implementation of Millenium Develop Goals (MDGs), the country still faces many challenges in the sustainable development process. Economic development still depends heavily on exploiting natural resources and low labor productivity. Consumption patterns are also considered not so efficient, which use a lot of energy, raw materials and generate a huge a mount of waste. Consequently, ecological environment in many places has seriously been damaged, polluted and degraded to an alarming level. At the UN Sustainable Development Conference (2015), State President Truong Tan Sang affirmed that Vietnam committed to mobilizing all resources and the participation of government ministries and agencies at all levels, organizations, communities and the people to successfully implement the 2030 Agenda and the SDGs.

As a follow-up, the Government of Vietnam has nationalized the Sustainable Development Goals (SDGs) in the National Action Plan to implement the 2030 Agenda for SDGs in May 2017. As part of this process, the country has prepared a Voluntary National Review (VNR) for presentation at the United Nations High-level Political Forum 2018 on Sustainable Development (HLPF 2018). This VNR aims to share the initial achievements of the 2030 Agenda as well as Viet Nam's experience in SDG implementation with the international community.

Among 17 Sustainable Development Goals with 169 targets, the Government of Vietnam has decided to nationalize into 115 Viet Nam SDG (VSDG) specific targets in the Vietnam's National Action Plan for Implementation of Agenda 2030 for Sustainable Development, based on Viet Nam's national conditions and development priorities, and also built on the successful implementation of the Millennium Development Goals. In addition, Viet Nam has paid particular attention to vulnerable groups such as the poor, people with disabilities, women, children and ethnic minorities through a number of policies aimed at promoting social equality to ensure that no one is left behind.

Moreover, due to the interlinkaged nature among the SDGs, targets and indicators, particularly among SDG-2 on food, SDG-6 on clean water and sanitation, and SDG-7 on energy, the Government of Vietnam has strongly encouraged to pilot indicators that address the interlinkages between goals and targets. Solutions to any national and city problem, for example relared to energy security, should consider its potential impacts, either synergies or trade-offs within and across the sector.

In this context, this research has been designed to address the needs and fill the gaps that the country is now facing. The specific objectives of the research are included:

- To assess quantitative and qualitative relationships among the nationalized targets for SDGs, particularly focusing on three major dimensions: Food (SDG-2), Water (SDG-6) and Energy (SDG-7).
- To evaluate readiness of Vietnam for implementation of the relevant SDGs and its targets.
- To design a shortlist of prioritized interlinkages and targets that will help the country in formulating policies and actions to meet related SDG targets on Water-Food-Energy effectively and more swiftly.

3.3. Methodology

i. Readiness of countries to implement SDGs

The study collected information from relevant policies and laws that Vietnam has issued regarding SDGs; collected secondary data related to the socio-economic status, and a number of results of implementation of Vietnam's sustainable development programme related to water, energy and food (WEF).

Information and secondary data were collected from the following sources:

- Report on socio-economic development results from 2007–2018.
- Statistical results from agencies and organizations related to water - energy - food.
- Reports from UN, FAO, OECD and similar bodies
- Related domestic and foreign research programmes
- Office 21, the sustainable development office under the Ministry of Industry and Trade

The collected data was analyzed by descriptive and comparative statistical methods, to compare and contrast the achieved results with the targets of WEF.

Further, stakeholder perception on the WEF nexus perspective was evaluated by analyzing questionnaire responses of key personnel from the concerned sectors. The purpose of the questionnaire survey was to elicit the stakeholders' level of understanding of Food (SDG-2), Water (SDG-6) and Energy (SDG-7) and to evaluate country readiness to incorporate nexus aspects in the action plans towards SDGs.

A total of 30 people responded to the questionnaire, comprising five respondents from the water sector, five from the agriculture sector, five from National Institute of Nutrition and University of Public Health, five from the energy sector and 10 others, from Vietnam Agenda office, Vietnam Chamber of Commerce and Industry (VCCI), General Statistics Office of Viet Nam and international research organizations. All of the questionnaire responses were collected by personal interviews prosecuted by interactive discussion. The questionnaire is shown in Appendix 1.

ii. Quantitative assessment of relationships among proposed targets for SDGs

The quantitative assessment of relationships among three major dimensions: Food (SDG-2), Water (SDG-6) and Energy (SDG-7) was carried out according to the following steps:

- From qualitative assessment of relationships among targets of Food (SDG-2), Water (SDG-6) and Energy (SDG-7), choose targets which were assessed to be strong-to-moderate quantitively.
- Use secondary data on the results of implementing sustainable development goals from 2000 to 2016 of these targets for regression analysis by applying SPSS to obtain the correlation between targets with significant at the 0.01 level (2-tailed).
- From the regression analysis results, apply UCINET to reveal the interlinkages among relevant targets under Food (SDG-2), Water (SDG-6) and Energy (SDG-7).

iii. Prioritization of interlinkages for actions

The Analytic Hierarchy Process (AHP) was used to obtain the priority of interlinkages for actions (Saaty T.L., 1980). The research involved investigation of the opinions of key stakeholders on connectivity of

SDG targets on Water, Food and Energy by means of a survey questionnaire. Each expert entered their judgments and made a distinct, identifiable contribution to the issue. Pairwise questions were made from the results of stakeholder perception on the water-energy-food nexus perspective which were evaluated by analyzing questionnaire responses of key personnel from the concerned sectors. The questionnaire form consists of two parts: in the first part, demographics such as sex, age, education, and income, are asked; in the second section, explanations about questionnaire objectives are provided. From this section, the interviewee can fully understand the aim of the questionnaire. Interviewees were also given explanations about terminologies that were used in the questionnaire. In the last part, 16 pair-wise questions are asked to clarify the respondents' preferences. The targets chosen for pair-wise questions were those with interlinkages from 80–100% from the network analysis results.

An example of a pair-wise question between T6.1 and T.7.1 is shown in fig. 50. The actual questionnaire is given in Appendix 2.

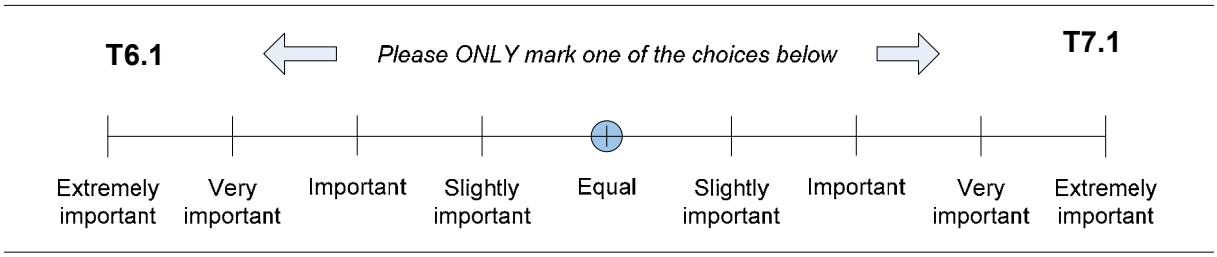


Figure 50: Example of pair-wise question

a. Stakeholder selection

Six different stakeholders were selected from ministries, institutes and NGOs. The sample size for each stakeholder is shown in Table 23.

Table 23: Questionnaire sample size

No.	Stakeholder	Symbol	Sample size
1	Ministry of Natural Resources and Environment	MONRE	10
2	Ministry of Agriculture and Rural Development	MARD	10
3	Ministry of Industry and Trade	MOIT	10
4	National Institute of Nutrition	NIN	10
5	Vietnam Chamber of Commerce and Industry	VICC	10
6	International research organizations (WB, GIZ, etc.)	NGOs	10

b. Survey method

The questionnaire surveys were conducted from 3 to 28 May, 2019 in Ha Noi through face to face inter-

views between the interviewers and different stakeholder groups. Six HUNRE students helped with the survey who were trained to understand the contents and methods of the interview. Each interview lasted from half to one hour.

c. Data analysis based on the interview answers

Saaty's pair-wise scale was adopted to calculate the relative importance of each attribute. Results of the pair-wise comparison were described in terms of integer values from 1 to 9 as shown in Fig 51, where the number "x" means that the attribute is x times more important than the other. After receiving the responses, allotting a number based on Saaty's scale, the elements are shown in a matrix and the eigen-vector is calculated. There are several other methods to obtain the weights from matrices such as logarithmic least squares method and least squares method; however, the eigen-vector method has been considered as the most promising method (Kousalya P and *et al.,* 2006).

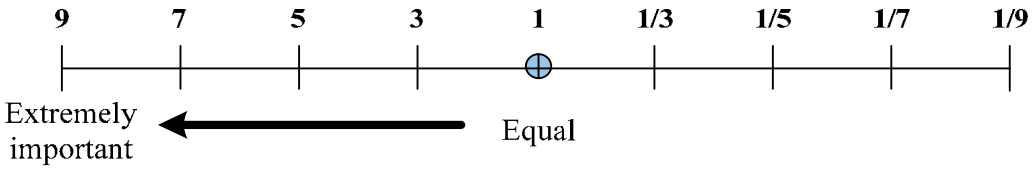
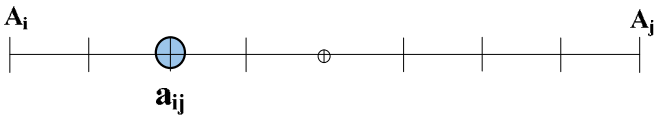


Figure 51: Integer values of the pair-wise comparison

(i) Eigen-vector method

The eigen-vector method is applied to obtain the importance weight (w_i) of each attribute "A_i". The pair-wise results are encoded by Saaty's scale and shown in a matrix (A). The element "a_{ij}" represents that "A_i is aij times more important than A_j".

$$A = \begin{array}{c} \\ A_1 \\ A_2 \\ \cdot \\ A_n \end{array} \begin{array}{c} \begin{array}{cccc} A_1 & A_2 & \cdots & A_n \end{array} \\ \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdot & \cdot & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \end{array}$$



Having recorded the numerical judgments a_{ij} in the matrix A, the problem now is how to calculate the numerical weight (w_i) of each attribute (A_i) from this matrix.

$$\begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ . & . & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} = \begin{bmatrix} w_1/w_1 & w_1/w_2 & \dots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \dots & w_2/w_n \\ . & . & \dots & \dots \\ w_n/w_1 & w_n/w_2 & \dots & w_n/w_n \end{bmatrix} \quad \text{(Eq. 1)}$$

When both sides of equation shown above (Eq. 1) are multiplied by the weight column vector $w = (w_1, w_2 \dots w_n)$, the right hand side of the Eq. 1 becomes "nw" as shown in the below equation (Eq. 2).

$$Aw = nw \quad \text{(Eq. 2)}$$

This is a system of homogenous linear equations. It has a nontrivial solution if, and only if, the determinant of A-nI vanishes, that is, n is an eigen-value of A, being I an n × n identity matrix. Saaty's method computes was the principal right eigen-vector of the matrix A, that is,

$$Aw = \lambda_{max} w \quad \text{(Eq. 3)}$$

where λ_{max} is the largest eigen-value of the matrix A. If matrix A is a positive reciprocal, one, then $\lambda_{max} \geq n$.

(ii) Consistency test

In the questionnaire survey, inconsistent answers are sometimes observed: for example, "A is better than B", "B is better than C", but "C is better than A".

The consistency test is one of the essential features of the AHP method and aims to eliminate any possible inconsistency revealed in the attribute weights, through the computation of consistency level of each matrix. To ensure credibility, Saaty defined the consistency index (CI) for a size n of a matrix as shown in Eq. 4.

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad \text{(Eq. 4)}$$

n : number of evaluating factor
λ_{max} : the maximum eigen-value of the matrix

The consistency index (CI) is used to determine and justify any inconsistency in the pair-wise comparison made by the respondents. If CI = 0, it represents complete consistency of the respondent's answers, while CI = 1 represents complete inconsistency. Saaty suggested that the answers with CI ≤ 0.1 are acceptable. However, in practice, CI of more than 0.1 sometimes has been accepted [11]. Therefore, the same criterion (0.2) was used in this study.

(iii) Procedure of calculation

After obtaining the pair-wise judgments (a), Saaty's scale is applied to change the results into a matrix (b). The normalized matrix is gained by dividing each element by the column-wise summation of the elements (c). Then, the eigen-vector is calculated by averaging the element in rows. Each element of this vector represents the weight of importance (d). The eigen-value (λ_{max}) is determined using the relationship $Aw = \lambda_{max} w$

(e). And then the consistency index is calculated. If CI ≥ 0.2, the answer is discarded.

3.3.3 Results and discussion

3.3.3.1 Readiness of country to implement SDGs

i. Institutional

The 2030 Agenda and Sustainable Development Goals (SDGs) are in line with the long-term development strategy of Viet Nam (hereafter, "Vietnam"). This was achieved through integrating some basic targets into the national 5-year socio-economic development plan. Currently, institutions for sustainable development have been established including the National Sustainable Development Council under Decision No. 1032/QD-TTg dated September 27, 2005 of the Prime Minister and the Office of Sustainable Development (Office 21) in the Ministry of Planning and Investment (MPI) according to Decision No. 685/QD-BKH of the Minister of MPI dated June 28, 2004. Accordingly, the functions and tasks of Office 21 are as follows:

1. Develop and synthesize annual and five-year action plans and plans to implement Vietnam's Agenda 21;
2. Organize the management and implementation of Vietnam's Agenda 21 on sustainable development; Unify management of activities on sustainable development in Vietnam; Coordinate to produce sustainable development programmes and projects among ministries and localities; Urge, monitor and evaluate the results of sustainable development activities of the whole country.
3. Preside over and coordinate with ministries to develop policy mechanisms and propose solutions to promote the implementation of Vietnam's Agenda 21.
4. Coordinate with ministries, localities and units to organize workshops, propagate, train and provide technical assistance information for sustainable development.
5. Establish a focal point to coordinate and promote international cooperation projects in the field of sustainable development.
6. Develop and implement projects on sustainable development according to the functions and tasks assigned.
7. Coordinate with agencies and organizations in Vietnam and abroad to promote the establishment of the National Sustainable Development Council.
8. Perform other duties assigned by the Minister.

Currently, 17 global SDGs have been nationalized into 115 Viet Nam SDG (VSDG) targets in the "National Action Plan for Implementation of the 2030 Agenda for Sustainable Development", based on Viet Nam's development context and priorities, and building on the successful implementation of the Millennium Development Goals (MDGs) according to Decision No. 662/QD-TTg dated May 10, 2017 of the Prime Minister. Further, on January 22, 2019, MPI issued Circular No. 03/2019/TT-BKHĐT on statistical indicators for sustainable development of Viet Nam. The General Statistics Office under the MPI presides and coordinates with relevant agencies to:

- Collect and synthesize statistical information under Vietnam's sustainable development statistical index, ensuring provision of complete, accurate and timely statistics and meeting international comparison requirements;
- Formulate and complete forms of information collection of Vietnam's sustainable development statistical indicators;
- Develop a statistical database for sustainable development statistics of Vietnam.

The Ministry of ministerial-level agencies, Government-attached agencies, Supreme People's Court, Supreme People's Procuracy and relevant agencies based on Vietnam's sustainable development statistical index have responsibilities for collecting and synthesizing assigned targets, and providing such to the General Statistics Office for compiling and publishing.

With the current institutional capacity, it can be assessed that Vietnam is carefully preparing the apparatus in order to successfully achieve the sustainable development goals.

ii. Policies

To implement the contents of Vietnam's Agenda 21 in 2004 under the Prime Minister's Decision No. 153/2004/QD-TTg on the sustainable development orientation of Vietnam, legal documents related to WEF criteria were issued:

- Constitution of the Socialist Republic of Vietnam, 2013
- Environmental Protection Law, 2014
- Water Resources Law, 2012
- Biological Diversity Law, 2008
- Electricity Law, 2004
- Law on amending and supplementing some articles of the Electricity Law 2004 No. 24/2012 / QH13 dated 20/11/2012
- Law on energy efficiency and efficiency, 2010
- Food Safety Law, 2010
- Resolution of the 11th Vietnam Communist Party Congress, Socio-Economic Development Strategy for 2011-2020.
- Decision No. 432/QD-TTg dated April 22, 2012 of the Prime Minister approving the National Strategy for sustainable development 2011-2020.
- Official Letter No. 3310 / BNN-KH dated October 12, 2009 of the Ministry of Agriculture and Rural Development, Approving the Strategy for Agriculture and Rural Development 2011-2020.
- Decision No. 122 / QD-TTg dated January 10, 2013 of the Prime Minister approving the National Strategy for the Protection, Care and Promotion of the People's Health 2011-2020, vision to 2030.
- Decision No. 376 / QD-TTg dated March 20, 2015 of the Prime Minister, approving the National Strategy on cancer, cardiovascular, diabetes, chronic obstructive pulmonary disease, bronchial asthma and Other non-contagious diseases in the period 2015-2025.
- Decision No. 172/2007 / QD-TTg of the Prime Minister dated 16 November 2007 approving the National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020.
- Decision No. 2139 / QD-TTg dated December 5, 2011 of the Prime Minister, National Strategy on Climate Change
- Decision No. 104/2000 / QD-TTg dated August 25, 2000 of the Prime Minister, the National Strategy for rural clean water supply and hygiene up to 2020.
- Decision No. 1250 / QD-TTg dated July 31, 2013 of the Prime Minister on the National Strategy on Biodiversity up to 2020 with a vision to 2030.
- Decision No. 81/2006 / QD-TTg dated April 14, 2006 of the Prime Minister approving the National Strategy on Water Resources to 2020.
- Decision No. 1393 / QD-TTg dated July 25, 2012 of the Prime Minister, National Green Growth Strategy 2011-2020
- Decision No. 1419 / QD-TTg dated September 7, 2009 of the Prime Minister, the strategy of cleaner

production in the industry until 2020.

- Resolution No. 24 / NQ / TW dated June 3, 2013 of the Party Central Committee on active response to climate change, strengthening natural resources management and environmental protection.
- Decision No. 32 / QD-TTg dated January 13, 2015 by the Prime Minister, Synchronous Program Development and upgrading of clusters and value chains of products of competitive advantage: Information technology, textiles, wage processing.
- Decision No. 76 / QD-TTg dated January 11, 2016 of the Prime Minister, the National Plan of Action for Sustainable Production and Consumption up to 2020 with a vision to 2030.
- Decision No. 366 / QD-TTg dated March 31, 2012 of the Prime Minister, National Target Program for Rural Water Supply and Sanitation 2012-2015.
- Decision No. 1427 / QD-TTg dated October 02, 2012 of the Prime Minister, the National Target Program on Energy Efficiency and Conservation in the period 2012-2015.
- Decision No. 1659 / QD-TTg dated November 7, 2012 of the Prime Minister, the National Urban Development Program 2012-2020.
- Resolution No. 46 NQ-TW dated February 23, 2005 of the Politburo on the protection, care and promotion of the people's health in the new situation.
- Resolution No. 63 / NQ-CP dated December 23, 2009 on National Food Security
- Decision No. 251 / QD-TTg of the Prime Minister dated 17 February 2016 approving the scheme on attraction, management and use of ODA capital and preferential loans of foreign donors in the period 2016-2020.
- Decision No. 644 / QD-TTg dated May 5, 2014 of the Prime Minister approving the Scheme on Support to Small and Medium Enterprises for the development of industrial linkage clusters in the value chain of rural agriculture.
- Decision No. 899 / QD-TTg dated June 10, 2013 of the Prime Minister on the project of agricultural restructuring in the direction of enhancing added value and sustainable development.
- Decision No. 428 / QD-TTg dated March 18, 2016 of the Prime Minister on the adjustment of the national electricity development planning for 2011-2020 with a vision to 2030 (hereinafter referred to as Electricity Regulation VII).

Basically, Vietnam has issued a number of policies to support the implementation of sustainable development goals in general and the goals of Water, Energy and Food in particular.

iii. Current status of SDG implementation in Vietnam

According to the Sustainable report 2019 - Transformations to achieve the UN's SDGs , overall performance of Vietnam is ranked at 54, a rise of three levels compared to the previous year (fig. 52). From the average performace of SDGs (fig. 53), only SDG-7 reached above 75%, while the performance of SDG-2 and 6 are still lower than 75%. Gnerally, SDG-2, SDG-6 and SDG-7 are trending up (Table 24).

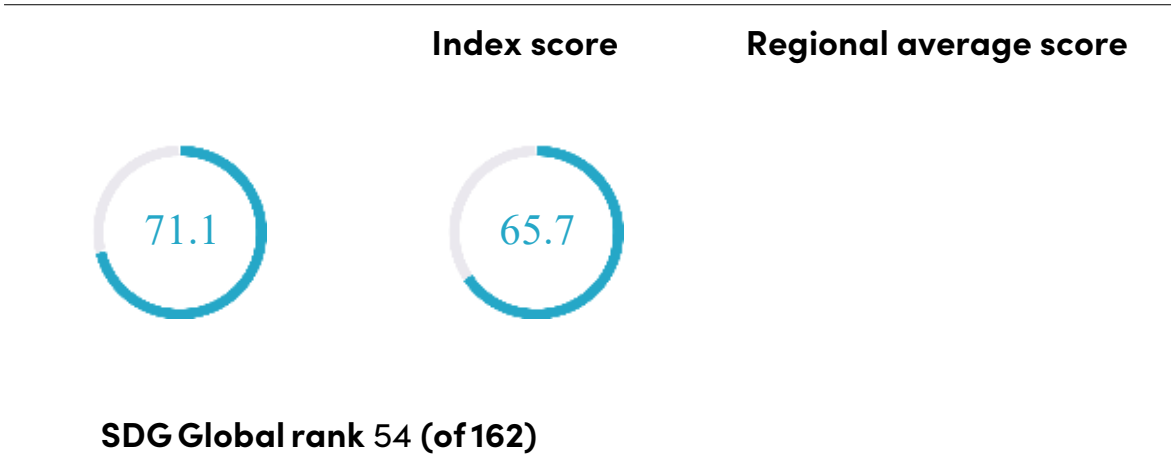


Figure 52: Overall performance

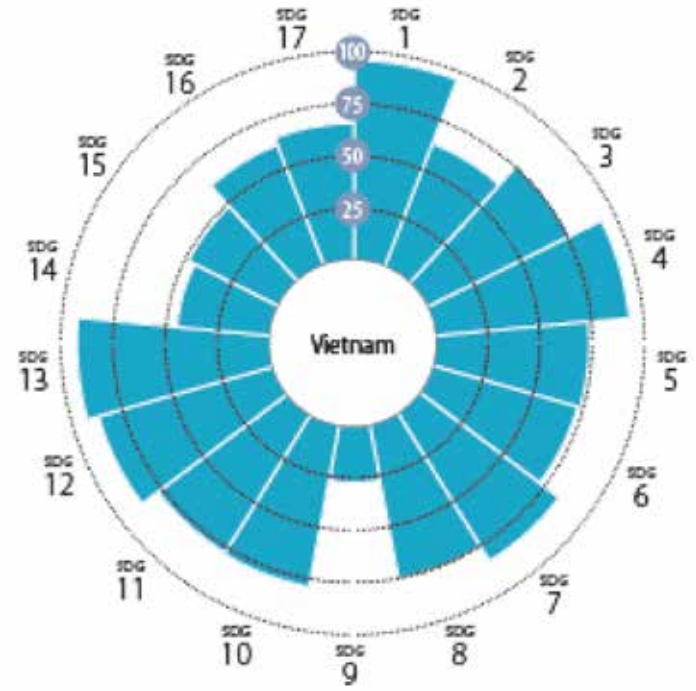


Figure 53: Average performace

Table 24: Trends of Water (SDG6), Energy (SDG7) and Food (SDG2) performance (UN, 2019)

No.	SDG	Value	Trend
1	**SDG2 – Zero Hunger**		
1.1	Prevalence of undernourishment (% population)	**10.8**	↑
1.2	Prevalence of stunting (low height-for-age) in children under 5 years of age (%)	**24.6**	↑
1.3	Prevalence of wasting in children under 5 years of age (%)	**6.4**	↑

No.	SDG	Value	Trend
1.4	Prevalence of obesity, BMI ≥ 30 (% adult population)	**2.1**	↑
1.5	Cereal yield (t/ha)	**5.4**	↑
1.6	Sustainable Nitrogen Management Index	**0.7**	••
1.7	Human Trophic Level (best 2-3 worst)	**2.3**	↓
2.	**SDG6 – Clean Water and Sanitation**		
2.1	Population using at least basic drinking water services (%)	**91.2**	↑
2.2	Population using at least basic sanitation services (%)	**78.2**	↑
2.3	Freshwater withdrawal as % of total renewable water resources	**12.8**	••
2.4	Imported groundwater depletion (m^3/year/capita)	**3.2**	••
2.5	Anthropogenic wastewater that receives treatment (%)	**0.2**	••
3	**SDG7 – Affordable and Clean Energy**		
3.1	Access to electricity (% population)	**100**	↑
3.2	Access to clean fuels & technology for cooking (% population)	**66.9**	↑
3.3	CO_2 emissions from fuel combustion / electricity output ($MtCO_2$/TWh)	**1.1**	↑

Notes:

↓ Decreasing → Stagnating

↑ On track or maintaining SDG achievement •• Information unavailable

The full title of Goal 2 "Zero Hunger" is "End hunger, achieve food security and improved nutrition and promote sustainable agriculture".

iv. Actions

On Jun 04, 2019, the Prime Minister signed Decision No. 681/QD-TTg promulgating a roadmap for implementing Vietnam's sustainable development goals by 2030.

The decision set out a roadmap to implement 17 sustainable development goals such as: End all forms of poverty; hunger eradication, ensuring food security, improving nutrition and promoting sustainable agricultural development; Ensure a healthy life and enhance the well-being of people of all ages; Ensuring quality, fair, comprehensive education and promoting lifelong learning opportunities for everyone; Achieving gender equality; increase rights and create opportunities for women and girls; Ensuring sustainable, comprehensive and continuous economic growth; creating full employment, productivity and good jobs for everyone; Ensuring sustainable production and consumption; Timely and effectively respond to climate change and natural disasters, and so on.

Regarding the goal of hunger elimination, ensuring food security, improving nutrition and promoting sustainable development, the Decision set out a roadmap to 2020 to basically solve hunger, until 2025 by which hunger should have been eradicated.

In order to achieve the 2030 goal of raising agricultural productivity and agricultural labor income by 1.5, the roadmap involves implementing a per capita income in rural areas of 43 million VND by 2020, 60 mil-

lion by 2025, and 90 million by 2030.

For the goal to 2030, 'Ensure that all learners are equipped with the knowledge and skills necessary to promote sustainable development', the roadmap clearly states: By 2020, 100% of teachers reaching the standard of training and above and the rate of schools having basic education programmes on gender, prevention of violence and abuse, providing knowledge about HIV by 2020 is 80%, and by 2025 this will increase to 90% and 100% by 2030.

For the purpose of achieving gender equality, increasing rights and opportunities for women and girls, significantly reducing all forms of violence against women and girls in public or private places, including the sale, sexual exploitation and other disclosure forms, the roadmap to 2020 states, as the percentage of women who have been discovered, supported and intervened in a timely manner, 70%, which is gradually increased to 80% in 2025 and 90% in 2030; The goal for the percentage of girls who report violence and abuse and discovered support and timely intervention by 2020 is 100%.

The roadmap for achieving the goal is to ensure sustainable, comprehensive and continuous economic growth; creating full employment, productivity and good jobs for everyone; from 2020 to 2030 GDP growth will maintain an increase of 5–6% annually; GDP growth per capita will maintain growth from 4–4.45% annually; the growth rate of labor productivity maintained at 5% annually.

The decision clearly states: For the goals which have no roadmap, the ministries and agencies assigned to preside over them will have specific plans and programmes to implement for each objective in accordance with the requirements of the national action to implement the Agenda for Sustainable Development approved by the Prime Minister.

In addition, a number of national action programmes have been prioritized by the government to achieve SDGs, including:

- Development of institutional systems suitable to sustainable development requirements
- Strengthening of sustainable development management capacity of staffs
- Mobilizing some people to participate in implementing sustainable development
- Developing and implementing action programmes on sustainable development of the sectors and localities
- Strengthening international and regional cooperation in sustainable development and environmental protection
- Positive trends in policies to ensure clean industrialization
- Placing of sustainable development of agriculture and rural development being as a top priority area as per the Strategic Orientation Documents for Sustainable Development

3.3.3.2 Stakeholder perception

(i). Perception of stakeholders on the importance of nexus aspects for the country actions on Water (SDG-6), Energy (SDG-7) and Food (SDG-2)

When asked about experiences with MDGs or other existing scientific evidences, all respondents think that the country's planning for SDG-2, SDG-6 and SDG-7 should be well coordinated to achieve sustainable development.

The qualitative weight for level of dependency of SDG-2 achievement on targets of SDG-6 (fig. 54) from interviewees showed that almost all interviewees think that there is strong dependency of SDG-2 achievement on targets of SDG-6 with the target 6.1 (Universal and equitable access to safe and affordable drinking water for all), 6.2 (Achieve access to adequate and equitable sanitation and hygiene for all), 6.3 (Substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity, and 6.7 (Support and strengthen the participation of local communities in improving water and sanitation management) with a ratio from 65–80%, while 50% of survey results show a low dependency of SDG-2 achievement on targets of SDG-6, with 50% of the target 6.4 (Implement integrated water resources management at all levels), 67% of 6.5 (Protect and restore water-related ecosystems) and 81% of 6.6 (Expand international cooperation and capacity-building for sustainable water management.

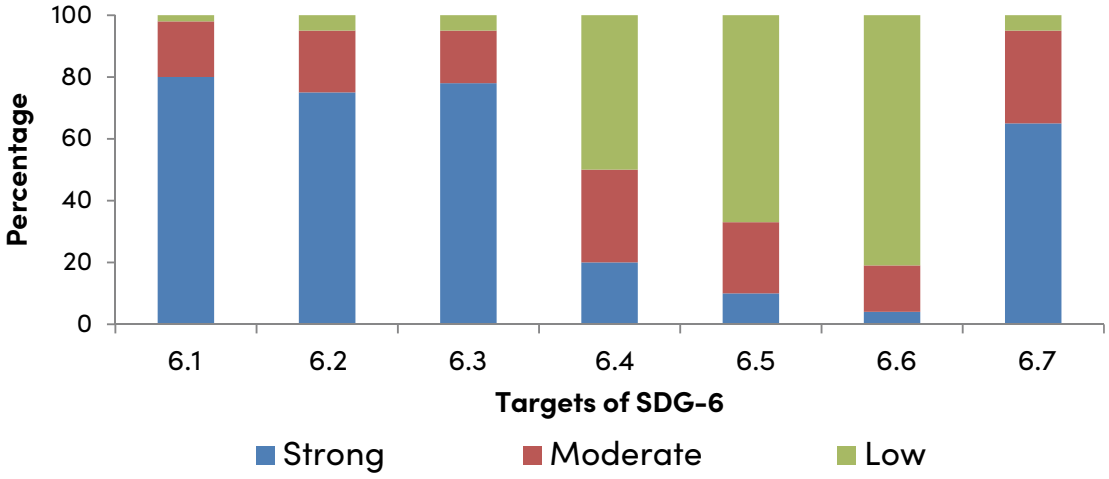


Figure 54: Level of dependency of SDG-2 achievement on targets of SDG-6

The level of dependency of SDG-2 achievement on targets of SDG-7 (fig. 55) is rated low for all targets. The low ratio comprises 83% of target 7.1 (Ensure universal access to affordable, reliable and modern energy services), 50% of 7.2 (Increase the share of renewable energy in the energy mix), 81% of 7.3 (Improvement in energy efficiency), 78% of 7.4 (Enhance international cooperation to facilitate access to clean energy research and technology), and 84% of 7.5 (Expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries). The ratio of qualitative weight for strong level of dependency of SDG-2 achievement on targets of SDG-7 is lower than 10%, except for target 7.2 (20%).

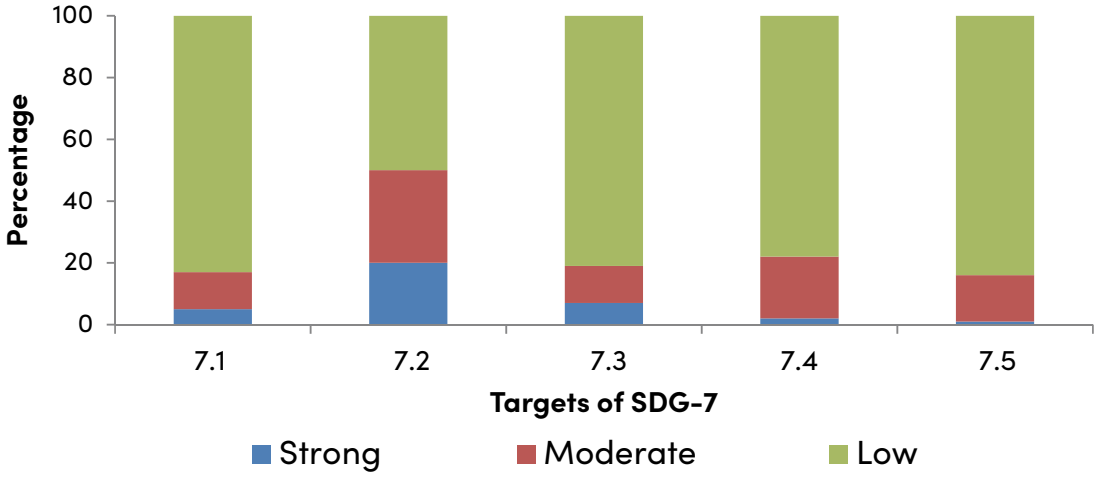


Figure 55: Level of dependency of SDG-2 achievement on targets of SDG-7

The survey results of the qualitative weight for the level of dependency of SDG-6 achievement on targets of SDG-2 (fig. 56) shows that there is a strong level of dependency of SDG-6 achievement on targets of SDG-2. The ratio varies widely: 87% of the target 2.1 (End hunger and ensure access by all people), 80% of 2.2 (End all forms of malnutrition), 85% of 2.3 (Double the agricultural productivity and incomes of small-scale food producers), 65% of 2.4 (Ensure sustainable food production systems and implement resilient agricultural practices), 75% of 2.5 (Maintain the genetic diversity of seeds), 85% of 2.6 (Increase investment in rural infrastructure, technology, research and extension service), and 65% of 2.8 (Ensure the proper functioning of food commodity markets). Only for target 2.7 (Correct and prevent trade restrictions and distortions in world agricultural markets) do interviewees think that the level of dependency is moderate. The ratio of low level of dependency is small, from 1–10%.

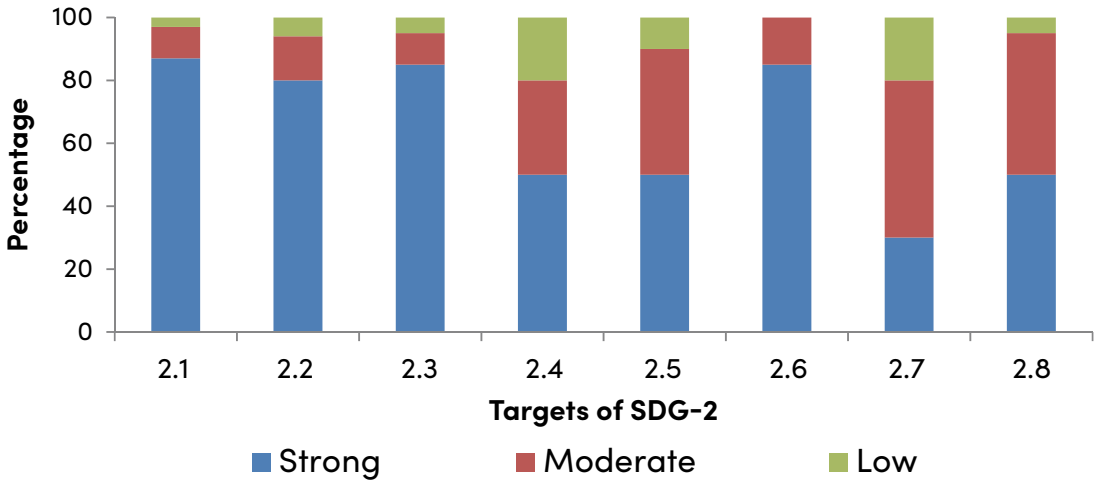


Figure 56: Level of dependency of SDG-6 achievement on targets of SDG-2

Figure 57 shows qualitative weight for the level of dependency of SDG-6 achievement on targets of SDG-7.

In Vietnam, the government monopolizes in the supply of energy, so when evaluating target 7.1 (Ensure universal access to affordable, reliable and modern energy services), interviewees think that it has low level of dependency of SDG-6 (17%), although the contribution of hydro power to the national grid electricity is not too low. Currently, according to the electricity plan, the ratio of renewable energy is being increased, thus all interviewees suggest that there is a strong level of dependency of SDG-6 achievement on targets of SDG-7 in the target 7.2 (Increase the share of renewable energy in the energy mix), while the qualitative weight on target 7.3, 7.4 and 7.5 shows a low level of dependency of SDG-6 achievement on targets of SDG-7.

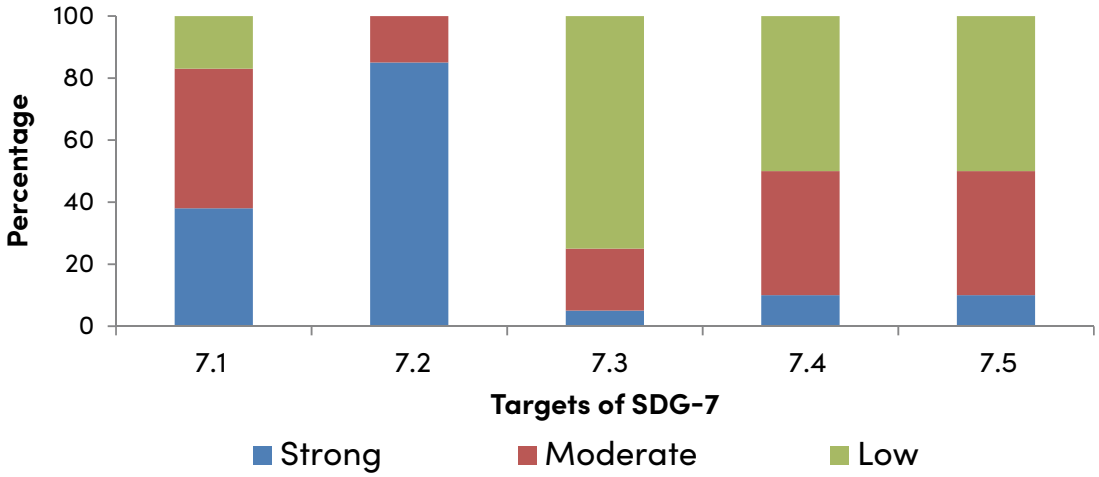


Figure 57: Level of dependency of SDG-6 achievement on targets of SDG-7

Figure 58 shows qualitative weight for the level of dependency of SDG-7 achievement on targets of SDG-2

The reviews show a strong level of dependency of SDG-7 achievement on targets of SDG-2, especially on targets 2.1, 2.3, 2.4, 2.6. There is a low level of dependency on the targets of 2.5, 2.7 and 2.8, while target 2.2 is assessed as of moderate level.

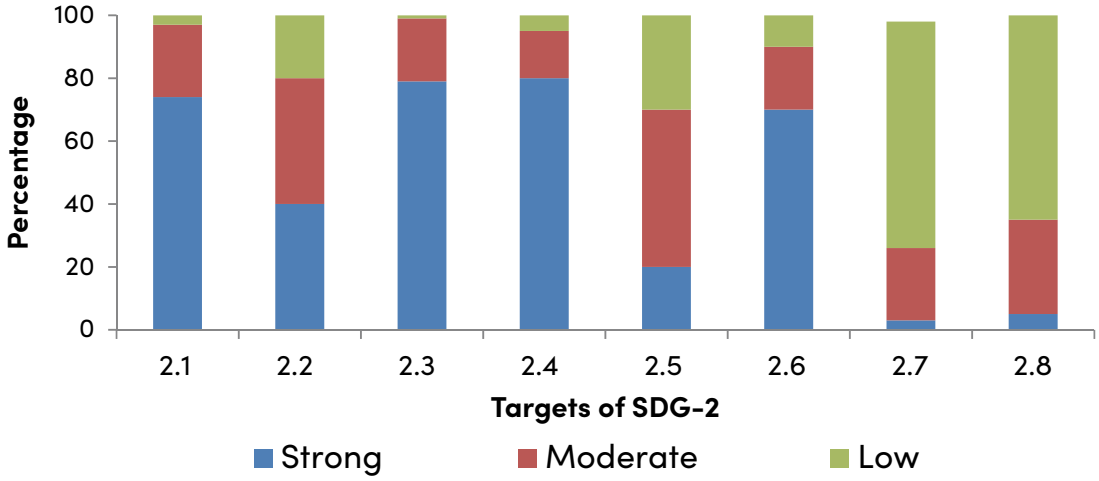


Figure 58: Level of dependency of SDG-7 achievement on targets of SDG-2

Figure 59 shows qualitative weight for level of dependency of SDG-7 achievement on targets of SDG-6

The level of dependency of SDG-7 achievement on targets of SDG-6 is strong for targets 6.1, 6.2 and 6.3, moderate for target 6.4, 6.5 and 6.6 and low for target 6.7.

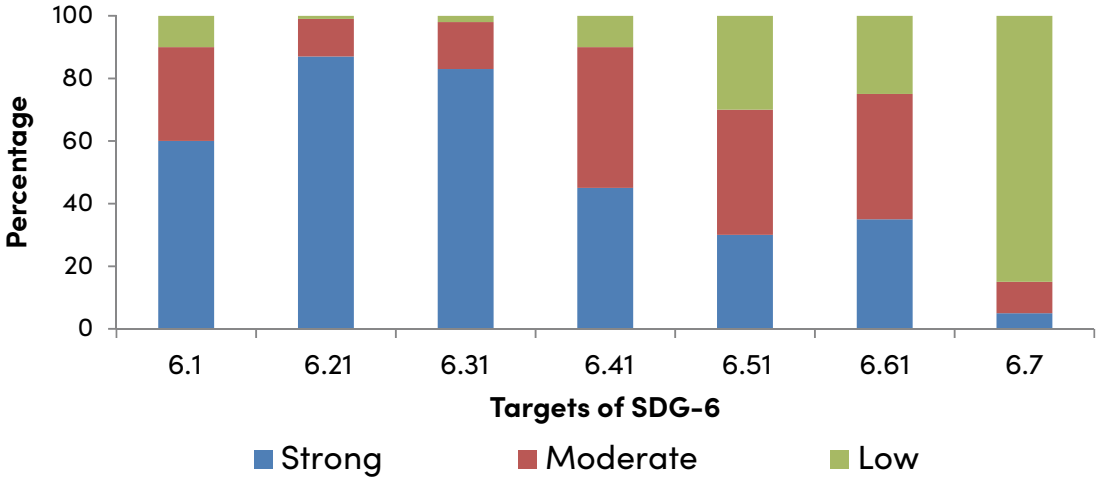


Figure 59: Level of dependency of SDG-7 achievement on targets of SDG-6

Figure 60 shows Key influence of SDG- 2, SDG-6 and SDG-7 for country planning

The stakeholder p[perception assessed the key influence of SDG- 2, SDG-6 and SDG-7 for country planning including policy making, budget allocation, promoting itegrted planning and guiding development cooperation as strong, with a ratio from 67–87% in all criteria.

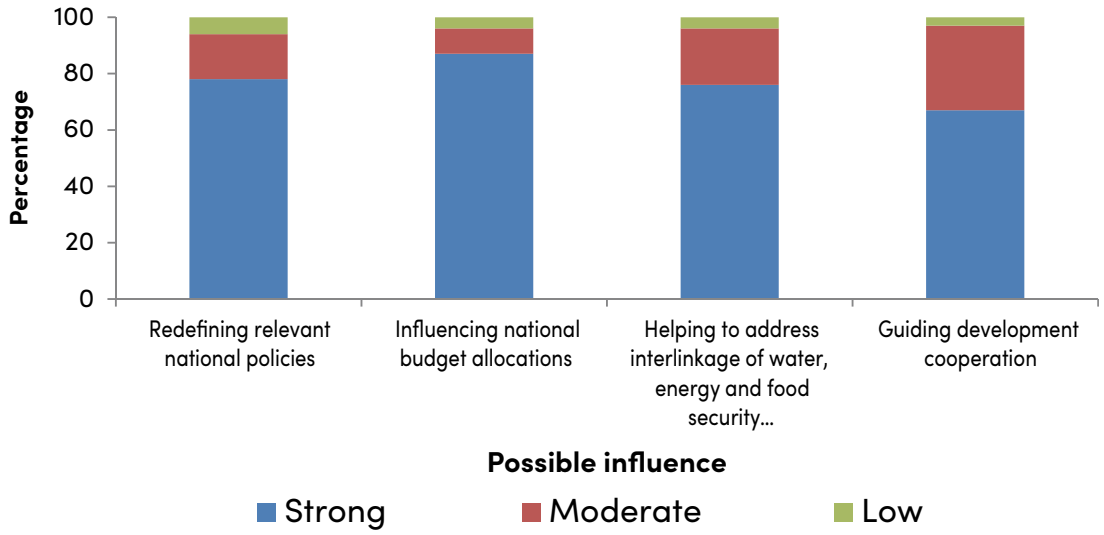


Figure 60: Key influence of SDG- 2, SDG-6 and SDG-7 for country planning

Figure 61 shows qualitative weight for level of integration of water, energy, food nexus in country actions and policy

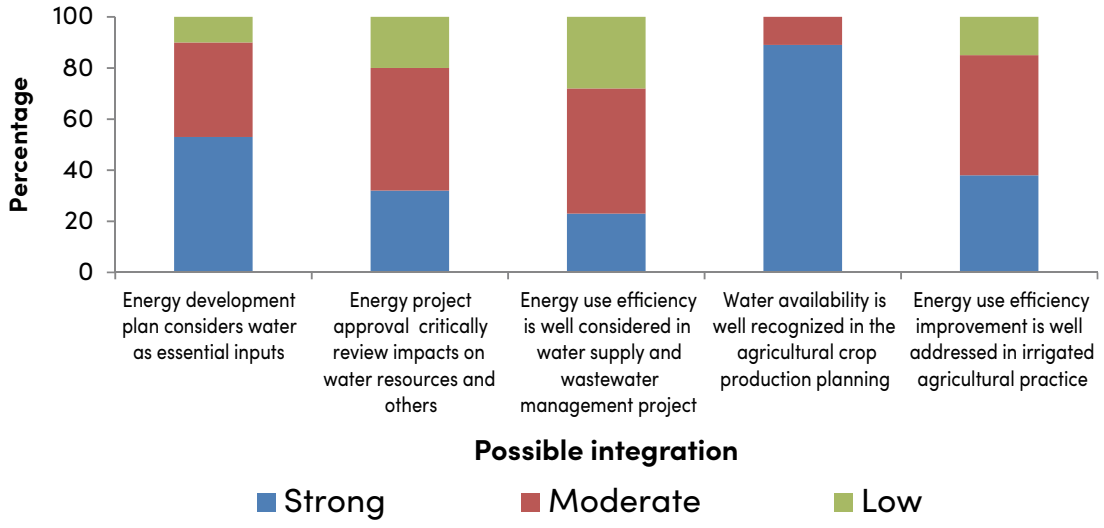


Figure 61: Qualitative weight for level of integration of water, energy, food nexus in country actions and policy

The level of integration of water, energy, and food nexus agreed on is from moderate to strong in country actions and policy on (1) Energy development plan considers water as essential inputs; (2) Energy project approval critically reviews impacts on water resources and others, (3) Energy use efficiency improvement is well addressed in irrigated agricultural practice and (4) Energy use efficiency improvement is well addressed in irrigated agricultural practice; is strong in (5) Water availability is well recognized in the agricultural crop production planning; and moderate to slow in (6) Energy use efficiency is well considered in

water supply and wastewater management project.

(ii) Perception of stakeholders about readiness of the country to incorporate nexus aspects in the country actions on Water (SDG-6), Energy (SDG-7) and Food (SDG-2)

All interviewees think that the country is ready to implement the globally adopted target since it is in line with national targets, and also ready to implement global targets, but needs adjustment with national mid-long-term policies for all of SDG-2 (food), SDG-6 (water) and SDG-7 (energy).

READINESS STATUS	Opinion (Yes/No)
Food	
Country is ready to implement globally adopted target, since it is in line with national targets	*Yes*
Country is ready to implement global targets, but need adjust with national mid-long-term policies	*Yes*
Country is not ready to achieve global target, but willing to achieve it if international supports are available	*No*
Country will not follow global target	*No*
Water	
Country is ready to implement globally adopted target, since it is in line with national targets	*Yes*
Country is ready to implement global targets, but needs adjusting with national mid-long-term policies	*Yes*
Country is not ready to achieve global target, but willing to achieve it if international supports are available	*No*
Country will not follow global target	*No*
Energy	
Country is ready to implement globally adopted target, since it is in line with national targets	*Yes*
Country is ready to implement global targets, but needs adjustment with national mid-long-term policies	*Yes*
Country is not ready to achieve global target, but willing to achieve it if international supports are available	*No*
Country will not follow global target	*No*

Opinion on the country's readiness level to integrate nexus approach in implementation plan of SDG-2, SDG-6 and SDG-7
show that the country is ready to adopt a nexus approach but it needs significant efforts and international supports to do so.

Efforts are necessary to adopt a nexus approach in the process of translating global goals to the country actions

All national efforts on (1) Improvement of institutional coordination; (2) Need to establish coordinating body; (3) Sectoral plans should go through a cross sectoral discussion and approval process; (4) Financial allocation should be well coordinated, and (5) Awareness raising and capacity building of policy and decision makers are weighted strong with a ratio larger than 80% (fig. 62). No evaluation is rated as low, while international efforts is rated as moderate to strong.

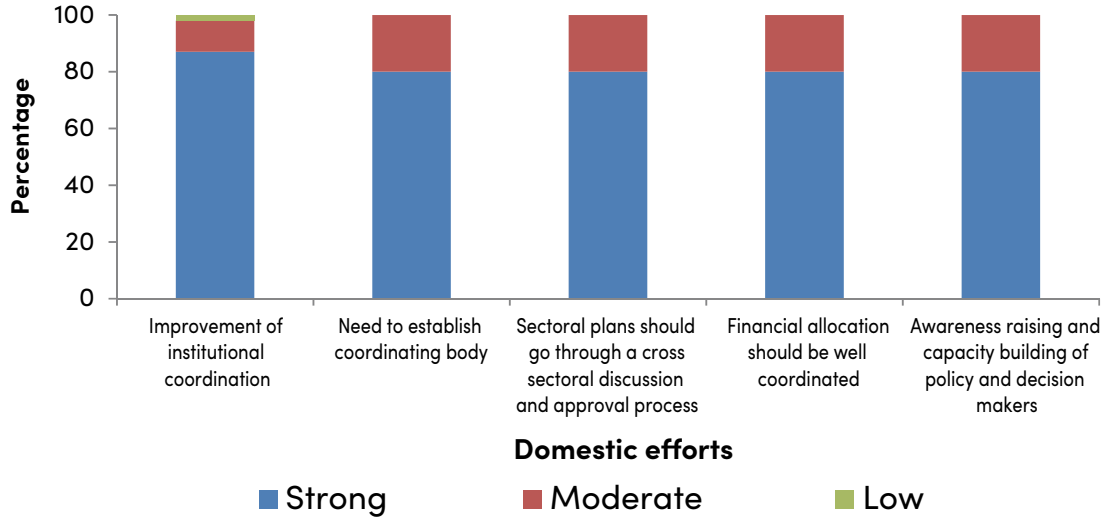


Figure 62: Domestic efforts are necessary to adopt nexus approach

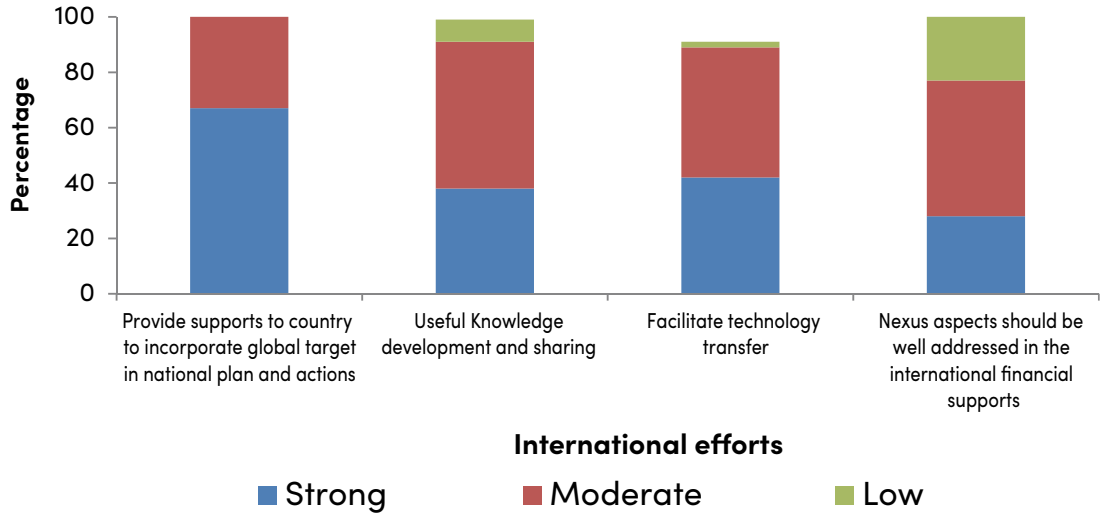


Figure 63: International efforts are necessary to adopt nexus approach

Coordination at national level is critical for planning of SDGs in a integrated manner. The agency can be the coordinating body for SDGs planning

All interviewees think that the agency to coordinate SDG planning should be Vietnam Agenda office, Ministry of Industry and Trade. There is no need to develop a new agency.

(iii). Perception of stakeholders about readiness of the country to establish an integrated monitoring approach on Water (SDG-6), Energy (SDG-7) and Food (SDG-2)

All interviewees think that the country has sufficient data available to monitor SDG-2, SDG-6 and SDG-7 in an integrated manner but that significant efforts are needed for all of SDG-2 (food), SDG-6 (water) and SDG-7 (energy).

3.3.3.3 Regression analysis and network analysis

The quantitative assessment of relationships among three major dimensions, Food (SDG-2), Water (SDG-6) and Energy (SDG-7) was based on the qualitative assessment results from the stakeholder surveys. Nine targets with strong to moderate correlation (three each of SGD-2, SDG-6 and SDG-7) were choosen for the regression analysis. The correlation among relevant targets is shown in Table 25 and the interlinkages among relevant targets under Food (SDG-2), Water (SDG-6) and Energy (SDG-7) are shown in figs. 64–67.

The results show that there are 16 out of 36 target couples which are closely correlated to each other on a strong to moderate level. A change in this target affects the achievement of the sustainable development goals of the other targets. These related targets are divided into two groups: (1) the targets in a goal and (2) the targets between different goals.

(i) Correlation of targets in a goal

SDG-6 (Water) (Energy): T6.1, T6.2 and T6.3 very strongly correlate. This reflects the true conditions of Vietnam. When water quality is improved through the expansion of construction and operation of wastewater treatment systems (T6.3), the water environment is protected, and safe water supply of sufficient quantity and quality is available to the public. (T6.1). Access to clean water will help ensure hygienic conditions; additionally, with adequate and equitable hygiene (T6.2), indiscriminate cinnamon release is also minimized, and environmental quality especially in rural areas is improved, which contributes to reducing the pressure of water pollution and implementing successfully target T6.1.
SDG-7: Among T7.1, T7.2 and T7.3, only T7.1 correlates with T7.3. In the context of fossil fuels becoming depleted, energy production costs are increasing, while demand increases continuously for economic development and booming population growth, and energy efficiency improvement (T7. 3). When T7.3 is implemented successfully, it will help to increase energy saving and contribute to successful implementation of the goal of ensuring energy access for all people (T7.1).
SDG-2 (Food): Like SDG6, the targets (T2.1, T2.2 and T2.3) are related with each other. The correlation of T2.1 and T2.2 is strong while the correlation of couples T2.1-T2.3 and T2.2-T2.3 is moderate. The results are consistent with the fact when all people are provided with enough food for their daily life (T2.1), the rate of malnutrition will also decrease (T2.2). Currently, Vietnam has successfully implemented this goal by ensuring 100% of people are not hungry. Therefore, a doubling of the agricultural productivity and loss of small-scale food producers did not contribute significantly to the change in the results of achieving targets T2.1 and T2.2.

(ii) Correlation of targets in different goals

When considering the correlation between the targets on SDG-2, SDG-6 and SDG-7, couples have strong

correlations including T6.1-T7.1, T6.1-T7.3, T6.2-T7.1, T6.2-T7.3, T6.3-T7.1, T6.3-T7.3 and moderate correlation including: T2.1-T7.2, T2.2- T7.2, T2.3-T7.2.

Couples of T6.1-T7.1, T6.1-T7.3 refer to achievements of universal and equitable access to safe and affordable drinking water. In order to produce and distribute clean water to all people in the country, electricity is also required for treatment processing. Achievement of access to adequate and equitable sanitation and hygiene (T6.2) and improvement of water quality by reducing pollution (T6.3) only succeed when the electricity sources are provided especially in the operation of the wastewater treatment systems (T6.2-T7.1, T6.2-T7.3, T6.3-T7.1, T6.3-T7.3). [please check- grammar is unclear]. Based on the current conditions of Vietnam, the study has found no relationship between sustainable targets on water with that to improve the rate of renewable energy use (T7.2).

Although the evaluation results show a moderate correlation of targets T2.1-T7.2, T2.2-T7.2, T2.3-T7.2, it also shows the important role of sufficient energy supply in food production, poverty reduction, reducing the rate of malnutrition and increasing agricultural crop productivity.

The above results show that targets of SDG-6 and SDG-2 are closely related to the targets of SDG-7. Meanwhile, no relationship between the targets of SDG-2 and SDG-6 has been found. This shows that there is currently no interaction between water consumption for water supply and food production and malnutrition reduction.

Table 25: Correlation among relevant targets

	T2.1	T2.2	T2.3	T6.1	T6.2	T6.3	T7.1	T7.2	T7.3
T2.1	**1.000**								
T2.2	0.995	**1.000**							
T2.3	0.833	0.894	**1.000**						
T6.1	-0.995	-1.000	-0.894	**1.000**					
T6.2	-0.996	-0.999	-0.893	0.999	**1.000**				
T6.3	-0.994	-0.946	-0.758	0.946	0.946	**1.000**			
T7.1	-0.986	-0.986	-0.890	0.986	0.986	0.934	**1.000**		
T7.2	-0.847	0.867	0.728	-0.867	-0.866	-0.805	-0.83	**1.000**	
T7.3	-0.947	-0.947	-0.765	0.947	0.948	0.999	0.933	-0.807	**1.000**

Note: *Correlation is significant at the 0.01 level (2-tailed).*

Strong correlation (>0.9) Moderate correlation (0.6-0.8)

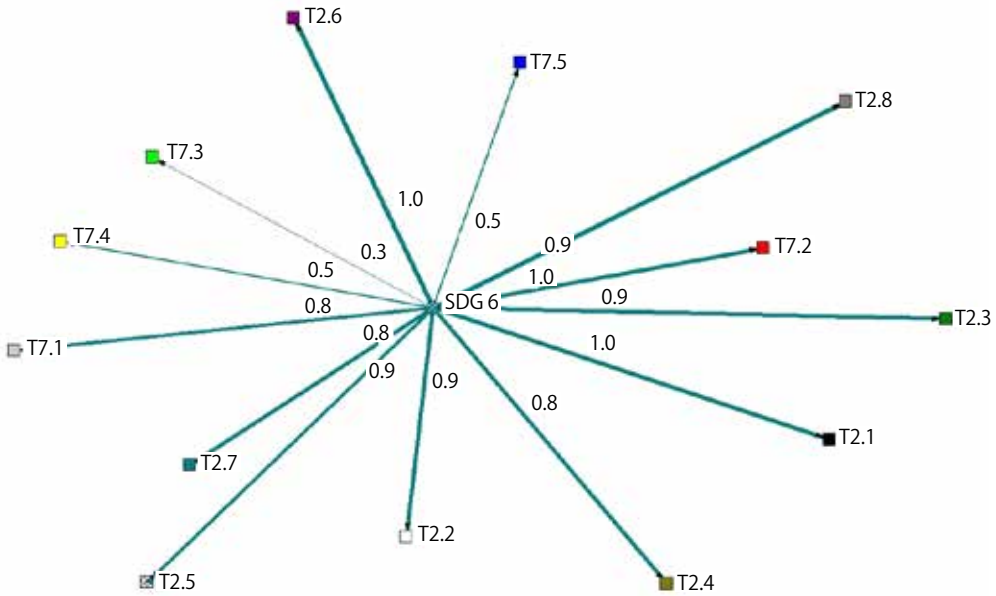


Figure 64: SDG-6 (Water) and SDG-7 (Energy), SDG-2 (Food)

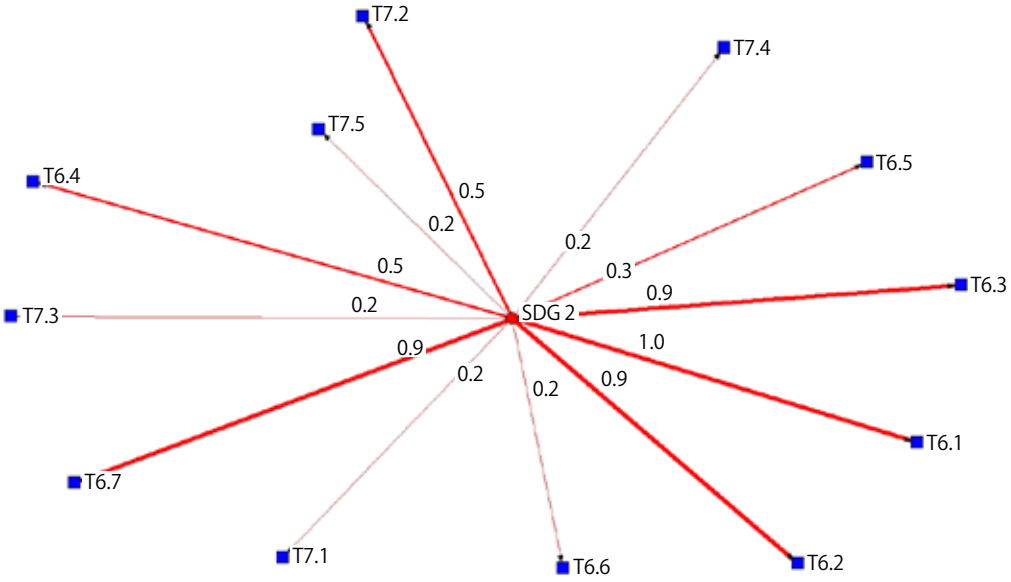


Figure 65: SDG-2 (Food) and SDG-6 (Water), SDG-7 (Energy)

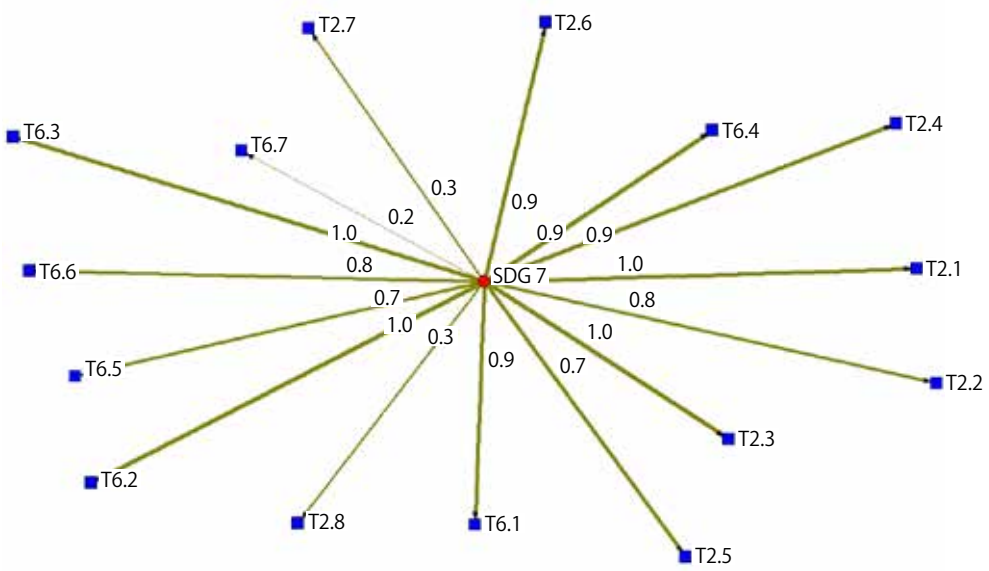


Figure 66: SDG-7 (Energy) and SDG-2 (Food), SDG-6 (Water)

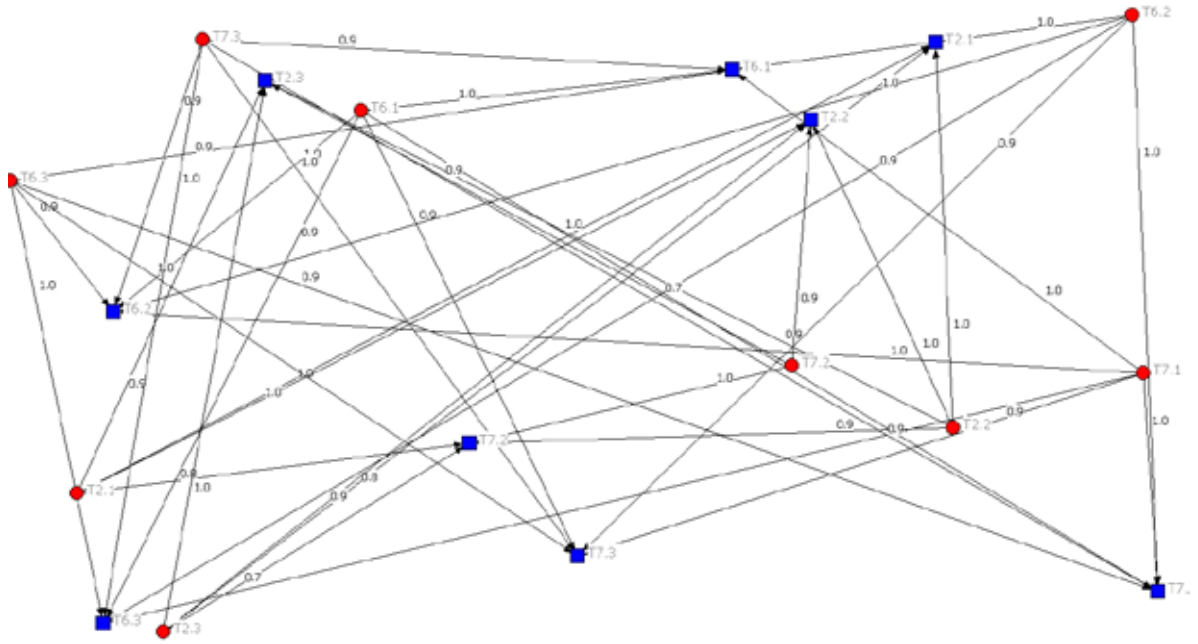


Figure 67: Interlinkages among relevant targets under SDG-2 (Food), SDG-6 (Water) and SDG-7 (Energy)

3.3.3.4 Prioritization of interlinkages for actions

Figures 68–70 show the estimated weight for each attribute. The figure shown in each column represents the weight of importance for the attribute, calculated based on the eigen-vector procedure.

When the targets from the SDG-6 were compared (fig. 68), T6.1 was given the highest priority by MON-

RE, while T6.3 was given less priority. On the other hand, NIN gave the highest priority on T6.3, and they put off T6.1MARD and NGOs preferred T6.2. MOIT and VICC gave the nearly same priority for the three targets.

The priorities of SDG-7 are shown in fig. 69. T7.1 received more attention than T7.2 and only MOIT and NIN put first priority on T7.2. Fig. 70 shows the stakeholders' preferences on SDG-2, which varied. MOIT and NGOs showed the highest preferences for T2.1. On the other hand, MARD, MONRE gave the lowest priority for T2.1 and gave high priority for T2.3. Similar preferences on the three targets were also found for MONRE.

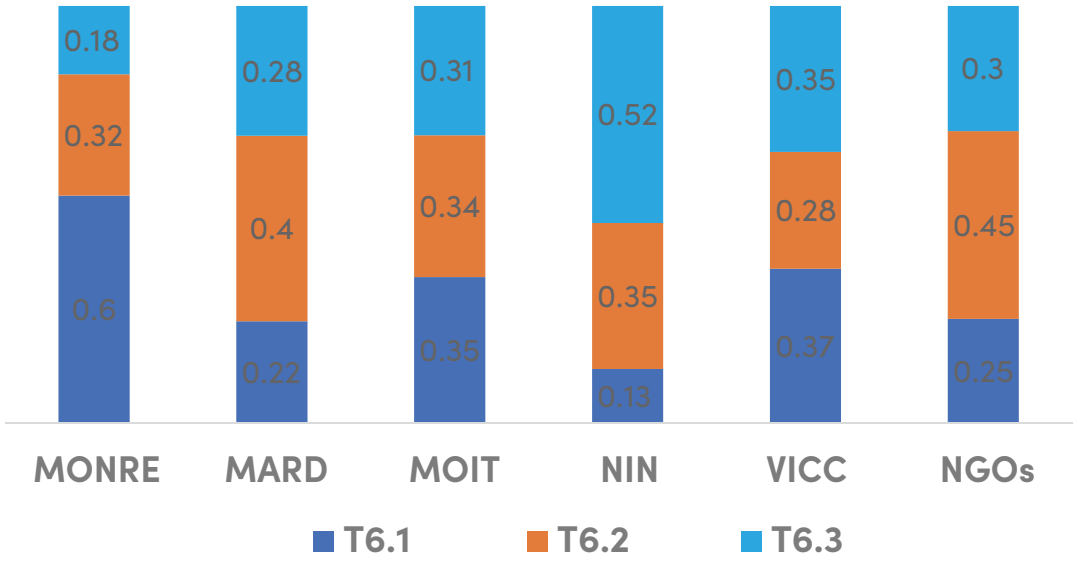


Figure 68: Comparison of important targets of SDG-6 (Water)

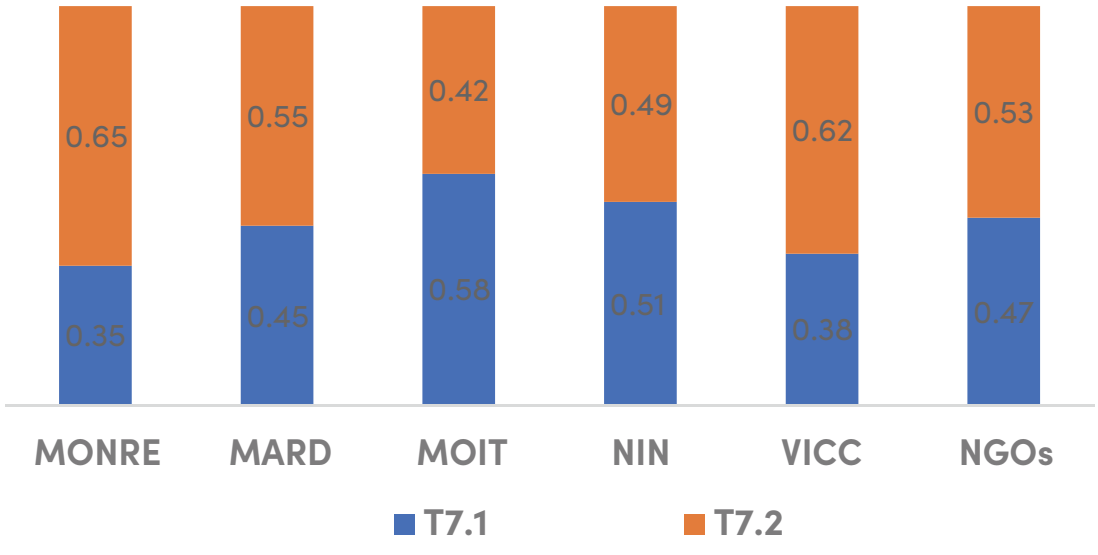


Figure 69: Comparison of important targets of SDG-7 (Energy)

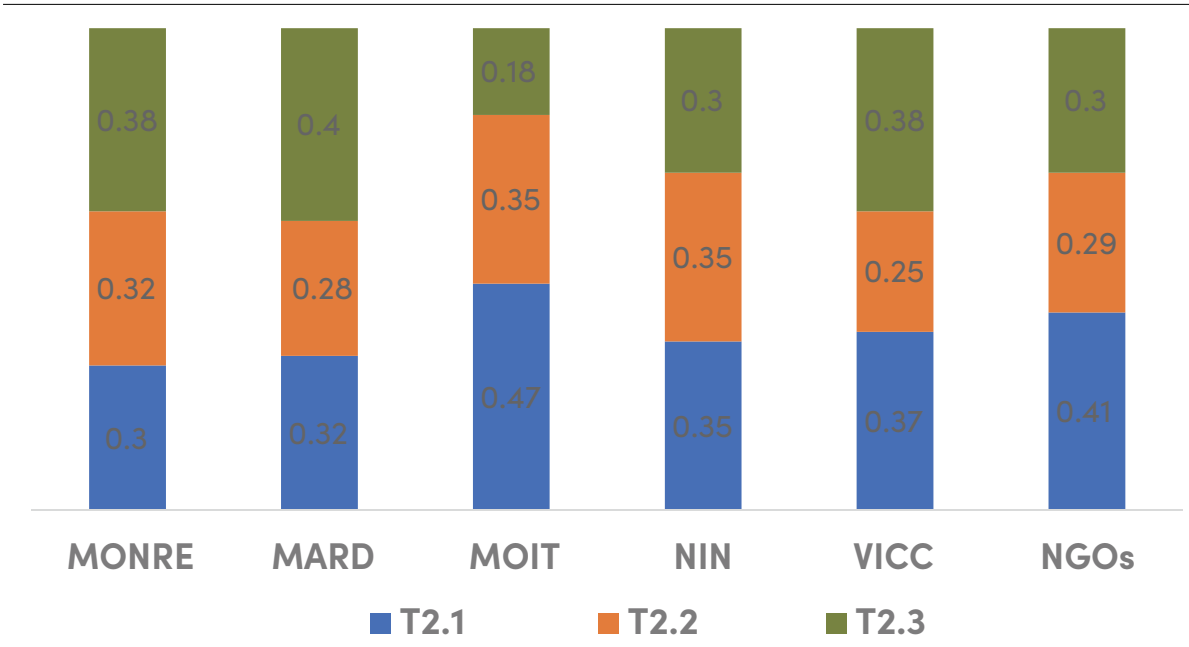


Figure 70: Comparison of important targets of SDG-2 (Food)

After the calculation of the weight in each level, the absolute weight of each attribute (all chosen targets from SDG-6, SDG-7 and SDG-2) was calculated as shown in fig. 71. The absolute weights can be directly compared between the different stakeholders. The results show that MONRE wants to concentrate on T6.1, T7.2, T6.3, T6.2. MARD prefers T6.1, T2.3, T7.2, T7.1. MOIT is concerned with T6.1, T2.3, T7.2, T2.1. NIN prefers T6.1, T2.1, T2.2, T6, 2, T7.2. VICC concentrates on T6.1, T7.2, T7.1, T2.1. NGOs are concerned with T2.1, T6.2, T7.3, T6.3. The different ministries, institutes and organizations exhibited different priorities in implementing the sustainable development goals. From a general viewpoint, the prioritized targets range from T6.1, T7.2, T6.2, T7.1, T2.1 and T2.2. Based on the different functional roles, each stakeholder should issue appropriate policies on the basis of synthesizing and synchronization to reach the sustainable development goals in Water-Food-Energy.

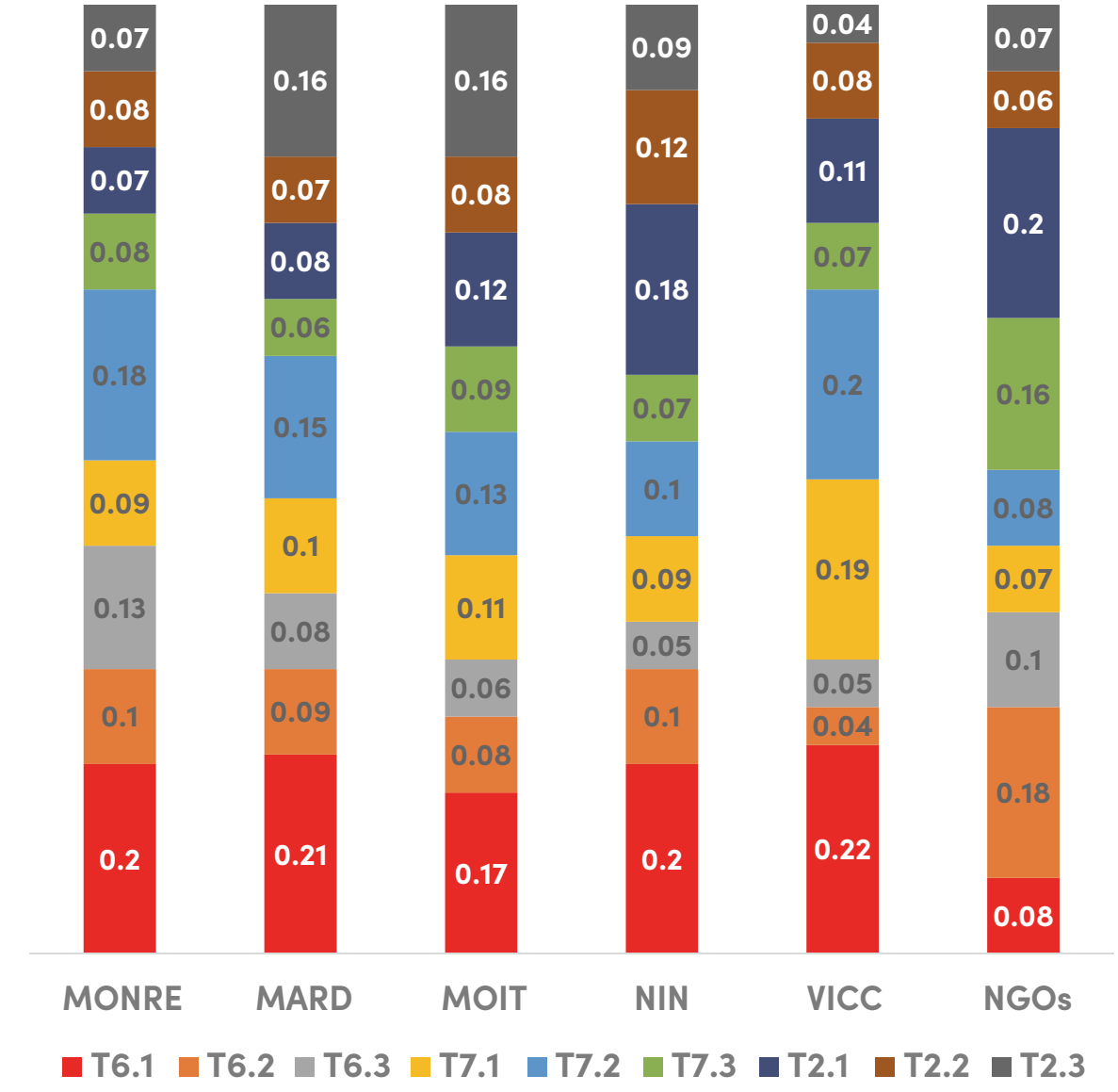


Figure 71: Weight of interlinked targets under SDG-6, SDG-2 and SDG-7

From the weight of interlinked targets under SDG-6, SDG-2 and SDG-7 from different stakeholder viewpoints and the results of ccorrelation analysis among relevant targets, the prioritization of interlinkages in Vietnam is found as follows (Table 26):

Table 26: Prioritization of interlinkages in Vietnam under SDG-6, SDG-2 and SDG-7

	T2.1	T2.2	T2.3	T6.1	T6.2	T6.3	T7.1	T7.2	T7.3
T2.1									
T2.2	0.995								
T2.3	0.833	0.894							
T6.1									
T6.2				0.999					
T6.3				0.946	0.946				
T7.1				0.986	0.986	0.934			
T7.2		0.867	0.728						
T7.3				0.947	0.948				

Note:

High priority (>0.9) Moderate priority (0.6-0.8)

Table 26 shows that when T6.1, T7.2, T6.2, T7.1, T2.1 and T2.2 are prioritized to implement, they will lead to sustainable development of other targets, including T6.3, T7.3 and T2.3 accordingly.

3.3.4 Conclusion

Research results show that Vietnam has institutions and government apparatus for the implementation of sustainable development goals. Vietnam has issued many policies related to sustainable development, in which Food (SDG-2), Water (SDG-6) and Energy (SDG-7) targets are considered as a key goal for the economic development of country. The results of qualitative and quantitaitive analysis of he correlation between the targets showed that there are 16/36 target couples which are closely correlated to each other from the strong to moderate levels. The change of this target affects the achievement of the sustainable development goals of the other targets. Strong correlation between targets in each goal has been found. In different goals, targets of SDG-6 and SDG-2 have a strong relationship with that of SDG-7. Meanwhile the relationship between the targets of SDG-2 and SDG-6 has not been found.

The weight of interlinked targets under SDG-6, SDG-2 and SDG-7 results showed that the different ministries/institute/organization have difference in priority to implement the sustainable development goals. From general viewpoint, the short-list of prioritized interlinkages in Vietnam are included T6.1, T7.2, T6.2, T7.1, T2.1 and T2.2. Based on the different functional roles, each stakeholder should issue appropriate policies on the basis of synthesizing and synchronizing and actions to meet related targets on Water-Food-Energy effectively and more swiftly.

To comprehensively evaluate the implementation of sustainable development goal of each country in particular, in addition to the three key goals of water, energy, food, the study also proposes to expand the evaluation of other relevant goal to water, energy, food to see more clearly the essential role of these three goals in relation to the successful implementation of sustainable development.

4. Conclusions

4. Conclusions

Water, energy and food are basic elements for survival and essential inputs for economic growth and sustainable development. Therefore, the importance of water, energy and food security has been well recognized The 2030 Agenda for Sustainable Development with 17 goals; and particularly reflected in the following Sustainable Development Goals (SDGs) including SDG-2 (food), SDG-6 (water) and SDG-7 (energy) The world has been facing various challenges of security of these three resources. Particularly, with Asia and the Pacific region taking the foremost role in terms of economy and development, the continuing growth in population and rapid urbanization process will place immense pressures on these resources in many cities and provinces around the region, which will lead to increasing conflicts unless an integrated planning and decision making framework is incorporated in development pathways. The study was conducted to identify priority interlinkages between the targets of SDG-2, SDG-6 and SDG-7 that would guide the policy and decision makers to take integrated approach for SDGs implementation. In order to achieve this objective, the study employed a set of both qualitative and quantitative methods including stakeholder perception survey, network analysis, regression analysis and cross sectorial group discussion, through case studies conducted in Bangladesh, India and Viet Nam. Following are the key findings of the study

- Three priority targets for each SDGs including SDG-2, SDG-6, and SDG-7 were identified for each case study countries. However, priority interlinkages varied country to country depending on national strategic visions and priorities.
- Key stakeholders of the case study countries (India, Bangladesh and Viet Nam) have high level of perception about interdependency of SDG-2, SDG-6 and SDG-7.
- In case of India, out of 182 interlinkages, 124 of them showed synergistic relationship. It implies that there is high potential to capture synergies through taking the nexus approach in SDGs implementation that can provide resource effective solutions and contribute to achieve three key SDGs swiftly. The identified nine priority targets are included T 2.1, T 2.2, T 2.4, T 6.1, T 6.2, T6.3, T 7.1, T 7.2 and T 7.3. Among the interactions between these nine targets, eight interlinkages are identified as high priority ($p > 0.9$) for immediate integrated planning and actions. Total ten interactions are moderate ($p= 0.6$ to 0.9) and eight are low priority interlinkages ($p<0.6$).
- In case of Bangladesh identified priority SDGs targets on food, water and energy security are T 2.1, T 2.2, T 2.4, T 6.1, T 6.2, T6.3, T 7.1, T 7.2 and T 7.3. Total three interlinkages are identified high priority ($p> 0.9$), two are moderate ($p= 0.6$ to 0.9) and sixteen are low priority interlinkages ($p<0.6$).
- In case of Viet Nam, the different ministries/institute/organization have difference in priority to implement the sustainable development goals. However, the stakeholder workshop come up with an agreed short list of priority targets for Vietnam including T6.1, T7.2, T6.2, T7.1, T2.1 and T2.2. The quantitative assessment of dependency between the prioritized targets, nine interactions are found high priority and four are medium priority.

Since SDGs are interdependent, under the business as usual approach the country cannot achieve them. Hence, an integrated approach is required and water energy and food nexus approach provided an entry point to capture and utilise potential synergies in implementation of SDG-2, SDG-6 and SDG-7 collectively.

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ISBN 978-4-88788-238-6