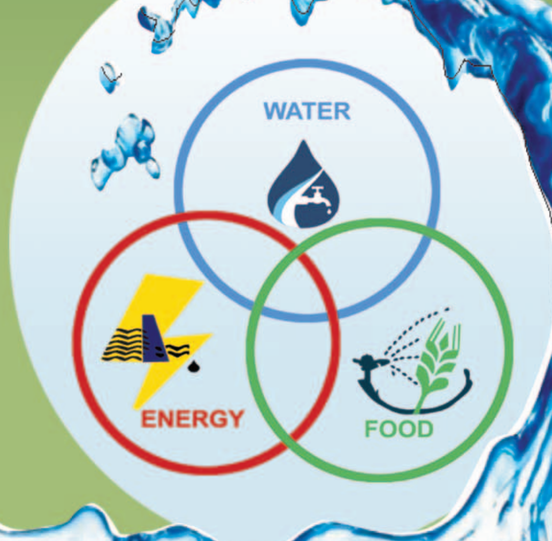
SAARC OUTLOOK

Water-Energy-Food Nexus in SAARC Countries



SAARC Agriculture Centre (SAC)

SAARC Outlook on Water-Energy-Food Nexus in SAARC Region

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December 2015

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Published in December 2015

ISBN: 978-984-34-0623-1

Citation: Kumar, A. and Gurung, T.R., (Eds). 2015. SAARC Outlook on Water-Energy-Food Nexus in SAARC Region

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Cover Design: Dr. Tayan Raj Gurung, Senior Program Specialist (NRM)

Price
US$. 20.00 for SAARC Countries
US$. 50.00 for other countries

Printed at
Natundhara Printing Press
Email: natundhara2014@gmail.com

Foreword

The SAARC Region is predominantly agrarian region and fast emerging as a major player in the global economy. The pathway of the economic progression is strongly supported by agricultural and non-agricultural industrial expansion. SAARC Region is also home to the largest number of people living below the poverty line in the world. Besides, it is also reported that about half of this region's population is food-energy deficient. About 20% lack access to safe drinking water. In the wake of growing water stress, these countries are faced with a common challenge of as to how to grow more food with the same or less land, less water, and increased energy costs. According to the Intergovernmental Panel on Climate Change (IPCC, 2014), it predicted that South Asia may experience some of the devastating impacts of flooding, food shortages, and stagnating economic growth due to advancing climate change.

Food and water are basis for human existence and energy is vital to human development. The process of sustainable development is basically dependent on adequate access to these resources and their sustainable management. The inter-connectedness between the water, energy, and food systems is traditionally characterized by the three bilateral interfaces of energy-water, energy-food, and food-water, which comprises linkages representing resource supplies, end-use demands and requirements, and natural and human engineered technologies, processes, and infrastructures necessary to produce, supply, and deliver the resource to meet the end-users' requirements. The water-energy-food nexus approach is extremely relevant to South Asia, which has just 3% of the world's land, but has to feed 1.6 billion people, which account for about one-fourth of the world's population. Rice and wheat, the staple foods in this region, need huge amounts of water and energy. Freshwater, once abundant, is under growing stress due to the increased demand for competing uses, and climate change is creating additional uncertainties. In view of the growing water stress and shortage of energy, there is a big challenge of how to produce more food with less land, less water and less energy. In this backdrop, WEF nexus approach is increasingly seen as a viable option to meet these challenges in the SAARC region.

This book entitled "SAARC Outlook on Water-Energy-Food Nexus in SAARC Region" is an attempt to bring a comprehensive overview of potentials and challenges in WEF Nexus in the region. I would like to take this opportunity to express my sincere appreciation to Dr. Arvind Kumar, President, India Water Foundation and Dr. Tayan Raj Gurung, Senior Program Specialist (NRM), SAARC Agriculture Centre who succinctly put together the manuscript. I am confident that this compilation will facilitate further research and development in Water-Energy-Food in SAARC Region.

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Executive Summary

SAARC Region represented by 8 countries (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka), is home to over one fifth of the world's population and is the most densely populated geographical region in the world. It is known to be the most disaster prone region in the world. SAARC Region's vulnerability to the impacts of climate change in terms of natural and man-made disasters is profound, principally for reasons of the high rates of population growth, and natural resource degradation, with continuing high rates of poverty and food insecurity. In general, past and present climate trends and variability in SAARC Region can be characterized by increasing air temperatures and increasing trend in intensity and frequency of extreme events in SAARC Region over the past many decades. The Intergovernmental Panel on Climate Change (IPCC) report released in March-end 2014, entitled *Climate Change 2014: Impacts, Adaptation and Vulnerability*, has predicted that SAARC Region to experience some of the devastating impacts of flooding, food shortages, and stagnating economic growth due to advancing climate change. The stark and sobering conclusions of the IPCC report predicted that the future effects of climate change will touch every corner of the globe in general and SAARC Region in particular, with potentially profound consequences for international peace and prosperity. For instance, a rising sea level and reduced production in agriculture are likely to cause the biggest threats in the near future. Dhaka, Kolkata and Mumbai, which are home to over 46 million people and rising, are expected to confront the greatest risk of flood-related damage over the ensuing decades. Rising sea levels are also likely to inundate vast tracts of land in Bangladesh and Maldives thereby posing a serious threat to agriculture.

The drought and variations in seasonal rainfall coupled with devastation that flooding could wreak in SAARC Region's low-lying and urban areas will adversely impact agriculture in Pakistan, India, and Bangladesh. Shifting pattern of monsoons may affect the amount of water availability in SAARC Region, which is already one of the world's most water-stressed regions. The IPCC also projects that climate change will make SAARC Region home to the 'largest numbers of food-insecure people' by mid-21st century. The small-holder rain-fed farmers, who constitute the majority of farmers in SAARC Region and possess low financial and technical capacity to adapt to climate variability and change, are likely to be significantly affected by the process of climate change.

The IPCC report calls for 'enhanced regional cooperation,' to insulate the region from the potential threats of climate change. In the wake of low coping capacity of the rural poor, especially in the marginal areas, there is a need to mainstream the good practices for adaptation to climate change into sustainable development planning in the region; and water-energy-food nexus approach is widely seen as the most viable option in this regard.

Water-Energy-Food (WEF) Nexus

Discourse on the inter-relatedness of water, energy and food security has been able to garner widespread recognition almost throughout the globe in recent years. Burgeoning population, rapid pace of urbanization, changing lifestyles and dietary habits, along and climate change etc., have emerged as major drivers of increase in global demand, especially in water, energy and food sectors; and each of these sectors faces its own supply risks; hence, interdependence of these sectors has reinforced the water, energy, and food security nexus (Beisheim, 2013).

Water, energy, and food systems derive sustenance from common stocks of natural resources and need connected and shared infrastructures to provide essential inputs to social-ecological systems. Construction of a shared set of policy spaces facilitated by the interdependencies of these infrastructures entails significant implications pertaining to national planning and management decisions which bear the potential to cause adverse cascading effects on the security of these vital resources (Waksom et al., 2014). Accordingly, context-specific paths of coherent institutionalization of shared governance, and horizontal, vertical and financial governmental coordination become necessary to prevent negative externalities across resources to become co-constraints of sustainable development.

The inter-connectedness between the water, energy, and food systems is usually illustrated by the three bilateral interfaces of energy-water, energy-food, and food-water, which comprise linkages representing resource supplies, end-use demands and requirements, and natural and human engineered technologies, processes, and infrastructures essential to produce, supply, and deliver the resource to meet the end-user demand. These bilateral interfaces constitute a dynamic set of non-linear interacting processes linked through a complex network of feedbacks, rendering the analysis of sector-to-sector interfaces insufficient to capture the complexity of the water-energy-food (WEF) system (Hibbard et al., 2014). These interactions and feedbacks are of varying intensity and timing, and depend on the scope, characteristics and geography of the WEF system under consideration.

The mounting global scarcity crisis, especially in water, energy, food and finance sectors, which assumed serious dimensions by 2008, compounded by growing concerns about the long-term availability of non-renewable resources, gave rise to the discourse on water-energy-food nexus (Allouche et al., 2013). Articulation of the concept of 'sustainable development', in the *Report of the World Commission on Environment and Development: Our Common Future* (1987), set forth a new 'global agenda for change', which emphasized on the significance of incorporating the environment and natural resource dimensions in the development discourse.

Undoubtedly the concept of sustainable development, which has become mainstreamed in global, regional and national development planning, emphasizes on the interdependencies between social, economic and environmental policies and the need for more integrated development paradigms; nevertheless, the integration of these three development pillars remains segmented, and improved governance has become increasingly introduced as a core component of efforts to achieve sustainable development.

Emergence of complementary approaches promoted by integrated water resources management and the green economy have enabled the WEF nexus conceptual framework to wield a significant influence on a new physical and economic resource realism that has permeated the global community (Bazilian et al., 2011; Foran, 2013). This pattern is said to be characterized by five attributes: the lack of undeveloped resource preserves; the challenges of exploiting new resources; the emergence of new consumers; the volatility of resource prices; and the broadening of actors engaged in governing resources (UNESCAP, 2013).

The World Economic Forum is generally credited to be the first to bring the issue of the risk correlation between the water, energy and food sectors to political attention at the Davos Summit through the issuance of the Global Risks 2011 report. Subsequently, many global and regional conferences and meetings were held during the preparation phase for the United Nations Conference on Sustainable Development (Rio+20 held in June 2012) that highlighted the interdependencies between water, energy and land resources (Bizikova et al. (2013) and UNESCAP (2013)).

The Bonn 2011 Nexus Conference, “The Water, Energy and Food Security Nexus – Solutions for the Green Economy”, called for a more integrated approach for achieving food, water, and energy security as a key aspect of moving towards a green economy. The Rio+20 declaration, ‘The Future We Want’ (2012), later emphasized the need to address the core issues of food, water, and energy in a manner that reduces adverse impacts on biodiversity, air quality and climate, although the declaration made no specific reference to the nexus.

The Bonn 2014 conference, "Sustainability in the Water-Energy-Food Nexus”, emphasized the need for coherence of cross-sector policy efforts and cross-border cooperation as necessary for the successful governance of the complex risks to sustainable supply of water, energy, food and ecosystem services. Besides, the latest report of the Working Group II of the Intergovernmental Panel on Climate Change in March 2014, featured the "Water-Energy-Food/Feed/Fiber Nexus as Linked to Climate Change" as a cross-chapter theme; and the WEF nexus was central to the agenda of the Stockholm World Water Week 2014.

WEF Nexus in SAARC Region

It is now widely acknowledged that the WEF nexus approach accords recognition to the interdependencies of water, energy, and food production, which aims to systemize the interconnections to provide a framework for assessing the use of all resources and to manage trade-offs and synergies (Bazilian et al., 2011; Scott et al., 2011; Hermann et al., 2012; Hussey and Pittock, 2012; Sharma and Bazaz, 2012).

With limited land resources, inadequate energy supply, and growing water stress, SAARC Region faces the challenge of providing enough water and energy to grow enough food for the burgeoning population. Hence, the concept of the WEF nexus is extremely relevant to SAARC Region, where more than 40% of the world's poor live and some 51% of the population is food–energy deficient (Ahmed et al., 2007). With just 3% of the world's land, SAARC Region has about one-fourth of the world's population. Food production in the region requires huge amounts of water and energy. Freshwater, once abundant, is under growing stress due to the increased demand for competing uses, and climate change is creating additional uncertainties (Eriksson et al., 2009). About 20% of the population of SAARC Region lacks access to safe drinking water (Babel and Wahid, 2008).

The increase in water stress and water demand raises questions about how to ensure enough water for growing food without losing hydropower for energy security. The energy required to make water available for crop production, for example through groundwater pumping, is in serious shortage (Shah, 2009); per capita energy consumption in this region is among the lowest in the world. With a large and burgeoning population, limited land resources, inadequate energy supply, and growing water stress, SAARC countries are faced with a common challenge of how to produce more food with the same or less land, less water, and increased energy prices.

Challenges

The major constraint in the nexus approach that adversely impacts water-food independence in SAARC Region is in the form of severe land degradation, particularly deforestation and forest degradation, erosion, landslides, overgrazing, biodiversity loss, declining productivity, and desertification (Pandit and Kumar, 2013). Besides, conversion of rangelands into rain-fed farming, harnessing of marginal lands quick-return commercial farming and extraction of mineral resources without adequate environmental protection have also contributed to land degradation (Singh, 2006; Tiwari and Joshi, 2012).

Gradual but heavy degradation of forests, which play pivotal role in replenishing ground-water and maintaining the volume of river water in the dry season, sequestering carbon, and supporting agriculture (Singh and Sharma, 2009), in the wake of the growing demand for timber and fuel-wood and inadequate management; has been instrumental in posing significant challenges to local people's livelihoods and food and energy security as they depend heavily on forest for fuel-wood, fodder, and other non-timber forest products (Rasul et al., 2008).

The watersheds in the mountainous region of SAARC Region have become more vulnerable to erosion, thereby, leading to loss of soil and nutrients, siltation of rivers and reservoirs, and increases in the incidence and severity of flooding. Watershed degradation is culminating in decreased groundwater recharge and consequent drying up of springs, streams, and other water sources. This has led to shortage of water for drinking, irrigation, and other livelihood activities in many parts of the region.

Hydropower potential has remained underutilized, especially in Nepal and Bhutan resulting in dependence on fossil fuels for power generation, which has exerted tremendous drain on valuable foreign exchange reserves of most of the countries of the region. No adequate attention has been paid to harness renewable energy and excessive use of biomass sources as fuel in rural areas has contributed more to pollution than as a source of energy.

These challenges highlight the urgency for providing adequate food and nutrition, access to modern energy, and safe water and sanitation to a burgeoning population without degrading the natural resource base. The water-energy-food nexus approach is seemingly a right move towards this direction.

Way forward

In SAARC Region, where food production has become increasingly water and energy intensive, WEF nexus assumes added significance. Tremendous increase in the demand for food, water, and energy in SAARC Region is taking place at such a time when land, water, and other natural and environmental resources are in either shrinking or depleting at a faster pace. Under this scenario, the increased food production in SAARC Region can only be had from the same or even less land. Water, energy and food related challenges facing SAARC Region can be aptly tackled via WEF nexus because, "The nexus approach provides a framework for better understanding of the interdependencies of the food, water, and energy sectors and linkages between upstream and downstream countries as well as better insights into how to address such challenges by maximizing synergies and managing trade-offs" (Rasul, 2014).

The interconnectedness and interdependence between food, water, and energy security, especially in the SAARC Region context, emphasizes the urgency for ascertaining inter-sectoral integrated solutions. Lack of appropriate incentives, paucity of capacity building and other policy and institutional mechanisms has already culminated thereby jeopardizing the food, water, and energy security in SAARC Region. Emphasis is stressed on identifying synergies across boundaries at the basin level by Crow and Singh (2009) to address the challenges of food, water, and energy security and Lindstro¨m and Granit (2012) have cited the example of the Aswan Dam on the Nile River, which not only contributes to mitigating drought and flood damage but also supplies electricity to half of the rural communities in Egypt, supports the fishing industry, and has created new livelihood opportunities.

On the basis of trends emerging from this paper, following suggestions are offered for the effective implementation of WEF nexus in SAARC Region:

- Synchronization of policy measures in water, energy and food sectors, keeping in view inter-relatedness and interdependencies of resources across both sectors and scales, upstream and downstream, as well as the role of regional ecosystems in long-term security of water, energy, and food in the region.
- Stress on facilitating reduction of inter-sectoral externalities by adopting integrated planning and management of water and energy sources and accordingly equal emphasis on managing land, forest, ecosystems, and agriculture to ensure food security.
- Introduction of regulatory mechanism for managing demand for water and energy and launch incentives for judicious use of water and energy for food production.
- Political will required to tackle issues related to trans-border water-sharing to pave way for better cooperation in implementing WEF nexus approach.
- Capacity building of the people inhabiting trans-border areas in the realms of conservation and judicious use of natural resources and improve their livelihoods.
- Cooperation in the management of trans-boundary river basins and share the fruits of WEF nexus for mutual benefit and region's development.

Contents

Chapter-1

Introduction

South Asia's geographic, political and juridical identity has been christened by the member countries of South Asian Association of Regional Cooperation (SAARC), which include Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka (See Map below). This region is home to over 1.60 billion people and they constitute one fifth of the world's population and it is the most densely populated geographical region in the world (Table-1.1). Undoubtedly, rapid pace of development has been registered, both industrially and economically, by South Asia; nevertheless, the region is confronted with a vast array of difficult challenges of meeting the growing demand of its burgeoning population for food, water, and energy notwithstanding climatic and other socioeconomic changes.

Map of SAARC Countries

India is the largest country in geographic terms followed by Pakistan and Afghanistan, as is revealed from Table 1.1. It is equally interesting to note that Maldives is the smallest country of the region. Afghanistan, Nepal and Bhutan are mostly mountainous regions and they are also land-locked countries; whereas Maldives and Sri Lanka are islands having large coastal areas. India, Pakistan and Bangladesh possess both mountainous regions as well as coastal areas. These geographic features of South Asian countries impact their political and socio-economic policies in diverse ways. It is further observed that India has the highest population followed by Bangladesh and Pakistan, while Maldives has the lowest population. It is also interesting to know that with the exception of Maldives, all other countries of South Asia have bulk of their respective populations inhabiting rural areas.

Table 1.1: Area and Population by Sex in SAARC Countries

SAARC Countries	**Area in '000'sq. km.**	**Last census year**	**Population**			**Decennial growth rate of population**	**Rural/Urban as percentage of total population**	
			Person	Male	Female		Rural	Urban
Afghanistan#	652.86	1979	14.6	7.5	7.1	-	12.6	2.0
Bangladesh*	147.57	2011	149.77	74.98	74.79	1.20 (p)	76.57 (p)	23.43 (p)
Bhutan	38.39	2005	0.64	0.33	0.30	na	69.10	30.90
India	3287.26	2011	1210.19	623.72	586.47	17.64	68.84	31.16
Maldives	300.00	2006	0.32	0.15	0.15	2.00	34.68	65.32
Nepal	147.18	2011	26.49	12.84	13.64	14.4	82.93	17.07
Pakistan	796.10	1998	132.40	68.90	63.50	57.09	67.50	32.50
Sri Lanka (a)	62.71	2012	20.2**	9.8**	10.4**	0.7***	81.7**	18.3**

1) Bangladesh, source: * = Adjusted population of Population & Housing Census in 2011. Urban adjusted population not yet finalised. (p) = provisional.

2) Afghanistan: # = 2011 mid-year population, figures are not census population.

3) Sri Lanka, source: Department of Census and Statistics, excluding Inland water (Total large inland water area = 2.91 '000). sq.km).

** Based on the 5% sample of the Census of Population and Housing – 2012. *** Average annual growth rate from 2001 to 2012 (percent).

Source: SAARCSTAT (2012). *SAARC Statistical Yearbook 2012*. Kathmandu, Nepal: SAARC Secretariat.

The Indus-Ganges-Brahmaputra plain of South Asia, which is one of the most populous areas in the world, is the storehouse of this region's food grains, especially rice and wheat. It is also one of the largest areas of irrigated agriculture, which is dependent in large part on water from the Himalayas. The other main farming systems in the region are highland mixed, rice, rain-fed mixed, and dry rain-fed. Recent years have witnessed rapid increase in demand for food and water in the wake of high population growth, changes in diet patterns and increasingly urbanized population.

South Asia: Human Development Index (HDI) Value and Rank

Human development is a process of enlarging people's choices. The most critical ones are to lead a long and healthy life, to be educated and to enjoy a decent standard of living. Additional choices include political freedom, guaranteed human rights and self-respect (UNDP, 1990: 10). The Human Development Index (HDI) is broadly construed in terms of a summary measure for assessing long-term progress in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living. A long and healthy life is measured by life expectancy.

Knowledge level is measured by mean years of education among the adult population, which is the average number of years of education received in a life-time by people aged 25 years and older; and access to learning and knowledge by expected years of schooling for children of school-entry age, which is the total number of years of schooling a child of school-entry age can expect to receive if prevailing patterns of age-specific enrolment rates stay the same throughout the child's life. Standard of living is measured by Gross National Income (GNI) per capita expressed in constant 2011 international dollars converted using purchasing power parity (PPP) rates (UNDP 2015b). The HDI indicators of South Asia countries are provided in Table 1.2

Table 1.2: South Asian Countries' HDI indicators for 2014

Country	HDI value	HDI rank	Life expectancy at birth	Expected Years of schooling	Mean years of schooling	GNI per capita (PPP US$)
Afghanistan	0.465	171	60.4	9.3	3.2	1,885
Bangladesh	0.570	142	71.6	10.0	5.1	3, 191
Bhutan	0.605	132	69.5	12.6	3.0	7, 176
India	0.609	130	68.0	11.7	5.4	5, 497
Maldives	0.706	104	76.8	13.0	5.8	15, 328
Nepal	0.548	145	69.6	12.4	3.3	2,311
Pakistan	0.538	147	66.2	7.8	4.7	4,866
Sri Lanka	0.757	73	74.9	13.7	10.8	9, 779
South Asia	0.607	-	68.4	11.2	5.5	5,605

Compiled from: UNDP (2015a). *World Development Report 2015*. New York: UNDP.

The country-wise analysis of the data shown in Table 1.2 makes it discernible that Afghanistan's HDI value for 2014 is 0.465, which places the country in the low human development category—positioning it at 171 out of 188 countries and territories. Undoubtedly, Afghanistan's HDI value increased from 0.228 to 0.465 between 1980 and 2014 and it recorded progress in each of the HDI indicators during this period: life expectancy at birth increased by 18.6 years, mean years of schooling increased by 2.4 years and expected years of schooling increased by 7.5 years and Afghanistan's GNI per capita decreased by about 17.4 percent between 1980 and 2014 (UNDP 2015b); nevertheless, this pace of progress has been of little help to uplift Afghanistan from the low human development category. Afghanistan's 2014 HDI of 0.465 is below the average of 0.505 for countries in the low human development group and below the average of 0.607 for countries in South Asia.

It is further observed that Bangladesh's HDI value for 2014 is 0.570, which puts the country in the medium human development category—positioning it at 142 out of 188 countries and territories. Bangladesh's HDI value increased from 0.338 to 0.570 between 1980 and 2014 and it also registered progress in each of the HDI indicators: life expectancy at birth increased by 18.1 years, mean years of schooling increased by 3.1 years and expected years of schooling increased by 5.1 years and Bangladesh's GNI per capita increased by about 178.0 during this period (UNDP 2015c). However, Bangladesh continues to remain at the lower side of the medium human development category because its 2014 HDI of 0.570 is below the average of 0.630 for countries in the medium human development group and below the average of 0.607 for countries in South Asia.

It is revealed from Table 1.2 that Bhutan's HDI value for 2014 is 0.605, which ranks the country in the medium human development category—positioning it at 132 out of 188 countries and territories. Bhutan's HDI value recorded an increase from 0.573 to 0.605 between 2010 and 2014 and it also recorded progress in each of the HDI indicators between 1980 and 2014: life expectancy at birth increased by 24.5 years, mean years of schooling increased by 0.7 years and expected years of schooling increased by 8.2 years and its GNI per capita increased by about 708.1 percent during this period (UNDP 2015d). However, Bhutan's 2014 HDI of 0.605 is below the average of 0.630 for countries in the medium human development group and below the average of 0.607 for countries in South Asia.

India's HDI value for 2014 is 0.609, which places the country in the medium human development category— positioning it at 130 out of 188 countries and territories. India's HDI value increased from 0.362 to 0.609 between 1980 and 2014, thereby, registering an increase of 68.1 percent or an average annual increase of about 1.54 percent during this period, which also witnessed India's progress in each of the HDI indicators in the same period: life expectancy at birth increased by 14.1 years, mean years of schooling increased by 3.5 years and expected years of schooling increased by 5.3 years and India's GNI per capita increased by about 338.0 percent during the same period (UNDP 2015e). However, India's 2014 HDI of 0.609 is below the average of 0.630 for countries in the medium human development group and above the average of 0.607 for countries in South Asia.

It is evidenced from Table 1.2 that the Maldives' HDI value for 2014 is 0.706, which puts the country in the high human development category—positioning it at 104 out of 188 countries and territories. The Maldives' HDI value increased from 0.603 to 0.706 between 2000 and 2014, thereby, registering an increase of 17.1 percent or an average annual increase of about 1.14 percent. The Maldives also progress in each of the HDI indicators between 1980 and 2014: life expectancy at birth increased by 23.8 years, mean years of schooling increased by 1.3 years and expected years of schooling increased by 0.6 years and GNI per capita increased by about 551.9 percent during the same period (UNDP 2015f). However, the Maldives' 2014 HDI of 0.706 is below the average of 0.744 for countries in the high human development group and above the average of 0.607 for countries in South Asia.

Nepal's HDI value for 2014 is 0.548, which places the country in the low human development category—positioning it at 145 out of 188 countries and territories. Nepal's HDI value increased from 0.279 to 0.548 between 1980 and 2014, and it recorded an increase of 96.2 percent or an average annual increase of about 2.00 percent. It is also evident that Nepal made progress in each of the HDI indicators in the same period: life expectancy at birth increased by 23.0 years, mean years of schooling increased by 2.7 years and expected years of schooling increased by 7.6 years as well as Nepal's GNI per capita increased by about 140.5 percent during the same period (UNDP 2015g). Undoubtedly, Nepal's 2014 HDI of 0.548 is above the average of 0.505 for countries in the low human development group; nonetheless, it is below the average of 0.607 for countries in South Asia.

It becomes noticeable from Table 1.2 that Pakistan's HDI value for 2014 is 0.538, which puts its ranking in the low human development category—positioning it at 147 out of 188 countries and territories. Pakistan's HDI value witnessed an increase from 0.353 to 0.538 between 1980 and 2014, which marked an increase of 52.5 percent or an average annual increase of about 1.25 percent. Pakistan recorded progress in each of the HDI indicators during the same period: life expectancy at birth increased by 9.2 years, mean years of schooling increased by 2.9 years and expected years of schooling increased by 4.1 years as well as its GNI per capita increased by about 99.7 percent in the same period (UNDP

2015h). Undoubtedly, Pakistan's 2014 HDI of 0.538 is above the average of 0.505 for countries in the low human development group; nevertheless, it is below the average of 0.607 for countries in South Asia.

Table 1.2 makes it discernible that Sri Lanka's HDI value for 2014 is 0.757, which puts the country in the high human development category— positioning it at 73 out of 188 countries and territories. Sri Lanka's HDI value increased from 0.571 to 0.757 between 1980 and 2014, having recorded an increase of 32.5 percent or an average annual increase of about 0.83 percent. Sri Lanka also made progress in each of the HDI indicators: life expectancy at birth increased by 6.7 years, mean years of schooling increased by 3.7 years and expected years of schooling increased by 3.7 years as well as its GNI per capita increased by about 281.7 percent during the same period (UNDP 2015i). Sri Lanka's 2014 HDI of 0.757 is above the average of 0.744 for countries in the high human development group and above the average of 0.607 for countries in South Asia.

The HDI ranking of the countries of South Asia, as briefly appraised above, shows that Afghanistan, Nepal and Pakistan are placed in the low human development group and each country's HDI is below the average of HDI for South Asia. On the other hand, Bangladesh, Bhutan and India are placed in the medium human development category and HDI of Bangladesh and Bhutan is below the average HDI for South Asia, while India, which is also placed in the medium human development category, has HDI above the average South Asian HDI. On the contrary, Maldives and Sri Lanka rank in the high human development category and both possess HDI which is above the average HDI for South Asia. This demonstrates that there is high incidence of poverty in South Asia.

Poverty in South Asia

According to *Human Development Report 2013*, poverty can be measured more comprehensively using the Multidimensional Poverty Index (MPI), which looks at overlapping deprivations in health, education and standard of living. The MPI is the product of the multidimensional poverty headcount (the share of people who are multi-dimensionally poor) and the average number of deprivations that each multidimensionally poor household experiences (the intensity of their poverty). Focusing on the intensity of poverty enables the MPI to provide a more complete picture of poverty within a country or a community than is available from headcount measures alone (UNDP 2013: 27). As per World Bank data collected between 2001 and 2011 in the 104 countries covered by the MPI, about 1.56 billion people—or more than 30% of their population—are estimated to live in multidimensional poverty. This exceeds the estimated 1.14 billion people in those countries who live on less than $1.25 a day, although it is below the proportion that lives on less than $2 a day (World Bank 2012).

As per *Human Development Report 2013*, the highest MPI value in South Asia is in Bangladesh (0.292 with data for 2007), followed by Pakistan (0.264 with data for 2007) and Nepal (0.217 with data for 2011). The proportion of the population living in multidimensional poverty is 58% in Bangladesh, 49% in Pakistan and 44% in Nepal, and the intensity of deprivation is 50% in Bangladesh, 53% in Pakistan and 49% in Nepal. Undoubtedly, a sizeable proportion of the population (headcount) lives in multidimensional poverty in Bangladesh than in Pakistan; nonetheless, the intensity of deprivation is higher in Pakistan. Besides, in Bangladesh and Nepal, the living standards dimension contributes more than the health and education dimensions, but in Pakistan, the health dimension contributes more than the other two dimensions (UNDP 2013: 29).

Out of the total population of the world, almost one quarter- about 1.6 billion people live in South Asia. South Asia is also home to the largest number of people living below the poverty line in the world (SAARC, 2014), where more than 40 percent of the world's poor live. Out of the eight countries, four countries fall in the category of the United Nations (UN) defined least developed countries (LDCs), of which three are landlocked. The share of distribution of GDP among the South Asian countries indicated there was a lack of symmetrical distribution. A majority of the South Asian population is suffering from destitution, deprivation and misery. Although Sri Lanka and the Maldives are comparatively better, South Asia as a region is still 'inhumane' in terms of access to income, health and education, which is essential for decent living as per international standards. The Maldives and Sri Lanka have low poverty levels at 5.2 and 5.3 percent, respectively. The same measurements also depict the grave intensity of deprivation in Pakistan, India, Bangladesh and Nepal, hovering around 50 percent. Likewise, the poverty intensity is high in Bhutan at 43.9 percent (*Daily Times*, 6 March 2014).

Vulnerability to Climate Change

South Asia is known to be the most disaster-prone region in the world and its vulnerability to the impacts of climate change in terms of natural and man-made disasters is profound, principally for reasons of the high rates of population growth, and natural resource degradation, with continuing high rates of poverty and food insecurity. Climate change is a major concern in this region; its impacts include changes in temperature and precipitation, increased climatic variability, altered monsoon patterns, and increased frequency of extreme events such as drought and flood, as well as accelerated melting of Himalayan glaciers, all causing alterations in natural resources and the environment. Future availability of freshwater is uncertain given changes in glacier, snow, and permafrost melt and shifting rainfall patterns. Cereal production is expected to suffer more in South Asia than in other regions; crop yields in South Asia could decrease by up to 30% by 2050 with no change in practices (IPCC, 2007).

The Intergovernmental Panel on Climate Change (IPCC), in its report released in March-end 2014, had predicted that South Asia may experience some of the devastating impacts of flooding, food shortages, and stagnating economic growth due to advancing climate change. The stark and sobering conclusions of the IPCC report predict that the future effects of climate change will touch every corner of the globe in general and South Asia in particular, with potentially profound consequences for international peace and prosperity (IPCC, 2014).

In Bangladesh, Bhutan, northern India, and Nepal, the increasing frequency and strength of extreme weather events can cause flooding, landslides, and damage to crops, infrastructure, and property; while areas of Bangladesh, India, the Maldives, and Sri Lanka are at high risk from sea-level rise that may displace human settlements, cause saltwater intrusion and loss of agricultural land and wetlands, and damage tourism and fisheries. Undoubtedly, some crops in parts of the region may benefit from future warmer temperatures, but the overall impact of climate change on agriculture in South Asia is expected to be negative, posing a serious threat to regional food security (ADB 2014).

Adverse impact of climate change will also affect water resources. Water supply in Bangladesh, Bhutan, Nepal, and Sri Lanka is likely to be higher due partly to the positive effects of increased rainfall, whereas, on the other hand, due to variations in intensity and distribution of rainfall, the region as a whole will experience water deficit, particularly in India. Besides, **c**limate and anomalous weather events will likely result in a rise of vector- and waterborne diseases in South Asia.

A report published by Asian Development Bank (ADB) in June 2014 has stated that climate change is likely to affect both energy generation and demand in South Asia. Changes in temperature and precipitation can reduce the capacity of hydropower plants and efficiency of distribution systems, hence reduce energy supply. Meanwhile, aside from normal determinants such as population and economic development, climate change will place a higher demand for energy, due to higher requirements for heating and cooling. It is further stated that by 2050s, the highest gap between energy demand and energy supply due to climate change is estimated to range from 4.2% in Sri Lanka to 31.8% in Nepal. Only India and Sri Lanka may experience slightly improved energy supply coverage between 2030s and 2050s (Ibid.).

While calculating the loss in economic terms due to climate change, the ADB report states that the region of South Asia will lose nearly 2% of its gross domestic product (GDP) by 2050, which could rise to 9% by 2100—even under optimistic climate projections—if the countries do not take early action. And losses will be higher still when the damage from extreme weather events is included.

Conclusion

Besides, about half of this region's total population is food-energy deficient (Ahmed et al. 2007). About 20% lacks access to safe drinking water (Babel and Wahid 2008). Paradoxically, many countries of South Asia have large population, but are endowed with limited land and natural resources. In the wake of growing water stress, these countries are faced with a common challenge of as to how to grow more food with the same or less land, less water, and increased energy costs. A sizeable number of people in South Asia, especially in rural areas, are poverty-stricken and the added hazards from global climate change will affect those people the most, making their escape from poverty even more difficult. In the wake of burgeoning population, limited natural resources and vulnerability to climate change in the region of South Asia where more than 40% of the world's poor live and about half of the population is food–energy deficient, ensuring food security and providing access to safe drinking water and modern energy for all can better be facilitated by adopting Water-energy-food nexus approach. The recently adopted sustainable development goals (SDGs) by the UN General Assembly in September 2015 lay adequate emphasis on water-energy-food (WEF) approach and the integration of these SDGs into the national policies by individual countries of South Asia is expected to address the questions of poverty alleviation, ensuring water, energy and food security as well as meeting the challenge of climate change in accordance with the provisions of Paris accord on climate change agreed to in early December 2015.

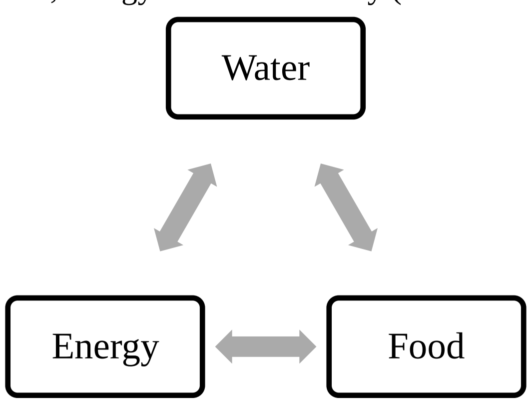
Chapter – 2

Water-Energy-Food Nexus Framework

Food and water are *raison d'être* for human existence and energy is vital to human development. The process of sustainable development is basically dependent on adequate access to these resources and their sustainable management. Water, energy and food (WEF) are inter-related, inter-dependent and inter-connected with each other (Figure 2.1). The inter-connectedness between the water, energy, and food systems is traditionally characterized by the three bilateral interfaces of energy-water, energy-food, and food-water, which comprises linkages representing resource supplies, end-use demands and requirements, and natural and human engineered technologies, processes, and infrastructures necessary to produce, supply, and deliver the resource to meet the end-uses' requirements (ESCWA, 2015).

Water is a necessary input for producing agricultural goods in the fields and along the entire agri-food supply chain. Energy is required to produce and distribute water and food: to pump water from groundwater or surface water sources, to power tractors and irrigation machinery, and to process and transport agricultural goods. Currently, agriculture is the largest user of water at the global level, accounting for 70% of total withdrawal. The food production and supply chain accounts for about 30% of total global energy consumption (FAO, 2011). There exist multiple synergies and trade-offs between water and energy use and food production. Using water to irrigate crops might promote food production but it can also reduce river flows and hydropower potential.

Growing bio-energy crops under irrigated agriculture can increase overall water withdrawals and jeopardize food security. Converting surface irrigation into high efficiency pressurized irrigation may save water but may also result in higher energy use. Recognizing these synergies and balancing these trade-offs is central to jointly ensuring water, energy and food security (WWDR 2014: 54).



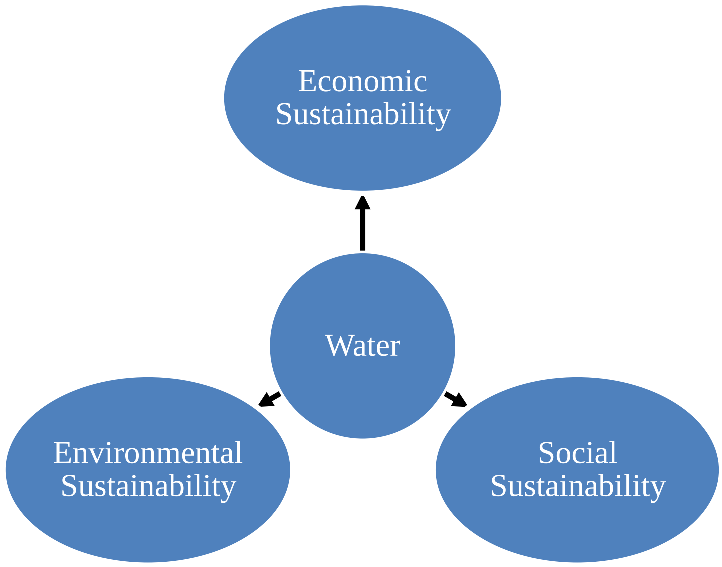


Figure 2.1: Inter-connectedness between Water, Energy and Food

According to Hibbard et al. (2014), these bilateral interfaces constitute a dynamic set of nonlinear interacting processes linked through a complex network of feedbacks, rendering the analysis of sector-to-sector interfaces insufficient to capture the complexity of the WEF system. These interactions and feedbacks are of varying intensity and timing, and depend on the scope, characteristics and geography of the WEF system considered. Complex and dynamic nature of nexus interactions facilitates their occurrence within a context of transformational processes. A report by FAO (2014) points out that policies targeting 'sector-specific optima' entail the possibility of resulting in cross-sectoral, cross-scale risks and uncertainties that can immensely affect the initial conditions that dictated the design of these policies such as societal structures, resources availability and fiscal conditions. Some experts have opined that the political ecology of the nexus cannot be neglected, as it highlights the historical, cultural and socio-political dimensions that underpin a given resource nexus (Foran, 2013; Allouche et al., 2013).

Rapid pace of industrialization, urbanization and burgeoning population have been exerting additional pressure on water, energy and food resources, which are limited and depleting at fast pace. Recognizing that judicious use of these resources is a *sine qua non* for sustainability, the international community has come to focus its attention on the water-energy- food nexus approach, especially after 2011. The call for an integrated approach to water, energy and food security was given by the World Economic Forum 2011, the Bonn2011 Nexus Conference, the sixth World Water Forum, and World Water Week 2012. The Rio

+ 20 declaration ‘The Future We Want’, has stressed the need to address society’s core issues of food, water, and energy security in a manner that reduces the adverse impacts on nature–water, biodiversity, air, and climate.

Recently, the Bonn 2014 conference, "Sustainability in the Water-Energy-Food Nexus”, emphasized the need for coherence of cross-sector policy efforts and cross-border cooperation as necessary for the successful governance of the complex risks to sustainable supply of water, energy, food and ecosystem services. Moreover, the latest report of the Working Group II of the Intergovernmental Panel on Climate Change in March 2014, featured the "Water-Energy-Food/Feed/Fiber Nexus as Linked to Climate Change" as a cross-chapter theme; and the WEF nexus was central to the agenda of the Stockholm World Water Week 2014.

Scholarly community and experts also vouch for the nexus approach because it recognizes the interdependencies of water, energy, and food production and aims to systemize the interconnections to provide a framework for assessing the use of all resources and to manage trade-offs and synergies (Bazilian et al., 2011; Scott et al., 2011; Hermann et al., 2012; Hussey and Pittock, 2012; Sharma and Bazaz, 2012). In pragmatic terms, the WEF nexus has come to be defined as an approach to assessment, policy development and implementation that focuses simultaneously on water, energy and food security (Bizikova et al., 2014). Besides, it also presents a conceptual and analytical approach to socio-ecological systems and offers a framework for coordinated management and use of natural resources across sectors and scales (FAO, 2014).

2.1 Emphasis on WEF Nexus Approach

Recognizing the inextricable linkages between water, energy, climate and food security, and the natural resources that determine them (Olsson, 2013), it has been argued by some scholars and policy makers that integrating these concerns within a 'nexus' approach can better transition societies towards a green economy and hence wider sustainability (Hoff, 2011). Another concomitant development that provided the impetus to the recognition of water-energy-food (WEF) nexus was the occurrence of global food and economic crises in 2008 and subsequently drew considerable scholarly attention (Bazilian et al., 2011; Hoff, 2011; ICIMOD, 2012).

Bach et al. (2012) have opined that nexus approach acknowledges the linkages between water, energy and food resources in management, planning and implementation. In the burgeoning global population, which is hurtling towards over 8 billion, need for more conscious stewardship of the requisite resources required has become significant. The general vulnerability of resource production systems and the overexploitation of water in particular were brought to limelight by the unstable food prices and their linkages to the vagaries of climate change.

In the backdrop of these developments, the World Economic Forum (WEF) in its annual meeting held in 2008 agreed upon a Call to Action on Water, which was designed to re-examine the relationship between water and economic growth. Subsequently, business leaders and policy makers developed the water-energy-food (WEF) nexus concept, resulting in the WEF’s 2011 report (WEF, 2011), which constitutes a major source of guidance. The following Bonn 2011 Nexus Conference then became the first globally recognized event held on the water, energy and food security nexus.

According to Bach et al. (2012), the Mekong2Rio Conference proved instrumental in taking a step forward in exploring the water, energy and food security nexus in a trans-boundary context and it was deemed as a step towards moving from rhetoric to practice. Many efforts have been made to finesse nexus thinking in the form of policy dialogues, such as the Bonn 2013 conferences, promotion by the WEF and Global Water Partnership (GWP) and an emerging academic research agenda. However, conceptualizations on nexus are still developing.

Recent years have seen the European Union (EU) along with Germany, the International Food Policy Research Institute (IFPRI), the WWF and the WEF heavily promoting the nexus approach to developing countries. It is interesting to note that the WEF nexus was one of the main approaches considered by the United Nations in setting its sustainable development goals (SDGs). In the wake of nexus approach garnering such a high-level support, it can be expected that the nexus discourse would be influencing national water governance strategies.

Broadly speaking, the interpretation of the nexus discourse makes discernible major differences, which are critically apparent in the empirical foci of nexus research and neologisms employed. These include *inter alia*: the 'water-food-energy-climate nexus' (WEF, 2011; Beck and Villarroel Walker, 2013); the 'water and food nexus' (Mu and Khan, 2009); the 'water-energy nexus' (Scott et al., 2011; see also Perrone et al., 2011; Hussey and Pittock 2012); the 'energy-water nexus' (Marsh and Sharma, 2007; Murphy and Allen, 2011; Stillwell et al., 2011); the 'bio-energy and water nexus' (UNEP, 2011); the 'energy-irrigation nexus' (Shah et al., 2003); 'water-energy-food security nexus' (Bazilian et al., 2011; ICIMOD, 2012; Bizikova et al., 2013; Lawford et al., 2013); and related concepts such as 'land use-climate change-energy nexus' (Dale et al., 2011) and a range of development-related nexus approaches (see Groenfeldt, 2010).

Thus, it can be said that the nexus concept is not a unified concept and its interpretation seemingly varies according to the focus of sectoral integration studied and the geopolitical context. Whatever sectoral focus is adopted – energy, climate or food focus – all these sectors are invariably linked to water resource protection.

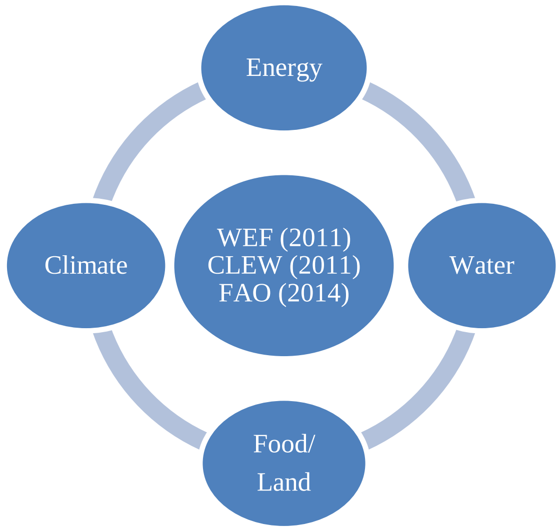
2.2 Leading Conceptual Frameworks for Understanding the Nexus

Bizikova et al. (2014) have opined that the WEF nexus can be defined as an approach to assessment, policy development and implementation that focuses simultaneously on water, energy and food security. According to a FAO report (FAO, 2014), nexus presents a conceptual and analytical approach to socio-ecological systems and offers a framework for coordinated management and use of natural resources across sectors and scales. Recent years have seen emergence of different conceptualizations of the nexus which are endowed with variations in their scope, goals, and understanding of drivers and pressures.

The modular aspects of the nexus make it discernible as to how different sectors and issue areas have been incorporated into nexus frameworks and over time, various institutions and organizations have sought to expand the scope to include additional issues of particular concern to their specific mandates. Undoubtedly, this 'additionality' is evident in different nexus modules; nevertheless, it can also be evidenced that inter-linkages between water, energy and food/land remain at the core of the nexus concept. The major conceptual frameworks put forward in recent years on the nexus include: World Economic Forum (2011); the Bonn 2011 Nexus Conference; the International Centre for Integrated Mountain Development (ICIMOD, 2012); the United Nations Economic Commission for Europe (UNECE, 2013); the United Nations Environment Program (UNEP, 2014); the International Institute for Sustainable Development (Bizikova et al., 2013, 2014); the World Business Council for Sustainable Development (2013); the FAO (2014); and the CLEW (2011).

2.2.1 The World Economic Forum (2011)

The nexus framework presented by the World Economic Forum (2011) is designed to support decision-makers to elicit better analysis of the global risk landscape and respond proactively and adequately to shocks and crises. Along with the "macroeconomic imbalances" nexus and the "illegal economy" nexus, the WEF nexus is presented as a major global risk area. The framework includes population and growth dynamics, environmental pressures, and climate-change related risks affecting the nexus; and identifies some important interactions among the elements of the nexus, such as water use in the food and energy sectors, and energy intensity in the food agro-chain. Resource security is further featured as one of the main risks to monitor; specifically, food, water and energy security are linked to economic risks, economic disparity, and global governance failures (Figure 2.2). The main policy recommendations include integrated and multi-stakeholder resource planning; community-level empowerment and implementation; market-led resource pricing; and technological and financial innovation for managing the nexus (ESCWA 2015).

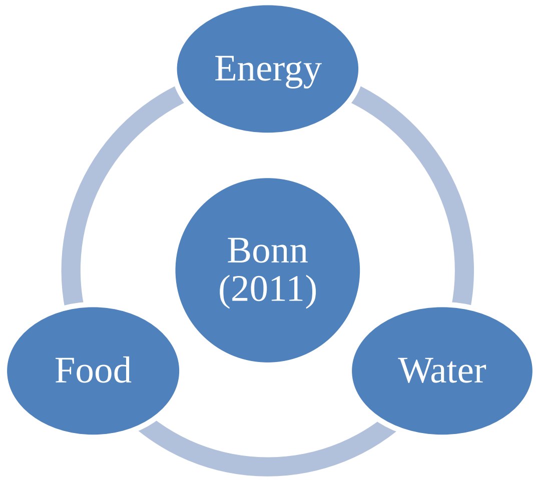


Source: ESCWA 2015

Figure 2.2: The World Economic Forum WEF Nexus Framework

2.2.2 Bonn 2011 Conference WEF Nexus Framework

The Bonn 2011 Nexus Conference presented a framework which aimed at developing a new nexus-oriented approach which is required to address unsustainable patterns of growth and impending resource constraints and, in doing so, promote security of access to basic services. The framework veers around water availability and on the interdependencies needed to achieve water supply security, energy security and food security. The framework accounts for global trends including urbanization, population growth and climate change (Figure 2.3). Opportunities to improve water, energy and food security included increasing resource productivity; using waste as a resource in multi-use systems; stimulating development through economic incentives; governance, institutions and policy coherence; benefiting from productive ecosystems; integrated poverty alleviation and green growth; and capacity building and raising awareness. The framework highlighted the importance of implementing policies which would generate sufficient additional benefits to outweigh transaction costs associated with stronger integration across sectors.

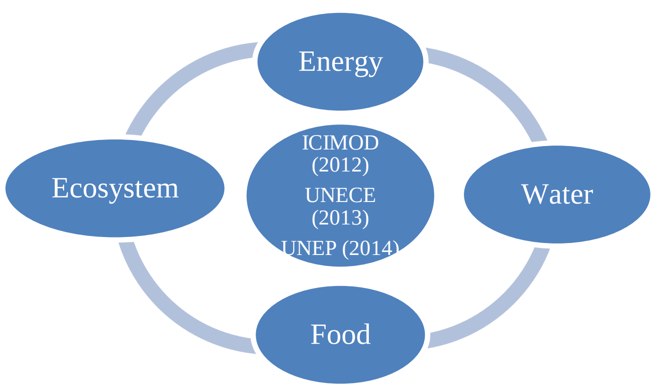


Source: ESCWA 2015

Figure 2.3: Water-Energy-Food Nexus Framework presented at the Bonn 2011 Nexus Conference

2.2.3 ICIMOD (2012) WEF Nexus Framework

The International Centre for Integrated Mountain Development (ICIMOD) has developed WEF nexus framework, which it has been applied to the Himalayas and South Asia (ICIMOD, 2012; Rasul, 2014). This approach focuses on ecosystems, goods and services, which must be protected and enhanced to ensure their resilience and their support to the water, energy, and food sectors (Figure 2.4). Policy recommendations include the restoration of natural water storage capacities, the development of a climate-smart and socially sound infrastructure, and the introduction of incentive mechanisms for managing ecosystems.



Source: ESCWA 2015

Figure 2.4: Water-Energy-Food Framework developed by ICIMOD

2.2.4 UNECE (2013) WEF Nexus Framework

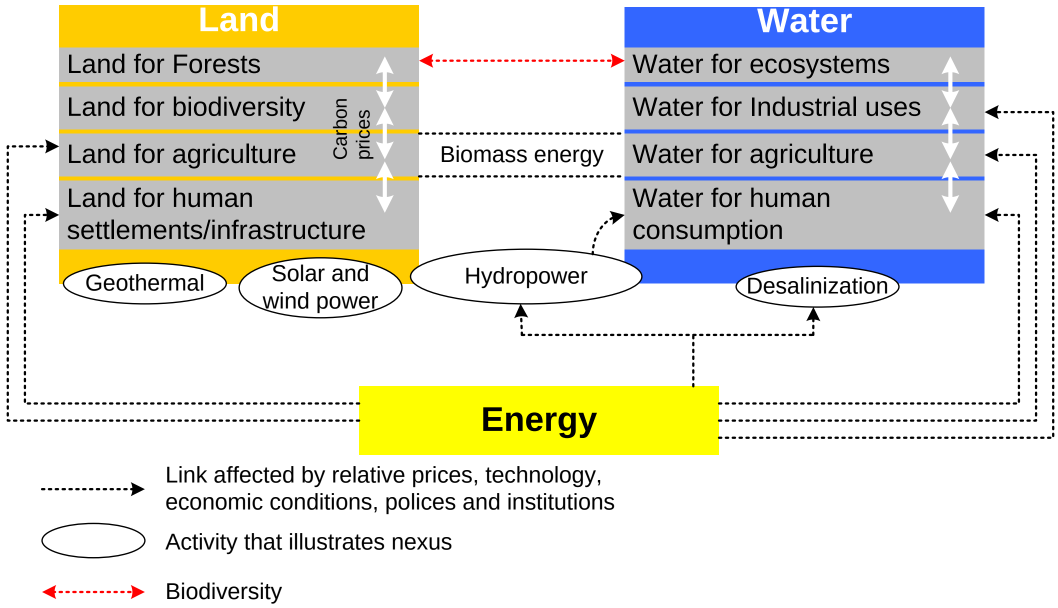
The United Nations Economic Commission for Europe (UNECE) in 2013 adopted WEF nexus approach, which is closely related to ICIMOD approach as shown in Figure 4. The UNECE 2013 nexus links water, energy and food to ecosystems. The framework recognizes that the functioning of ecosystems should not be compromised by development objectives. Shortcomings in inter-sectoral coordination are further presented as a major challenge on the national and trans-boundary levels, where the trade-offs and externalities may cause frictions between riparian countries and different interests.

2.2.5 UNEP (2014) WEF Nexus Framework

The WEF nexus framework developed by the United Nations Environmental Program (UNEP) resembles in many respects with the ICIMOD nexus framework (Figure 4). However, the UNEP (2014) framework considers ecosystems both "inside" and "surrounding" the nexus. The framework recognizes the inter-linkages between security and sustainability of water, energy and food systems, and incorporates the land dimension and climate change external influence. The approach considers the opportunities for basin organizations to implement a nexus approach to water governance, playing a key role with regard to ensuring energy and food security, particularly in terms of hydropower and balancing bio-fuel production with food crop production (Bolee et al., 2014; Hoa, 2014).

2.2.6 ODI-ECDPM-DIE (2012) WEF Nexus Framework

The WEF nexus framework, as proposed The European Development Report (EDR) (2012), broadens the nexus' perspective by explicitly considering competing land uses, for agriculture, forest cover, human settlements and infrastructure, and biodiversity; and competing water sectoral demands (Figure 2.5). Three players are involved in the success of this transformation: the public sector, through the setting and coordination of policies and regulations; the private sector, through more inclusive and sustainable business models; and regional and global players, through policy, trade, global governance, and development assistance. The EDR (2012) report calls for a radical rethink of the world's approach to natural resources, and a transformative action in addressing the demand, supply, efficiency and resilience of natural resources management in meeting current and future consumption needs. Furthermore, a full range of integrated solutions for an appropriate management of pressures on water, energy and land needs to be considered.

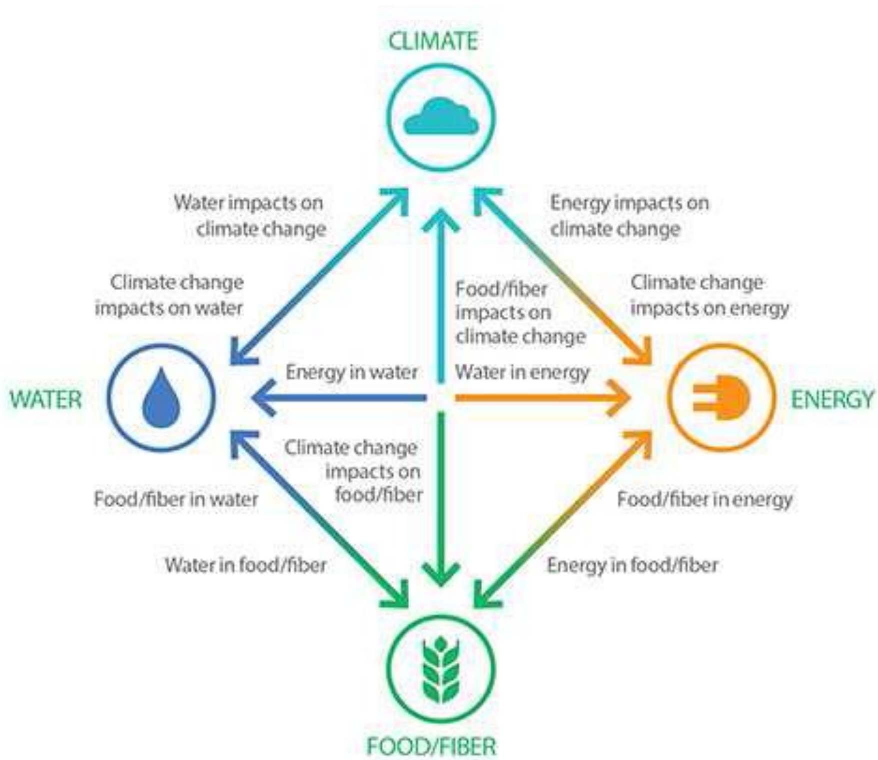


Source: EDR (2012)

Figure 2.5: The European Development Report (ODI-ECDPM-DIE) Nexus Framework

2.2.7 WBCSD (2013) WEF Nexus Framework

The WEF nexus framework developed by the World Business Council for Sustainable Development (WBCSD) aims at providing co-optimized solutions for water, energy and food that also incorporates the inputs needed for those sectors along the value chain, namely feed and fertilizers (Figure 2.6). The increasing realization by the private sector of the significance of adopting nexus thinking in order to better manage resource constraints and enhance efficiency has enabled the WBSCD to undertake analytical work to develop innovative policy and technology solutions to the world's interconnected water, energy, food, feed, and fiber challenges, and introduce the additional stresses posed by climate change (WBCSD, 2013). A wide range of opportunities encompassing solution areas include: bridging the knowledge gap; smart varieties; clever crop agronomy; mixed farming systems; better blue and green water productivity; efficient fertilizer production and farm operation and mechanization; and waste reduction.



Source: WBCSD (2013).

Figure 2.6: The WBCSD Resource Nexus Framework

2.2.8 FAO (2014) WEF Nexus Framework

The WEF nexus framework presented by FAO (2014) envisages adoption of a holistic vision of sustainability, and explicitly addresses complex interactions and feedback between human and natural systems (Figure 2.7). The resource base covers natural and socio-economic resources; and nexus interactions describe interdependencies, constraints and synergies (Weitz et al., 2014; FAO, 2014), in the context of global drivers, which include population growth, urbanization, climate change, cultural and social beliefs and behaviors as well as governance. It also introduces the importance of technology and innovation as drivers that affect the resource base. According to a report by FAO (2014a), this nexus approach is framed within the broader debate on sustainable development and as part its vision of sustainable food and agriculture to achieve its mandate of eradicating hunger, reducing poverty, and sustainably managing and using natural resources and ecosystems.

Another nexus framework, which is a result of the collaboration between several international organizations and research centers, and is elaborated by Bazilian et al., (2011), points to the tight, quantifiable, relationships between Climate, Land, Energy and Water (CLEW), with land identified as the basic resource and underlying constraint for examining food. This framework focuses on energy, and then conceptualizes Energy-Water-Food nexus interrelations through a quantitative framework that integrates water planning, energy planning and agro-ecological zoning models. This approach is akin to FAO (2014) framework hence it is shown in Figure 7.

Bazilian et al., (2011) have contended that the integrated modeling of Climate, Land, Energy and Water (CLEW) strategies could help policy makers to better manage energy, water and food needs. Concurrently, such an approach would help decision makers assess the likely impacts of policy options on the broader CLEW system, by highlighting and quantifying the trade-offs and synergies associated with competing resource management and supply strategies.

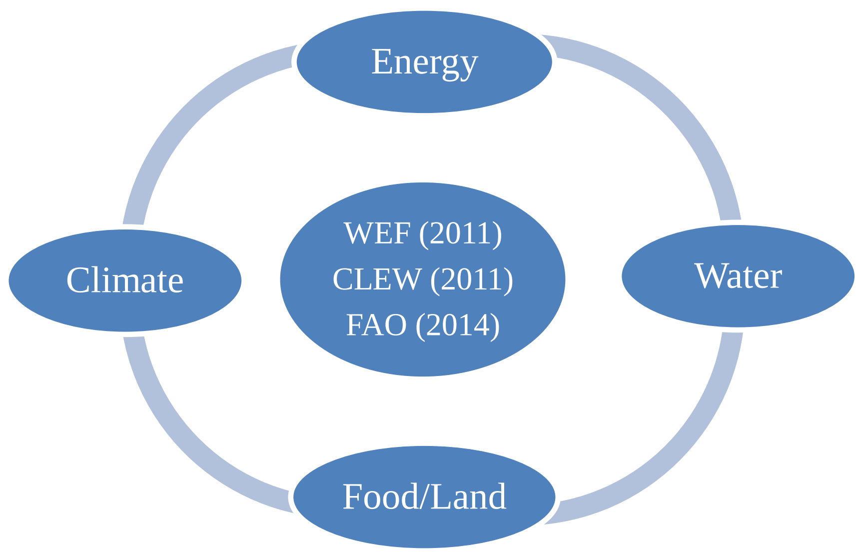


Figure 2.7: The FAO Approach to the Water-Energy-Food Nexus

3. WEF Nexus and Sustainable Development Goals (SDGs)

Nexus thinking prominently features in the 17 SDGs and 169 targets adopted by the UN General Assembly in late September 2015. The WEF nexus has been accorded specific place. The SDG-1 aims at ending the poverty in all its forms and this is the ultimate objective of the WEF nexus approach. The nexus thinking is reflected in SGD-2 which emphasizes on ending hunger, achieving food security and improved nutrition as well as promotion of sustainable agriculture. Food security is one of the major constituents of WEF nexus approach. Ensuring availability and sustainable management of water has been designated as SDG-6 and it constitutes the main constituent of WEF nexus. The SDG-7 aims at ensuring access to affordable, reliable, sustainable and modern energy to all and energy is also one of the major constituents of the WEF nexus. This close proximity between some of the major SDGs and the WEF nexus shows the importance of nexus approach in realizing the SDGs.

It is noteworthy that a number of processes were launched by the United Nations General Assembly (UNGA) in their preparations for the post-2015 development agenda and during deliberations on the sustainable development goals (SDGs), which clearly emphasized on inter-linkages. The Open Working Group, established by the UNGA to prepare a proposal for the SDGs, emphasized in its 10th session the inter-linkages between the goals related to poverty eradication, sustainable agriculture, food security and nutrition, water and sanitation, health and population dynamics, sustainable cities and human settlements, ecosystems and biodiversity, climate, and sustainable production and consumption; even though no reference was made to nexus terminologies (Open Working Group, 10 Session, 31March-4 April 2014).

Subsequently, the Proposal of the Open Working Group for SDGs, submitted in July 2014, stated in its introduction that the goals and targets integrate economic, social and environmental aspects and recognize their inter-linkages in achieving sustainable development in all its dimensions. In July 2014, a background issues brief to the 2nd Meeting of the High-Level Political Forum stressed on integrated policy-making and coordination as essential for the overall policy coherence of a universal, people-centred, sustainable development in the post-2015 development agenda (HLPF, 2014).

A nexus approach assumes important implications by identifying and quantifying trade-offs and synergies in terms of investment requirements and policies, and entails the potential of influencing the financing of sustainable development objectives at the local and international levels. It is noteworthy in this regard that Weitz et al. (2014) have offered some recent reflections on cross-sectoral integration in the design of the SDGs. It is argued by them that as SDG targets cut across and support multiple development goals, identifying targets at the nexus of different sectors can be instrumental in producing a more concise SDG framework with more robust solutions, avoiding redundancies and contradictions, while helping managing complexity.

Likewise, taking cognizance of the water-energy-land nexus is regarded as necessary for achieving coherence across goals for Brandi et al. (2013). It is further argued that the integrative character of the SDGs can be ensured by using second-order conditions related to the different dimensions of sustainable development, e.g. where the social and environmental dimensions are binding on the target and goal setting of an economic goal; while taking into account cross-sectoral interdependencies and constraints along the water, energy, land and ecosystems nexus. This makes it amply clear that the nexus approach has come to play an important role in the newly adopted SDGs as part of the post-2015 agenda. Likewise the WEF nexus assumes added significance in implementing the SDGs.

4. Conclusion

The nexus concept is construed within a wider context of sustainable development, implementation of which is said to have since posed significant challenges for policy makers worldwide due to its inherent ambiguities and irreducibly normative assumptions. The securitization is a seen as a critical concern within nexus thinking and consequently it has featured in the various nexus frameworks from WEF (2011) onwards. Thus, nexus could be seen as novel, or at least exhibiting some novel elements, particularly in terms of holistically integrating different policy sectors, encouraging business involvement, promoting economically rational decision making and privileging water securitization in the pursuit of sustainable development.

The water-energy-food nexus approach is extremely relevant to South Asia, which has just 3% of the world's land, but has to feed 1.6 billion people, which account for about one-fourth of the world's population. Rice and wheat, the staple foods in this region, need huge amounts of water and energy. Freshwater, once abundant, is under growing stress due to the increased demand for competing uses, and climate change is creating additional uncertainties (Eriksson et al., 2009). In view of the growing water stress and shortage of energy, there is a big challenge of how to produce more food with less land, less water and less energy. In this backdrop, WEF nexus approach is increasingly seen as a viable option to meet these challenges in the SAARC region.

Chapter-3

Water Security in South Asia

A community is regarded to be water secure when it has sustainable access to freshwater of sufficient quantity and quality, or to the benefits derived there from; and the ability to minimize water-related risk and its various repercussions to an acceptable level – without compromising the supporting ecosystems (Magsig, 2014). Under the current prevailing circumstances, almost all countries of South Asia, perhaps with the exception of Bhutan, are confronted with the problem of water availability and more especially the seasonality of water availability against the requirements. The problem of demand and supply of water is most acute in India, Pakistan and Bangladesh. There has been a dramatic fall in renewable water resources in the region on a per capita basis since the 1960s.

Undoubtedly, South Asian region is endowed with extensive water resources and high potential for hydropower development; nevertheless, the available water resources are unevenly distributed, spatially and temporally. Besides, sharp seasonal variations in the volume of water flows due to climatic phenomena, such as monsoons and droughts in some countries, add to the difficulty of finding equitable and durable water sharing arrangements. Among the South Asian countries, India, the largest country in the region, has one sixth of the world's population and only one-twenty-fifth of the world's water resources. Pakistan depends on the Indus River as its primary source of water. Bangladesh is a downstream country where all of its rivers originate outside its borders, thus making it vulnerable to the quantity and quality of water that flows into it from upstream. The Ganges and Brahmaputra are the most important rivers for Bangladesh, supplying 85 per cent of all surface water during the dry season (RSIS, NTU, 2011).

Bhutan and Nepal are the only countries, which are regarded water rich countries from among the South Asian region. Maldives has attained remarkable success in rainwater harvesting, with only 25 per cent of its population dependent on groundwater for drinking and the remainder using rainwater and desalinated water for this purpose. Sri Lanka, though a water rich country, is also experiencing decline in water availability, which is estimated to decline to 1,900 cubic metres per capita by 2025. Though Afghanistan is located in arid environment, it is rich in water resources because of the series of mountains covered with snow (Babel and Wahid, 2008).

Declining trends in per capita availability of water in most countries of South Asia are becoming discernible due to a range of climatic and demographic factors. For instance, in India, per capita water availability is expected to decline below

1,000 cubic metres by 2025 (Bates *et al.*, 2008). Bulk of the water use in the region is limited to the agricultural sector, with almost 90 per cent water withdrawn used for agriculture, compared to the world average of 70 per cent (Babel and Wahid, 2008). Burgeoning population and exploitation of natural resources has rendered many parts of the region under water stress (Falkenmark *et al*., 1989). In addition poor water management practices have also compounded the negative impact on water availability, quality and the region's ecosystem in general.

With the population of South Asia projected to grow by 32 per cent in three decades – from 1.68 billion in 2010 to 2.22 billion in 2040 – the outlook under current trends is for greater competition over water between agriculture, urban centres and industry, and between countries which share rivers (Price, 2014). India hit the 'water stress' mark around a decade ago, Pakistan slightly earlier. Groundwater is fast depleting in India, Pakistan and Bangladesh, and there are few feasible options for increasing supply. Management and governance of water have not adapted to the escalating demographic pressures.

3.1 Water Security in Afghanistan

Afghanistan is a landlocked country that represents some of the most sparsely populated and ethnically diverse landholdings. Perched on the south western corner of the Himalayas, its topography includes a range of elevations such as the remote valleys and steep peaks of the Hindu Kush range. From altitudes of up to almost 8,000 meters, snowmelt and rains form four major river systems: the Amu Daria to the north, Helmand to the south, Harirud or Herierod to the west and Kabul to the east (Reich and Pearson, 2012). About three-quarters of the Afghan territory comprise mountains and hills, while lowlands include river valleys in the north and desert regions in the south and southeast. The Hindu Kush range, the westernmost extension of the Himalaya-Pamir mountain range, divides the country from west to east, while the Suleiman and Karakoram mountains flank the southern border with Pakistan. Major river valleys radiate from these mountains to the north, west and south, creating fertile valleys along which most agricultural and irrigation development occurs (Rout, 2008).

3.1.1 Water Resources

Despite its location in a semi-arid environment, Afghanistan is still rich in water resources mainly because of the high mountain ranges such as Hindu Kush and Baba, which mostly remain covered with snow. Over 80 percent of the country's water resources originate in the Hindu Kush mountain ranges at altitudes of over 2 000 m. The mountains function as natural water storage, with snow during the winter and snowmelt in the summer that supports perennial flow in all the major rivers (ICARDA, 2002). There is divergence in reports on the availability of arable land and water resources in Afghanistan (Cookson et al. 1992; IUCN 2010; Qureshi 2002).

Estimates by the United States Department of Agriculture Economic Research Services reveal an annual average water yield of about 75 billion m3, or around 60 million acre feet in Afghanistan, of which about 21 percent or 15.8 billion m3 is river water used for irrigation, 4 percent or 2.8 billion m3 is ground water used for irrigation, and roughly 2 percent or 1.4 billion m3 is either river or well water for other uses including domestic (IUCN 2010; Persaud 2012). The remainder is either untapped or unmeasured. Additionally only 2.6 million hectares or half of the country's irrigable area is currently being farmed (Kelly 2003; Qureshi 2002). Irrespective of its arid appearance Afghanistan is far from short of farmland or water.

Afghanistan is endowed with five major river basins: Kabul river basin, Helmand river basin, Hari Rod and Murghab river basins, Northern flowing rivers and Amu Darya river basin (Table 3.1).

Table 3.1: Afghanistan's renewable water resources by river basin

River basin	Area (km2)	Part of total area (%)	IRSWRa (km3/year)	TARSWRb (km3/year)	Groundwater recharge (km3/year)
Kabul (Indus)	72,600	11	11.5c	21.5c	1.92
Helmand & Western	270,000	41	9.3d	8.48d	2.98e
Hari Rod-Murghab	80,000	12	3.1	3.1	0.64f
Northern	75,000	12	1.9	1.9	2.14f
Amu Darya (Panj)	91,000	14	11.7g	20.7g	2.97
Other	63,400	10	-	-	-
Total	**652,000**	**100**	**37.5**	**55.58**	**10.65**

a. IRSWR= Internal Renewable Surface Water Resources
b. TRSWR= Total Actual Renewable Surface water Resources
c. Flow of Kumar, entering from Pakistan into Afghanistan, 10 km^3.
d. 0.82 km^3/year is to be reserved for the Islamic Republic of Iran from the Helmand river according to an agreement from 1972
e. Groundwater recharge: Helmand 2.48 km^3 and Western 0.5 km^3
f. Groundwater recharge: the figure for Northern (2.14 km^3) includes Murghab, while the figure of Hari Rod-Murghab (0.64 km^3) excludes Murghab (*Source: Uhl and Tahiri, 2003)*.
g. The flow of border river Panj where the Bartang enters is 33.4 km^3. According to a treaty in 1946 with the Soviet Union 9 km^3/year can be used by Afghanistan.

Sources: Adapted from Favre and Kamal, 2004; Rout, 2008; Uhl and Tahiri, 2003.

Encompassing a drainage area of 54 000 km^2 in Afghanistan, the Kabul river originates in the central region of the Hindu Kush, about 100 km west of Kabul and then flows eastward through Kabul and, after entering Pakistan, joins the Indus river east of Peshawar. Its main tributaries include the Logar, Panjsher (with its own major tributary the Ghorband), Laghman-Alingar and Kunar rivers. The Kabul river and other tributaries of the Indus together drain 11 percent of Afghanistan. The 1 300 km long Helmand river rises out of the central Hindu Kush mountains and then it flows in a southwesterly direction, then westwards to its terminus in the Sistan marsh along the border with the Islamic Republic of Iran. The Helmand river and its tributaries drain about 29 percent of Afghanistan's area.

The Hari Rod river encompasses 6 percent of the drainage area of Afghanistan. Another river, the Murghab river, also encompasses 6 per cent drainage area of Afghanistan. Northern flowing rivers originate on the northern slopes of the Hindu Kush and flow northwards towards the Amu Darya river. These river basins cover 12 percent of Afghanistan. Amu Darya river, also called the Oxus in Afghanistan, originates in the Afghanistan part of the Pamir river. Two main tributaries of Amu Darya –the Kunduz river and the Kokcha river – both originate in northeastern Hindu Kush and cover 14 per cent drainage area of Afghanistan.

The Kabul and Amu Darya river basins together cover one-quarter of Afghanistan and contribute almost two-thirds of surface water resources generated within its borders; or the internal renewable surface water resources (IRSWR) (Table 3.2). Total IRSWR is an estimated 37.5 km^3/year and total internal renewable groundwater resources (IRGWR) an estimated 10.65 km^3/year. Afghanistan being an arid country, the overlap is estimated to be only 1 km^3/year, or less than 10 percent of groundwater resources. This brings total internal renewable water resources (IRWR) to 47.15 km^3/year (Table 3.2).

Table 3.2: Renewable freshwater resources of Afghanistan

Precipitation (long-term average)	-	327	mm/yr
	-	231, 300	million m^3/yr
Internal renewable water resources (long-term average)	-	47, 150	million m^3/yr
Total actual renewable water resources	-	65, 330	million m^3/yr
Dependency ratio	-	29	%
Total actual water resources per inhabitant	2011	2, 019	m^3/yr
Total dam capacity	2009	3, 658	million m^3

Sources: Adapted from Favre and Kamal, 2004; Rout, 2008; Uhl and Tahiri, 2003.

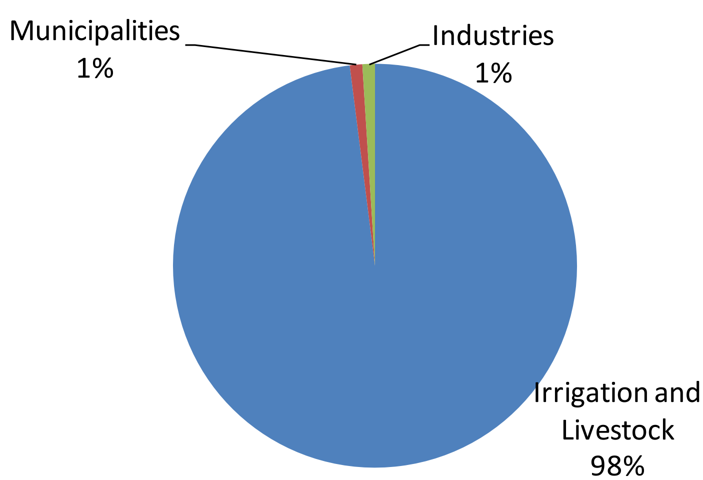
Some experts feel that Afghanistan's water resources are still largely underused and at the same time it is difficult to ascertain as to how much of this 'potential' resource can be accessed without causing any damage to livelihoods and ecosystem (Qureshi, 2002). For example, it is not fully known how much of the groundwater can be extracted without leading to an excessive decline in groundwater levels, which may result in a stage of 'water mining' (ibid). There are few environmentally important natural wetlands and lakes in Afghanistan (Favre and Kamal, 2004).

3.1.2 Water Use

Total water withdrawal in Afghanistan in 1998 was estimated at 20.373 km^3, of which 20.0 km^3 or 98 percent was for agriculture, 1 percent for municipal and 1 percent for industrial purposes (Table 3.3 and Figure 3.1). Of total water withdrawal, 17.317 km^3 or 85 percent was from surface water sources and the remainder 3.056 km^3 or 15 percent from groundwater (Figure 3.2) (Rout, 2008). In 1987, total water withdrawal was an estimated 26.11 km^3 of which 25.8 km^3 or 99 percent for agricultural purposes.

Table 3.3: Water use in Afghanistan

Water withdrawal	Year	Quantity	Frequency
Total water withdrawal by sector	1998	20, 373	million m^3/yr
-agriculture	1998	20, 000	million m^3/yr
-municipalities	2005	203	million m^3/yr
-industry	2005	170	million m^3/yr
-per inhabitant	1998	937	m^3/yr
Surface water and groundwater withdrawal (primary and secondary)	1998	20, 373	million m^3/yr
* as % of total actual renewable water resources	2000	31	%
Non-conventional sources of water	**-**	**-**	**-**
Produced wastewater	-	-	million m^3/yr
Treated wastewater	-	-	million m^3/yr
Direct use of treated wastewater	-	-	million m^3/yr
Desalinated water produced	-	0	million m^3/yr
Direct use of agricultural drainage water	-	-	million m^3/yr



Total 20.373 km^3

Figure 3.1: Water withdrawal by sector in Afghanistan, 1998

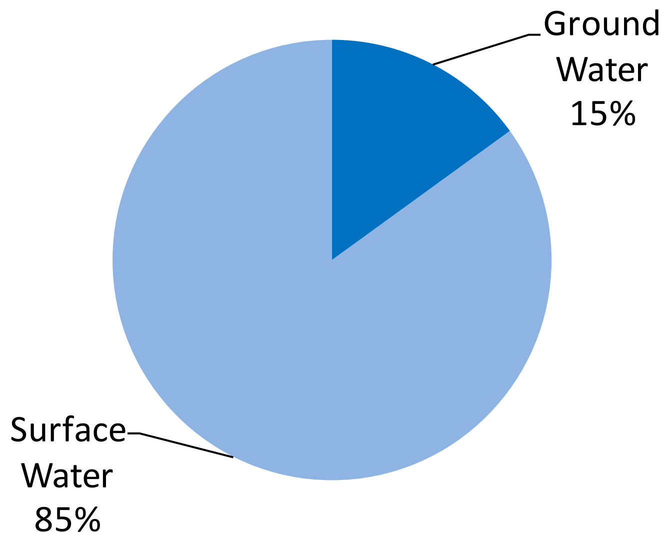


Figure 3.2: Water withdrawal by source in Afghanistan, 1998

Favre and Kamal (2004) have cited data from the Government of Afghanistan's 1980s yearbook statistics, according to which, the total annual groundwater extraction amounted to some 3 km^3. Uhl and Tahiri (2003) estimated groundwater withdrawal for irrigation to be 2.8 km^3/year. Historically, groundwater withdrawal has been largely limited to water from shallow unconfined aquifers abstracted using karez and traditional wells from which water is drawn using animal power (arhad). More recently, deeper confined aquifers are being developed for domestic and municipal water supply using modern well-drilling techniques (Rout, 2008).

3.1.3 Water Management

Institutional mechanism is in place for Afghan water management. The Ministry of Water and Energy (MWE) is responsible for mapping, monitoring and management of surface water and groundwater resources. Urban water supply is the responsibility of the Ministry of Public Works. Water supply and sewerage disposal in the Microrayon area of Kabul is the duty of the Microrayon Maintenance Department. The mandate of the Central Authority for Water and Sanitation is urban water supply within the areal limits of the Master Plan of the city. The Ministry of Mines is responsible for groundwater investigation and survey, especially for 'deep' hydro-geological mapping of strategic plans for optimal exploitation of resources. The municipalities are responsible for surface water drainage and solid waste disposal. The Ministry of Rural Development is active in designing deep wells and networks for parts of Kabul City outside the Master Plan, where shallow groundwater is salty.

According to Rout (2008), overall water system management at community level in rural level is led by a senior representative called *wakil* (Herat) or *mirab bashi* (Kunduz and Balkh). This person is usually a well-respected community member and landowner with experience and knowledge of the system as well as influence with the local government. In addition to system management, the representative also has the broader responsibility of liaising with adjacent irrigation communities, particularly over customary rights on the location and operation of the *sarband*. In some locations, a main canal committee supports the wakil or mirab bashi, while in others by a *mirab* or *chak bashi*. In both cases, the supporting role represents the different upper, middle and lower sections of a system. In larger systems, a *badwan* is responsible for operation and maintenance of the *sarband* because of its importance and high maintenance requirements. Through a *mirab* (water master) (Herat) or *chak bashi* (Kunduz and Balkh) or a village committee, the recipient community is usually responsible for the management of operation and maintenance of all canals and structures downstream of the secondary canals to farm turnouts.

The *mirab* or *chak mirab* is typically a well-respected landless sharecropper with a working knowledge of system operation and maintenance. This official, may have one or two assistants, and is usually elected by water rights holders (landowners), or their sharecropping representatives, and serves as a link between the government water authority personnel and farmers. *Mirabs* generally receive some compensation in the form of farm products, such as wheat, for performance of their duties (ICARDA, 2002). Surface water systems are largely managed as autonomous units. While there are variations in structure, they essentially follow similar principles regarding election of representatives, payment for services, and contributions to maintenance and capital works. These organizations follow many of the concepts behind water user associations: stakeholder participation, community-based representation, financial independence and hydraulic integrity. Government involvement is generally minimal and largely confined to provision of emergency rehabilitation, dispute resolution and, in some instances, holding the register of water rights (Rout, 2008).

3.1.4 Environment and Health

The ongoing process of climate change has impacted water sector in Afghanistan thereby engendering many environmental problems, mainly the degradation of water tables and wetlands and deforestation (some 40 percent of forests have been cut down) (IRIN, 2003). Besides, excessive use of groundwater for a variety of purposes has significantly depleted water tables and aquifers throughout Afghanistan and, if the trend is not reversed soon, the country will face a severe shortage of drinking water. The recurrent droughts, low precipitation and poor water management have exacerbated the water crisis. Over the past several years, groundwater sources have been reduced by about 50 percent. Limited access to surface water has prompted many farmers, mostly in the drought-stricken south and north, to increasingly use groundwater to irrigate agricultural land or dig deep wells. The majority of the population uses groundwater as its prime, and often only, source of drinking water and as groundwater level reduces, the number of people with access to drinking water would decline (IRIN, 2008).

According to Qureshi (2002), surface water quality in Afghanistan is excellent in the upper basins of all rivers throughout the year and good in the lower basins in spite of large irrigated areas. As far as known, the presence of saline soil in irrigated areas is not caused by poor water quality but rather by either over-irrigation (water-logging) or lack of irrigation water (fallow fields and high groundwater table). Favre and Kamal (2004) have argued that groundwater quality is generally good, but varies from place to place. In lower reaches of river valleys, groundwater is frequently saline or brackish and not usable for either drinking or irrigation. The water related problems in a river basin being usually complex and interlinked, call for a holistic and integrated approach to tackle the problems because no single and isolated solution can work effectively. It essentially requires the setting of goals, preparing plans, collaborating with different institutions and stakeholders and above all effective implementation of the proposed management options (ICARDA, 2002). Across the country 174 hydrological stations are being installed, the network of stations will measure rainfall, relative humidity, water level, water quality, temperature and sunshine (FAO-Water, 2011).

3.2 Water Security in Bangladesh

Bangladesh is a low-lying riverine country, which is situated in the deltaic part of the region, where huge volume of water enters into the country from outside and flow into the Bay of Bengal through three mighty rivers and their tributaries and distributaries, namely the Ganges, the Brahmaputra and the Meghna drain. The Ganges, the Brahmaputra and the Meghna river systems drain a total catchment area of about 1.72 million sq km through Bangladesh into the Bay of Bengal. Out of this large catchment area, only 7% lies in Bangladesh. The other co-riparian countries are India, Nepal, Bhutan and China (Nishat, 2001). Bangladesh is dependent on river water for human consumption, crop irrigation, fisheries, transportation and conservation of biodiversity. With rapid industrialization and population growth in the region, agrarian demand for water is also competing with hydropower and industrial demand. In parts of the GBM Basin there are disturbing signs of decreasing dry-season river flows with serious consequences for agricultural yields and groundwater replenishment. The problem is further exacerbated by water pollution and inefficient water management.

3.2.1 Water Resources

Rivers and groundwater constitute the major sources of water in Bangladesh. There are 808 rivers in Bangladesh where most rivers rise from Himalayan reign and falls into the Bay of Bengal (Haque, 2008). There are 57 trans-boundary rivers that Bangladesh shares with its neighboring countries; 54 with India and 3 with Myanmar. The Ganges, the Brahmaputra and the Meghna river systems drain a total catchment area of about 1.72 million sq km through Bangladesh into the Bay of Bengal. Out of this large catchment area, only 7% lies in Bangladesh. The other co-riparian countries are India, Nepal, Bhutan and China (Nishat, 2001).

Bulk part of Bangladesh is located within the floodplains of three great rivers: the Ganges, Brahmaputra and Meghna (GBM), and their tributaries, such as the Teesta, Dharla, Dudhkumar, Surma and Kushiyara. The three major river systems drain into the Bay of Bengal through Bangladesh. The Brahmaputra river enters Bangladesh from the north and flows south for 270 km to join the Ganges river at Aricha, about 70 km west of Dhaka in central Bangladesh. The Ganges river flows east-southeast for 212 km from the Indian border to its confluence with the Brahmaputra, then as the Padma river for about a further 100 km to its confluence with the Meghna river at Chandpur. The Meghna river flows southwest, draining eastern Bangladesh and the hills of Assam, Tripura and Meghalaya of India to join the Padma river at Chandpur. The Meghna then flows south for 160 km and discharges into the Bay of Bengal (Tollner, 2007).

The collective water discharge of these three main rivers is among the highest in the world. Peak discharges are 100 000 m^3/s in the Brahmaputra, 75 000 m^3/s in the Ganges, 20 000 m^3/s in the upper Meghna and 160 000 m^3/s in the lower Meghna. There are 230 rivers criss-crossing the country, most of which are either tributaries or distributaries to the GBM river systems. The total length of the rivers is approximately 24 000 km and the total GBM catchment area is about 1.75 million km^2, out of which only 7 percent lies within Bangladesh. On average, 1 121.6 km^3 of water crosses the borders of Bangladesh annually, of which 85 percent between June and October. Around 48 percent (537.2 km^3) is contributed by the Brahmaputra, 47 percent (525.0 km^3) by the Ganges, 4 percent (48.4 km^3) by the Meghna/Barak and nearly 1 percent (11 km^3) by other minor rivers to Chittagong in the southeast (WRF, no date).

The properties of the groundwater storage reservoir and the volume of annual recharge determine the availability of groundwater resources in Bangladesh. Major factors determining groundwater availability, *inter alia*, include: the capacity of the country’s aquifers to store water, and the characteristics that govern economic withdrawal of groundwater for irrigation, domestic and industrial needs. The source of recharge is rainfall, flooding, and stream flow in rivers. The quaternary alluvium of Bangladesh comprises a huge aquifer with reasonably good transmission and storage properties. Heavy rainfall and inundation during the monsoon substantially recharge aquifers annually. A regional groundwater recharge assessment took place in 1987 by Master Plan Organization (MPO) under the National Water Plan (NWP) of the Ministry of Water Resources. Subsequently, MPO updated the groundwater resources assessment during the NWP Phase–II in 1991 and the average annual available groundwater recharge for the country was estimated at 21 km^3 (Table 3.4).

Table 3.4: Regional estimates of annual groundwater recharge as per National Water Plan of Bangladesh.

Region	Area (million ha)	Usable recharge (million m^3)		Available recharge(million m^3)	
		NWP-I	**NWP-II**	**NWP-1**	**NWP-11**
Northwest-NW	3,016	13, 400	12, 100	9, 480	9, 786
Northeast-NE	3,569	17, 800	23, 100	9, 615	9, 594
Southeast-SE	3,007	9, 000	9, 800	1, 538	1, 498
South Central-SC	1,426	3, 600	3, 500	1, 801	1, 249
Southwest-SW	2,562	3, 900	5, 600	1, 980	1, 961
Total	**13,580**	**47, 700**	**54, 100**	**24, 414**	**21, 088**

Sources: MPO, 1987 and 1991.

The internal renewable water resources are an estimated 105 km^3/year (Table 3.5). The overlap is considered negligible, this includes 84 km^3 of surface water produced internally as stream flows from rainfall and about 21 km^3 of groundwater resources produced within the country. Part of the groundwater comes from the infiltration of surface water with an external origin. Since annual cross-border river flows and entering groundwater are estimated to be 1 121.6 km^3, the total renewable water resources are therefore estimated to be 1 226.6 km^3.

Table 3.5: Renewable freshwater resources in Bangladesh

Category	Year	Quantity	Frequency
Precipitation (Long-term average)	-	2, 320	mm/yr
	-	334, 000	million m^3/yr
Internal renewable water resources (long-term average)	-	105, 000	million m^3/yr
Total actual renewable water resources	-	1, 226, 600	million m^3/yr
Dependency ratio	-	91.4	%
Total actual renewable water resources per inhabitant	2009	8, 343	m^3/yr
Total dam capacity	2013	6, 477	million m^3/yr

Source: Compiled from FAO-GWIS, 2014.

3.2.2 Water use

The total water withdrawal in Bangladesh in 2008 was an estimated 35.87 km^3, of which 31.50 km^3 (88 percent) was for agriculture, 3.60 km^3 (10 percent) for municipalities and 0.77 km^3 (2 percent) for industries (Table 3.6 and Figure 3.3).

Table 3.6: Water use in Bangladesh

Water withdrawal	Year	Quantity	Frequency
Total water withdrawal	2008	35, 870	million m^3/yr
-irrigation+ livestock	2008	31, 500	million m^3/yr
- municipalities	2008	3, 600	million m^3/yr
- industry	2008	770	million m^3/yr
* per inhabitant	2008	247	m^3/yr
Surface and Groundwater withdrawal	2008	35, 870	million m^3/yr
*as % of total actual renewable water resources	2008	2.9	%
Non-conventional sources of water			
Produced wastewater	-	-	million m^3/yr
Treated wastewater	-	-	million m^3/yr
Reused treated wastewater	-	-	million m^3/yr
Desalinated water produced	-	-	million m^3/yr
Reused agricultural drainage water	-	-	million m^3/yr

Source: FAO. Bangladesh water report 2012.

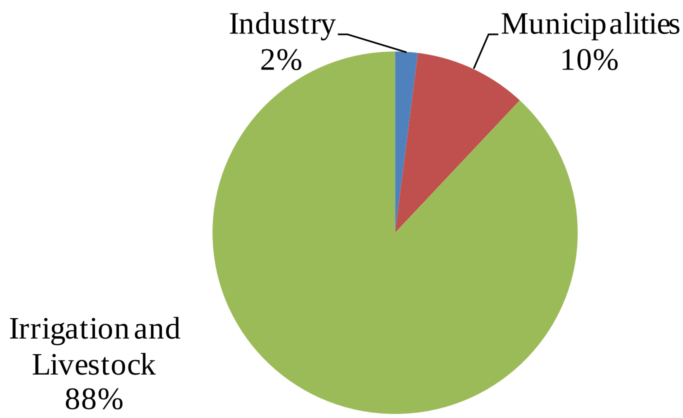


Figure 3.3: Water withdrawal by sector in Bangladesh, 2008

Approximately 28.48 km^3, or 79 percent of the total water withdrawal, comes from groundwater and 7.39 km^3, or 21 percent, from surface water (Figure 3.4).

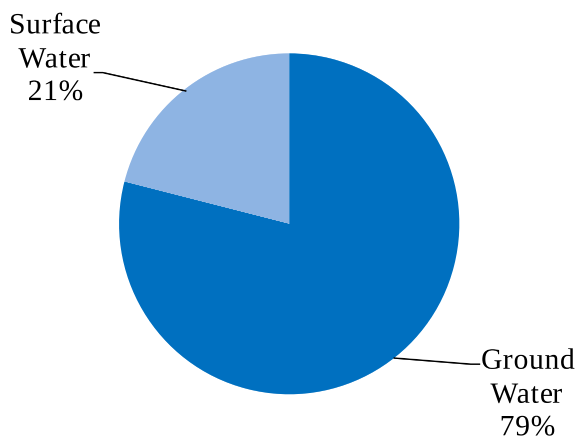


Figure 3.4: Water withdrawal by source in Bangladesh, 2008

3.2.3 Water Management

The Bangladesh Water Development Board (BWDB), which is under the Ministry of Water Resources (MoWR), Bangladesh, is responsible for the planning, implementation and operation of medium- and large-scale surface water irrigation schemes, FC and FCD projects. The Water Resources Planning Organization (WARPO), under the same ministry, has a mandate to ensure coordination of all relevant ministries through the National Water Council and to plan all aspects of water resources development including large-scale and minor irrigation, navigation, fisheries and domestic water supplies.

The Local Government Engineering Department (LGED), under the MoLG&RD, implemented Small-Scale Water Resources Development (SSWRD) projects Phase I and II by constructing 26 rubber dams in the medium and small rivers in different parts of the country. LGED was also responsible for participatory management of these projects, which was achieved by forming the Water Management Cooperative Associations (WMCAs) for each project. The Bangladesh Rural Development Academy (RDA), under the MoLG&RD, is currently implementing a package model of Multipurpose Low-Cost DTW Projects in different parts of the country with a view to achieving optimum utilization of water resources for irrigation, domestic and other purposes such as fisheries, livestock rearing and nurseries (Feroze, 2007).

In the wake of rapid pace of economic growth registered by Bangladesh during the 1980s, no specific policies or acts related to irrigation or water management were enacted. However, in view of growing demand for water by different sectors and vagaries of the climate change, the government of Bangladesh came out with various policies measures from the 1990s onwards. Policies measures like National Water Policy – NWPo (MoWR, 1999) and the National Water Management Plan – NWMP (MoWR, 2001) were, to some extent, designed to address water management issues. The NWMP, which was formed by the MoWR in 2001, has the mandate to address the overall issues of water resources management. It provides direction to short-, medium- and long-term action plans. The NWMP has emphasized the expansion of private STW irrigation in slow-growth regions and issues are to be addressed that are related to arsenic pollution and salinity; especially in the coastal areas.

3.2.4 Environment and Health

Bangladesh is widely acknowledged as one of the countries, which are most vulnerable to climate change. Besides, increased variability of temperatures and rainfall and increased occurrence of natural hazards entail the likelihood of jeopardizing the availability of both surface water and groundwater. This calls for ensuring a continuous and sustainable access to water resources to the people of Bangladesh. The limited availability of surface water during the dry season, heavy dependence is placed on the use of groundwater as a source of water for irrigation, municipal and industrial purposes. In many areas environmental hazards have been encountered, and a number of adverse effects have emerged owing to the overexploitation of groundwater, such as lowering of water tables, reduction in dry season flows of rivers and streams, groundwater pollution, intrusion of saline water in coastal areas, ecological imbalance and possible land subsidence. There is evidence of permanent depletion of groundwater levels in some locations, particularly in the Dhaka metropolitan area, where the water level's average annual decline is about 3 m (BADC, 2006), and in the northwest region of the country.

Pollution caused by agrochemicals, industrial waste and other sources has culminated in deterioration of water quality in many areas of Bangladesh. Arsenic contamination of groundwater, particularly water from STW and HTW, in 59 out of 64 districts, has been widely reported internationally. In most regions, maximum arsenic concentration has been found within the upper 50 m depth of aquifers (Water Aid, 2000). In many places, concentration of iron and arsenic in irrigation water has gone beyond the limit of the safe water quality standards of Bangladesh and the World Health Organization (WHO). Some diseases and health hazards such as arsenicosis, blindness, physical disability, occur as a result of arsenic toxicity to human body (RDA, 2001). Throughout the country, about 1.44 million tube-wells (STWS and HTWs have been affected by arsenic contamination and about 30 million people are exposed to arsenic toxicity (Ahmed, 2007).

Symptoms of deterioration in the natural hydrological regime are emerging in some parts of the country, particularly the Barind Tracts in the northwest region. Declining groundwater levels have affected water quality causing it to affect soils, the growth of agricultural crops, flora and fauna and to increase health hazards. Bangladesh needs to adhere to well-concerted measures to address environmental issues in order to harness the beneficial uses of water comprising both surface water and groundwater resources.

3.3 Water Security in Bhutan

The Kingdom of Bhutan is landlocked country located between the extensive borders of China and India. Bhutan, being in the eastern Himalayas, is mostly mountainous, with flat land limited to the broader river valleys and along the foothills bordering the Indian subcontinent. The country has three major landform features: the southern foothills, the inner Himalayas and the higher Himalayas. Owing to the extremely rugged mountainous terrain, only 100 000 ha or 3 percent of the total area is cultivated in 2009, of which 25 000 ha is under permanent crops. The country is heavily forested, 72.5 percent being under forests, and 10 percent is covered with year-round snow and glaciers (FAO, 2011).

3.3.1 Water Resources

Bhutan's total annual internal renewable surface water resources are an estimated 78 km^3 (Table 3.7). Owing to the mountainous geography of country, groundwater resources are probably limited and are drained by the surface water network, which means they are more or less equal to overlap between surface water and groundwater. Surface water leaving the country to India is an estimated 78 km^3.

Table 3.7: Renewable Freshwater Resources in Bhutan

Category	Quantity	Frequency
Precipitation (long-term average)	2, 200	mm/yr
	84, 500	million m^3/yr
Internal renewable water resources (long-term average)	78, 000	million m^3/yr
Total actual renewable water resources	78, 000	million m^3/yr
Dependency ratio	0.0	%
Total actual renewable water resources per inhabitant in 2009	109, 244	m^3/yr
Total dam capacity	-	million m^3

Source: Adapted from FAO-Aquastat-BTN (2012). *Water Report on Bhutan.*

Nearly every valley in Bhutan has a swiftly flowing river or stream, fed either by the perennial snow, the summer monsoon or both. Except for a small river in the extreme north that flows north, all rivers flow south towards India. The river basins are oriented north-south and are, from west to east. Most rivers are deeply incised into the landscape and hence the possibilities for run-of-the-river irrigation are limited. There are only two wastewater collection and treatment projects in the cities of Thimpu and Phuntsholing.

There are numerous natural lakes, many are located above 3 300 m and some above 4 200 m, which are primarily used to raise fish. Several large dams have been constructed to generate hydroelectric power. These include the 40 m high Chhuka dam (CHPP) on the Wang river in Chhukha district in the southwest, the 91 m high Tala-Wankha dam further downstream on the Raidak river near Phuntsholing town, the 33 m high Kurichhu dam on the Kuri river in Mongar district in the east, the Basochu dam (BHPP) near Wangduephodrang town in the centre-west. The 141 m high Punatsangchu dam on Puna Tsang river downstream of Wangduephodrang town is under construction.

3.3.2 Water Use

Total water withdrawal in Bhutan in 2008 was about 338 million m^3, all surface water, representing a mere 0.43 percent of the annual renewable water resources. About 94 percent of this water withdrawn is used for agriculture, while domestic and industrial sectors use 5 percent and 1 percent respectively (Table 3.8 and Figure 3.5).

Table 3.8: Water Withdrawal and Use in Bhutan

Water withdrawal	Year	Quantity	Frequency
Total water withdrawal	2008	338	million m3/yr
-irrigation+ livestock	2008	318	million m3/yr
-municipalities	2008	17	million m3/yr
- industry	2008	3	million m3/yr
*per inhabitant	2008	482	m3/yr
Surface water and groundwater withdrawal	2008	338	million m3/yr
*as of % of total actual renewable water resources	2008	0.43	%
Non-conventional sources of water			
Produced wastewater	-	-	million m3/yr
Treated wastewater	-	-	million m3/yr
Reused treated wastewater	-	-	million m3/yr
Desalinated water produced	-	-	million m3/yr
Reused agricultural drainage water	-	-	million m3/yr

Source: FAO-Aquastat-BTN (2011). *Bhutan Aquastat Survey*.

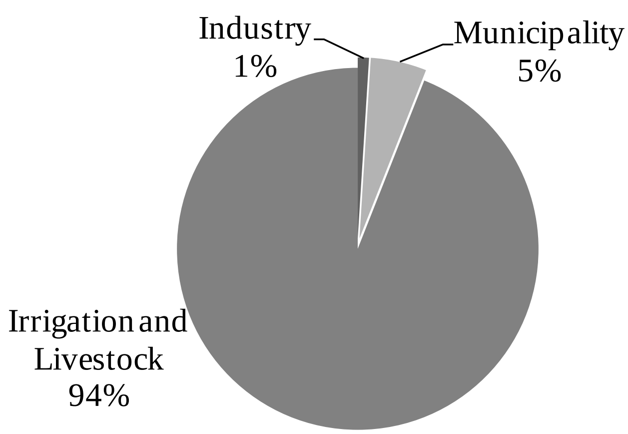


Figure 3.5: Water withdrawal by sector in Bhutan, 2008.

3.3.3 Water Management

There is no specific institutional mechanism responsible for water resources in Bhutan. In the wake of Bhutan's high hydropower potential, the Department of

Power has been entrusted with the responsibility for hydrological and meteorological data collection. Bhutan's National Environment Commission (NEC) is vested with the mandate to ensure effective coordination of national-level planning and development for all natural resources including water resources, formulation of water policy and the necessary legislation, setting up of water quality standards and guidelines, monitoring, evaluation and regulation of water use. It is also responsible for research and development, capacity building and human resources development, technical backstopping, data collection and dissemination, flood disaster management, etc.

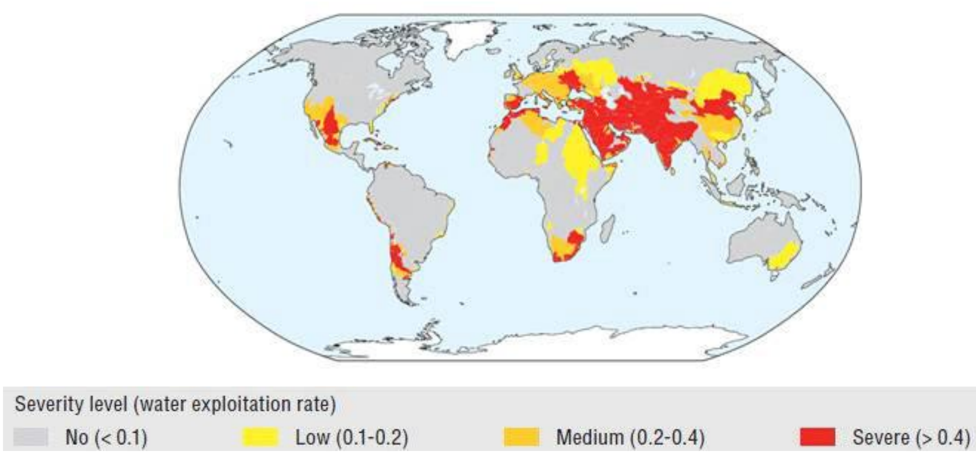
Undoubtedly, Bhutan is bestowed with substantial water resources; nonetheless, it experiences localized and seasonal water shortages for drinking and irrigation because there is uneven spatial distribution of precipitation, increasing sediment load in the rivers and wide variation between lean season and monsoon flows. Furthermore, the pressure on water resources is gradually increasing as a result of competing demands from various sectors. Floods and landslides accentuate the problem of water resources management. The existing water-related institutions have weak functional linkages with other subsectors relevant to water at policy, planning and implementation levels. This required the formulation of a national perspective on water resources and a Bhutan Water Policy was formulated in 2003. The Irrigation and Water Management Programme, as envisaged in Bhutan's Tenth Five-year Plan (2008–2013), has a goal to increase the portion of wetland with dry season irrigation (Tillier *et al*., 2010).

While recognizing water as a precious natural resource that is basic to all social, economic and environmental well-being, the Bhutan Water Policy (2003) emphasizes on the need for conservation and efficient management of the water resources, while ensuring sustainability and without damaging the integrity of the environment. The Policy adopts an integrated approach that recognizes natural linkages and covers all forms of resources including snow, glaciers, rivers, lakes, streams, springs, wetlands, rainwater, soil moisture and groundwater, to achieve poverty alleviation and increase Gross National Happiness (GNH). The Policy was framed within a broad multi-sectoral perspective which recognizes the responsibilities of the sub-sectors to play their role in meeting policy objectives.

The Bhutan Water Policy (2003) primarily addresses the following components: i) water user interests and priorities, ii) principles for water resources development and management, iii) international waters and iv) institutional development for water resources management. The first component includes the issues of water allocation, water for drinking and sanitation, water for food production, water for hydropower development, water for industrial use, and resolution of conflicting user interests. The second component includes water resources that are developed to ensure sustainability by adopting appropriate technologies and good management practices. The water resources are planned to be developed in an environmentally sustainable, economically feasible and socially acceptable manner with full participation of all stakeholders. Prevention and control of pollution and flood management are to be incorporated into the planning (BWP 2003 cited in ADB 2014).

3.4 Water Security in India

India faces a serious and persistent water crisis owing to a growing imbalance of supply and demand, as well as poor water resource management and climate change. India is projected to face severe water stress by 2050 (see Figure 3.6). Although industry is the largest contributor to India's GDP, agriculture accounts for nearly 90% of water use. Two-thirds of India's irrigation needs and 80% of domestic water needs are met using groundwater, contributing to the significant groundwater depletion rate. Although India has one of the world's largest irrigation systems, it is characterised by high levels of inefficient water use (OECD/FAO, 2014). Water quality is also an issue. The discharge of untreated sewage into water bodies is the most important source of water pollution in India; eighty percent of the sewage generated goes untreated. Finally, lack of access to improved water supply and adequate sanitation persists. According to the government census of 2011, only about 30% of the 167 million rural households in India have access to tap water and household toilets.



Source: OECD (2012), *Environmental Outlook to 2050: The Consequences of Inaction*

Figure 3.6: Water stress in India by river basin in 2050

3.4.1 Water Resources

India has an annual average precipitation of 1 170 mm and about 80 percent of the total area of the country experiences annual rainfall of 750 mm or more (Table 3.9). Owing to the large spatial and temporal variability in the rainfall, water resources' distribution is highly skewed in space and time. Rainfall and glacial snowmelt in the Himalayas are the two main sources of water in India are. Undoubtedly, snow and glaciers are poor producers of freshwater; nevertheless, these are good distributors as they yield at the time of need, in the hot season. Indeed, about 80 percent of the river flow occurs during the four to five months of the southwest monsoon season. Several important river systems originate in upstream countries and then flow to other neighbouring countries: the Indus river originates in China and flows to Pakistan; the Ganges-Brahmaputra river system originates partly in China, Nepal and Bhutan, and flows to Bangladesh; some minor rivers drain into Myanmar and Bangladesh. However, no official data are available regarding the annual flows into or out of India.

Table 3.9: Renewable Freshwater Resources in India

Category	Quantity	Frequency
Precipitation (long-term average)	1, 170	mm/yr
	3, 846, 500	million m^3/yr
Internal renewable water resources (long-term average)	1, 446, 000	million m^3/yr
Total actual renewable water resources	1, 911, 000	million m^3/yr
Dependency ratio	31	%
Total actual renewable water resources per inhabitant in 2009	1, 582	m^3/yr
Total dam capacity in 2005	224, 000	million m^3

Source: Adapted from Frenken (2012).

India is divided into 20 river units, 14 of which are major river basins, while the remaining 99 river basins have been grouped into six river units, as presented in Table 3.10. The spatial imbalance of water resources distribution can be appreciated by the fact that the Ganges-Brahmaputra-Meghna basin, which covers 34 percent of the country's area, contributes about 59 percent of the water resources. The west flowing rivers towards the Indus cover 10 percent of the area and contribute 4 percent of the water resources. The remaining 56 percent of the area contributes 37 percent to the runoff (Frenken, 2012).

Table 3.10: Basin-wise distribution of utilizable surface water resources in India

S.No	River basin unit	location	Draining into	Catchment area (% of the country)	Average annual runoff (km^2)	Exploitable surface water (km^2)
1.	Ganges	Northeast	Bangladesh	26.5	525.02	250.0
	Brahmaputra	Northeast	Bangladesh	6.0	537.24	24.0
	Meghna/Barak	Northeast	Bangladesh	1.5	48.36	
2.	Minor rivers of northeast	Extreme northeast	Myanmar	1.1	20.00	-
			Bangladesh		11.00	-
3.	Subernarekha	Northeast	Bay of Bengal	0.9	12.37	6.8
4.	Brahmani-Baitarani	Northeast	Bay of Bengal	1.6	28.48	18.3
5.	Mahanadi	Central-east	Bay of Bengal	4.4	66.88	50.0
6.	Godavari	Central	Bay of Bengal	9.7	110.54	76.3
7.	Krishna	Central	Bay of Bengal	8.0	78.12	58.0
8.	Pennar	Southeast	Bay of Bengal	1.7	6.32	6.9
9.	Cauvery (1)	South	Bay of Bengal	2.5	21.36	19.0
10.	East-flowing rivers between Mahanadi & Pennar	Central-east	Bay of Bengal	2.7	22.52	13.1
11.	East-flowing rivers between Kanyakumari & Pennar	Southeast	Bay of Bengal	3.1	16.46	16.7
12.	West-flowing rivers from Tadiri to Kanyakumari	Southwest	Arabian Sea	1.7	113.53	24.3
13.	West flowing rivers from Tapi to Tadiri	Central-west	Arabian Sea	1.7	7.41	11.9
14.	Tapi	Central-west	Arabian Sea	2.0	14.88	14.5
15.	Narmada (2)	Central-west	Arabian Sea	3.1	41.64	34.5
16.	Mahi	Northwest	Arabian Sea	1.1	11.02	3.1
17.	Sabarmati	Northwest	Arabian Sea	0.7	3.81	1.9

S.No	River basin unit	location	Draining into	Catchment area (% of the country)	Average annual runoff (km^2)	Exploitable surface water (km^2)
18.	West flowing rivers of Kutsh and Saurashtra	Northwest	Arabian Sea	10.0	15.10	15.0
19.	Rajasthan inland basin	Northwest	-	-	Negligible	-
20.	Indus eastern tributaries (3a)	Northwest	Pakistan	-	11.0	
	Indus western tributaries (3b)			10.0	62.21	46.0
-	Total considering Indus treaty	-	-	100.0	1, 869.37	690.3

Notes:

1. The assessment for Cauvery was made by the Cauvery Fact Finding Committee in 1972 based on 38 years' flow data at Lowe Anicat on Coleroon. An area of 8, 000 km^2 is not accounted for in this assessment.
2. The potential of the Narmada basin was determined on the basis of catchment area proportion from the potential assessed at Garudeshwar as given in the report on Narmada, Water Disputes Tribunal Decision (1978).
3. Under the Indus Water Treaty (1960), between India and Pakistan, the following is foreseen: (a). All waters of the tributaries of the Indus originating in India (11.1 km^2) shall be available for unrestricted use by India (Sutlej, Beas, Ravi), except some domestic and non-consumptive use. (b). All waters of the western tributaries (Chenab, Jhelum) shall be available for unrestricted use by Pakistan, except for some domestic use, non-consumptive use, agricultural use, generation of hydroelectric power; total flow of western rivers is estimated around 232.48 km^3 (flow from China to India is estimated at 181.62 km^3 and flow generated within India at 50.83 km^3), of which 170.27 km^3 should then be reserved for Pakistan and therefore 62.21 km^3 is available for India.

Source: FAO-Aquastat-Ind, 2012.

The leading rivers of India can be classified into four groups: the Himalayan rivers, the rivers of the Deccan plateau, the coastal rivers and the rivers of the inland drainage basin. The Himalayan rivers (Ganges, Brahmaputra, Indus) are formed by melting snow and glaciers as well as rainfall and, therefore, have a continuous flow throughout the year. As these regions receive very heavy rainfall during the monsoon period, the rivers swell and cause frequent floods. The rivers of the Deccan plateau (with larger rivers such as Mahanadi, Godavari, Krishna, Pennar and Cauvery draining into the bay of Bengal in the east, and Narmadi and Tapi draining into the Arabian sea in the west), making up most of the southern-central part of the country, are rain-fed and fluctuate in volume, many of them being non-perennial. The coastal rivers, especially on the west coast, south of the Tapi, are short with limited catchment areas, most of them being non-perennial. The rivers of the inland drainage basin in western Rajasthan in the northwestern part of the country, towards the border with Pakistan, are ephemeral and drain towards the salt lakes such as the Sambhar, or are lost in the sands (FAO-Aquastat, 2012).

Assessment of the potential surface water resources is facilitated on the basis of the natural runoff of the rivers. Looking at the mechanism laid down in the Indus Water Treaty (1960) between India and Pakistan, however, these are an estimated 1 869.37 km^3, of which only 690.31 km^3 are considered usable or exploitable because of constraints related to topography, uneven distribution of the resource over space and time, geological factors and contemporary technological knowledge (Frenken, 2012).

India's annual renewable ground water resources are an estimated 432 km^3, of which around 90 percent or 390 km^3 are considered overlap between surface water and groundwater. Annual internal renewable surface water resources (IRSWR) have been estimated as 1 446.42 km^3, of which 1 404.42 km^3 surface water, 432 km^3 groundwater and 390 km^3 overlap. The IRSWR have been estimated by deducting the inflow from the total renewable surface water resources. Besides this outflow to Pakistan from the Indus basin, 1 121.62 km^3 flows annually to Bangladesh (525.02 km^3 from the Ganges, 537.24 km^3 from the Brahmaputra, 48.36 km^3 from the Meghna and 11 km^3 from other rivers into southeast Bangladesh), and 20 km^3 flows to Myanmar (FAO-Aquastat, 2012). In 1996, produced wastewater was an estimated 25.4 km^3. In 2004, wastewater production in urban centres (rural areas with larger population have not been accounted) was an estimated 10.585 km^3 and the treated wastewater was about 2.555 km^3 (*ibid*.).

There is paucity of reliable data on the number or the status of desalination plants or on their capacities or technologies adopted. Estimates indicate, however, that there are more than 1 000 membrane-based desalination plants of various capacities ranging from 20 m^3/day to 10 000 m^3/day. There are few thermal-based desalination plants. In 1996, some 550 000 m^3 of seawater were desalinated in the Lakshadweep Islands, mainly using electro dialysis and reverse osmosis (RO). Solar stills are also installed on the peninsula, as in Gujarat in the northwest.

The total constructed water storage capacity, up to 2005, was 224 km^3. Another 76.26 km^3 are estimated to be possible from dams under construction and 107.54 from dams under consideration. Seven dams have a reservoir capacity that exceeds 8 km^3. They are the Nagarjuna Sagar dam on the Krishna river (11.56 km^3), the Rihand dam on the Rihand river (10.6 km^3), the Bhakra dam on the Sutlej river (9.62 km^3), the Srisailam dam on the Krishna river (8.72 km^3), the Hirakud dam on the Mahanadi river (8.1 km^3), the Pong (Beas) dam on the Beas river (8.57 km^3) and the Ukai dam on the Tapti river (8.5 km^3) (Frenken, 2012).

3.4.2 Water Use

It is estimated that in 2010 total water withdrawal was 761 km^3 of which 91 percent, or 688 km^3, are for irrigation. About 56 km^3 are for municipal and 17 km^3 for industrial use (Table 3.11 and Figure 3.6).

Table 3.11: Water Withdrawal and Use in India

Water withdrawal	**Year**	**Quantity**	**Frequency**
Total water withdrawal	2010	761, 000	million m3/yr
-irrigation+ livestock	2010	688, 000	million m3/yr
-municipalities	2010	56, 000	million m3/yr
- industry	2010	17, 000	million m3/yr
*per inhabitant	2010	630	m3/yr
Surface water and groundwater withdrawal	2010	761, 000	million m3/yr
*as of % of total actual renewable water resources	2010	40	%
Non-conventional sources of water			
Produced wastewater	1996	25, 410	million m3/yr
Treated wastewater	-	-	million m3/yr
Reused treated wastewater	-	-	million m3/yr
Desalinated water produced	1996	0.55	million m3/yr
Reused agricultural drainage water	2010	113, 470	million m3/yr

Source: FAO-Aquastat-Ind, 2012.

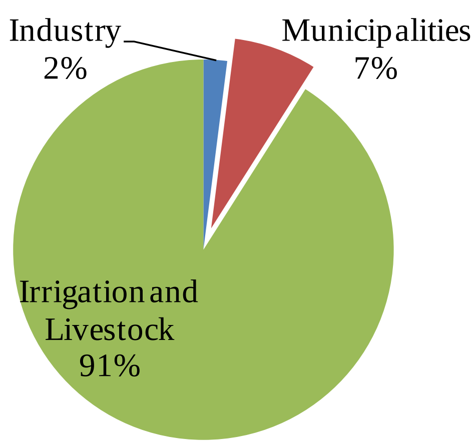


Figure 3.6: Water withdrawal by Sector in India, 2010 (Total withdrawal 761km^2)

In 2010, primary surface water withdrawal accounted for 396 km^3, primary groundwater withdrawal accounted for 251 km^3, and reused agricultural drainage water accounted for 113 km^3. In 1996, some 550 000 m^3 of seawater were desalinated (Figure 3.7).

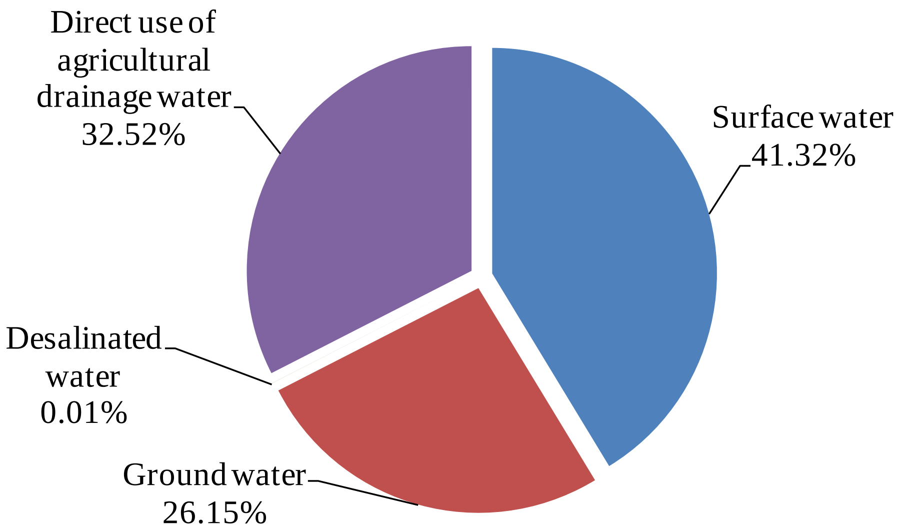


Figure 3.7: Water withdrawal by source in India, 2010.

In 1990, total water withdrawal was an estimated 500 km^3, of which 92 percent was for irrigation. Primary surface water withdrawal was 362 km^3, while the amount coming from primary groundwater was an estimated 190 km^3.

3.4.3 Water Management

Water is a State subject under the Indian Constitution and the states are responsible for water management. The federal states are primarily responsible for the planning, implementation, funding and management of water resources development. The responsibility in each state is borne by the Irrigation and Water Supply Department. The Inter-State Water Disputes Act of 1956 provides a framework for the resolution of possible conflicts. At central level, which is responsible for water management in the union territories and in charge of developing guidelines and policy for all the states, three main institutions are involved in water resources management: The Ministry of Water Resources (MWR) is responsible for laying down policy guidelines and programmes for the development and regulation of the country’s water resources. The ministry’s technical arm, the Central Water Commission (CWC), provides general infrastructural, technical and research support for water resources development at state level. The CWC is also responsible for the assessment of water resources.

The erstwhile Planning Commission of India, now replaced by NITI Ayog, was responsible for the allocation of financial resources required for various programmes and schemes of water resources development to the states as well as to the MWR. It was also actively involved in policy formulation related to water resources development at the national level. The Ministry of Agriculture promotes irrigated agriculture through its Department of Agriculture and Cooperation. The Central Pollution Control Board (CPCB) is in charge of water quality monitoring, and the preparation and implementation of action plans to solve pollution problems. The Central Groundwater Authority, established in 1996, is responsible for regulating and controlling groundwater development to preserve and protect the resource.

Master Plan for Artificial Recharge to Ground Water in India, adopted in 2013, has identified a total area of about 9,41,541 sq.km. in various parts of country where artificial recharge to ground water is feasible. This also includes hilly terrains of some states and Islands where the structures are proposed to improve the sustainability of springs and freshwater. It is estimated that annually about 85,565 MCM of surplus run-off is to be harnessed to augment the ground water. Most of the basins of the country, particularly in Peninsular India are having marginal/negligible surplus runoff, where considerable space in underground reservoirs is available. Hence, surplus runoff is not available for recharge to ground water in various areas, which otherwise need artificial recharge. The surplus runoff available in North Eastern States, Himachal Pradesh and Islands is very high and due to limited space available underground for recharge, the surplus run off calculation is not separately given (MoWR-India, 2013).

However, for the stabilization of springs and improving the ground water scenario in existing localized ground water extraction areas, few recharge structures are identified and will be executed by considering the local ground slope and vulnerability of landslides, etc. in these areas. In rural areas, suitable structures like percolation tanks, check dams, nala bunds, gully plugs, gabion structures etc. and sub-surface techniques of recharge shaft, well recharge etc. have been recommended. Provision to arrest ground water flow through ground water dams has also been made in some states. The revised Master Plan envisages construction of about 1.11crore artificial recharge structures in urban and rural areas. This comprises of around 88 lakh recharge structures/ facilities utilizing rain water directly from roof top and around 23 lakh artificial recharge and rainwater harvesting structures for conserving surplus runoff and recharging ground water in aquifers. The break-up includes around 2.90 lakh check dams, 1.55 lakh gabion structures, 6.26 lakh gully plugs, 4.09 lakh nala bunds/cement plugs 84925 percolation tanks, 8281 sub-surface dykes, 5.91 lakh recharge shafts,1.08 lakh contour bunds,16235 injection wells and 23172 other structures which includes point recharge structures recharge tube-wells, stop dams, recharge trenches, anicuts, flooding structures, induced recharge structures, weir structures etc. In North Eastern States, Andaman & Nicobar and Sikkim emphasis has been given to spring development and 2,950 springs are proposed for augmentation and development (*ibid*.).

India adopted a National Water Policy in 1987, which was revised in 2002, for the planning and development of water resources to be governed at the national level. It emphasizes the need for river basin based planning of water use. The National Water Policy 2002 emphasized a participatory approach for water resources management. It has been recognized that participation of beneficiaries will help optimize the upkeep of the irrigation system and promote the efficient use of irrigation water. The participation of farmers in irrigation management is formulated based on the creation of water user associations (WUAs), which aim to: i) promote and secure distribution of water among users; ii) ensure adequate maintenance of the irrigation systems; iii) improve efficiency and economic use of water; iv) optimize agricultural production; v) protect the environment; and vi) ensure ecological balance by involving the farmers and inculcating a sense of ownership of the irrigation systems in accordance with the water budget and operational plan(NWP-India 2002) . The WUAs are formed and work guided by the executive instructions and guidelines which are laid down by each state government. A total of 55 500 WUAs were constituted in India covering 10.23 million ha.

India has adopted revised National Water Policy 2012, which has the following salient features:

- Emphasis on the need for a national water framework law, comprehensive legislation for optimum development of inter-State rivers and river valleys, amendment of Irrigation Acts, Indian Easements Act, 1882, etc.
- Water, after meeting the pre-emptive needs for safe drinking water and sanitation, achieving food security, supporting poor people dependent on agriculture for their livelihood and high priority allocation for minimum eco-system needs, be treated as economic good so as to promote its conservation and efficient use.
- Ecological needs of the river should be determined recognizing that river flows are characterized by low or no flows, small floods (freshets), large floods and flow variability and should accommodate development needs. A portion of river flows should be kept aside to meet ecological needs ensuring that the proportional low and high flow releases correspond in time closely to the natural flow regime.

- Adaptation strategies in view of climate change for designing and management of water resources structures and review of acceptability criteria has been emphasized.
- A system to evolve benchmarks for water uses for different purposes, i.e., water footprints, and water auditing be developed to ensure efficient use of water. Project financing has been suggested as a tool to incentivize efficient & economic use of water.
- Setting up of Water Regulatory Authority has been recommended. Incentivization of recycle and re-use has been recommended.
- Water Users Associations should be given statutory powers to collect and retain a portion of water charges, manage the volumetric quantum of water allotted to them and maintain the distribution system in their jurisdiction.
- Removal of large disparity in stipulations for water supply in urban areas and in rural areas has been recommended.
- Water resources projects and services should be managed with community participation. Wherever the State Governments or local governing bodies so decide, the private sector can be encouraged to become a service provider in public private partnership model to meet agreed terms of service delivery, including penalties for failure.
- Adequate grants to the States to update technology, design practices, planning and management practices, preparation of annual water balances and accounts for the site and basin, preparation of hydrologic balances for water systems, and benchmarking and performance evaluation (NWP-India 2013).

3.4.4 Environment and Health

Water quality is fast emerging a major issue in India. Although in their upper reaches most rivers are of good quality, the importance of water use for cities, agriculture and industries, and the lack of wastewater treatment plants in the middle and lower reaches of most rivers cause a major degradation of surface water quality. Groundwater is also affected by municipal, industrial and agricultural pollutants. The over exploitation of groundwater can also lead to seawater intrusion. For example, there is an inland advance of the saline-freshwater interface in the Chingelput district of Tamil Nadu, where a well field along the Korttalaiyar River supplies water to the city of Madras (Frenken, 2012).

Water security is emerging as an increasingly important and vital issue for India, with many Indian cities beginning to experience moderate to severe water shortages, brought on by the simultaneous effects of agricultural growth, industrialization and urbanization. These shortages would be further aggravated by receding of glaciers and dwindling fresh water resources. Population stress, irrigation requirements and industrialization are the major pressures for water insecurity. The environmental challenges of water resource development and management in India are expected to manifest themselves more explicitly and rapidly in the coming years. These environmental challenges may be addressed through four broad approaches (a) Improving efficiencies and minimizing losses (b) Recharging groundwater aquifers (c) Abatement and treatment of water pollution (d) Reuse and recycling of wastewater (CPCB, 2012).

According to India's Central Pollution Control Board estimates, about 50 billion litres of municipal water is required every day based on the population figures of urban India which is about 360 million. The urban population may exceed over 800 million by the year 2050 and the resultant municipal water requirement will be of the magnitude of over 110 billion litres per day. Besides the requirement of rural population (1.1 billion) shall be about 44 billion litres per day for the year 2050 (*ibid.*).

It is estimated that about 38,000 million litres per day (mld) of wastewater are generated in the urban centres having population more than 50,000 in India (housing more than 70% of urban population). The municipal wastewater treatment capacity developed so far in India is about 11,000 mld accounting for 29% of wastewater generation in these two classes of urban centers. In view of population increase, demand of freshwater for all the uses will be unmanageable. It is estimated that the projected wastewater from urban centres may cross 1,00,000 mld by 2050 and the rural India will also generate not less than 50,000 mld in view of water supply designs for community supplies in rural areas. However, waste water management is not addresses to that pace (ibid.).

Water-borne diseases have continued to increase over the years in spite of government efforts to combat them. States such as Punjab, Haryana, Andhra Pradesh and Uttar Pradesh are endemic for malaria as a result of the high water table, water-logging and seepage in the canal catchment area. There are also numerous cases of filariasis. In 1998 the population affected by water-related diseases was 44 million inhabitants (Frenken, 2012).

Climate change entails the potential of altering the distribution and quality of India's water resources. Potential impacts of global warming on water resources, *inter alia*, include: enhanced evaporation, geographical changes in precipitation intensity, duration and frequency (together affecting the average runoff), soil moisture, and the frequency and severity of droughts and floods. Future projections using climate models point to an increase in the monsoon rainfall in most parts of India, with increasing greenhouse gases and sulphate aerosols. Relatively small climatic changes can have huge impact on water resources, particularly in arid and semi-arid regions such as North-West India.

This will have impacts on agriculture, drinking water, and on generation of hydroelectric power, resulting in limited water supply and land degradation; occurrence of more intense rains, changed spatial and temporal distribution of rainfall, higher runoff generation, low groundwater recharge, melting of glaciers, changes in evaporative demands and water use patterns in agricultural, domestic and industrial sectors, etc. These impacts can also lead to severe influences on the agricultural production and food security, ecology, biodiversity, river flows, floods, and droughts, water security, human and animal health, rise in the snowline, reducing the capacity of these natural reservoirs, and increasing the risk of flash floods during the wet season. Increase in temperatures can lead to increased eutrophication in wetlands and fresh water supplies (CPCB, 2012).

3.5 Water Security in Maldives

The Maldives, comprising 1, 190 low-lying islands, spreading along a north-south axis over a distance of some 1 000 km, about 600 km southwest of Sri Lanka in the Indian Ocean, is a chain of Coral Atolls, a layer of recent sediments on top of older limestone. The upper sediments are of primary importance as freshwater lenses are found in this layer due to the moderate permeability of the rock. Freshwater lenses consist of a thin lens of freshwater floating on denser salt water. Due to increasing demands from population growth – particularly on the capital Male' – saltwater intrusion and pollution of groundwater from release of sewage, industrial effluent and poor agricultural practices, the Maldives can no longer rely on freshwater lenses to satisfy their freshwater needs (Kundzewicz 1998). The Maldives has no surface water, thus methods to meet demands for freshwater are limited to the remaining groundwater development, rainwater harvesting and desalination (MCST, 2000). The lack of surface water or usable groundwater has put the Maldives in a situation, referred to by Turton (1999) as 'water scarcity'.

3.5.1 Water Resources

In Maldives, there are no permanent rivers or streams on any of the islands, but small brackish ponds or freshwater lakes known as kulhis are found on some islands. Rainwater is collected on a small scale and used for drinking. It is extremely difficult to obtain suitable drinkable water in the Maldives. Groundwater is found in freshwater lenses underlying the atolls and floating on top of the saline water, but heavy abstraction for municipal use has depleted them, especially in the capital city of Male, causing saltwater intrusion. Groundwater is recharged by rainfall but becomes contaminated while percolating through the soil, which is generally polluted with organic and human waste. A rough estimate of the groundwater resources, based on an assumed 0.1 m/year recharge throughout the country (300 km^2), is 0.03 km^3/year, may be the Maldives' only renewable water resource. This is hardly exploitable because of seawater intrusion and pollution (Table 3.12).

Table 3.12: Renewable Freshwater Resources in Maldives

Category	Quantity	Frequency
Precipitation (long-term average)	1972	mm/yr
	590	million m^3/yr
Internal renewable water resources (long-term average)	30	million m^3/yr
Total actual renewable water resources	30	million m^3/yr
Dependency ratio	0	%
Total actual renewable water resources per inhabitant in 2009	96	m^3/yr
Total dam capacity	-	million m^3

Source: FAO-Aquastat-Mald, 2012

Desalination has become the only alternative means of providing a safe water supply in areas where the quality of water has been degraded, either by high salinity or polluted water, and where there is insufficient space available for rainwater collection and storage. This is the case in the capital Male and in what was the most densely populated island Kandholhudhoo in Raa Atoll, which once was home to over 3 000 people, but it was one of the islands most affected by the tsunami and all inhabitants were left homeless and had to evacuate. The first desalination plant in Male was installed in 1988 with a capacity of 200 m^3/day. In line with increases in population and water consumption, the capacity has been increased steadily and is now 5 800 m^3/day. The quantity of desalinated water used in Male has increased from 323 300 m3 in 1996 to 1 206 900 m^3 in 2001, equal to about 900 and 3 300 m^3/day respectively (Ibrahim et al., 2002). The desalination plant in Kandholhudhoo, constructed in 1999, has a production capacity of 50 m3/day (18 262 m^3/year), and is a reverse osmosis plant.

In May 1999, about 28 percent of the population of the Maldives had access to desalinated water and over 20 percent of the population almost entirely depended on desalinated water, besides the tourists on the resort islands. Desalination plants have been used in the Maldives' tourist resorts since the late 1970s. Currently each resort island has its own desalination plant, which is usually operated and maintained by a technician appointed for that purpose. In 2010, government of Maldives signed a water purchase agreement a large international company to provide potable water to the Southern Province of the Maldives. The company would construct six seawater reverse osmosis desalination plants with a total production of 3 000 m^3/day and will design and construct the distribution system to enable storage and delivery of potable water to over 4 500 households (IRC, 2010).

3.5.2 Water Use

In the absence of recent authentic data on water withdrawal in the Maldives, it is estimated that in 2008 the total municipal water withdrawal was 5.6 million m^3 against 3.3 million m^3 in 1987 (Table 3.13 and Figure 3.8). The industrial withdrawal was around 0.3 million m^3 against 0.1 million m^3 in 1987. No information is available on water withdrawal for irrigation. If, however, there is irrigation it will mostly rely on collected rainwater. This gives a total water withdrawal of 5.9 million m^3, of which 1.225 million m^3 is provided by desalinated water. The above amounts do not include water used by tourists. An estimated 500 000 tourists visit the Maldives per year and all tourist resorts have their own desalination plants. In addition, many people collect and store rainwater for their use, which is not included in the above amounts (Frenken, 2012).

Table 3.13: Water Withdrawal and Use in Maldives

Water withdrawal	Year	Quantity	Frequency
Total water withdrawal	2008	761, 000	million m3/yr
-irrigation+ livestock	2008	688, 000	million m3/yr
-municipalities	2008	56, 000	million m3/yr
- industry	2008	17, 000	million m3/yr
*per inhabitant	2008	630	m3/yr
Surface water and groundwater withdrawal	2008	761, 000	million m3/yr
*as of % of total actual renewable water resources	2008	40	%
Non-conventional sources of water			
Produced wastewater	-	-	million m3/yr
Treated wastewater	-	-	million m3/yr
Reused treated wastewater	-	-	million m3/yr
Desalinated water produced	2001	1, 225	million m3/yr
Reused agricultural drainage water	-	-	million m3/yr

Source: Frenken, 2012.

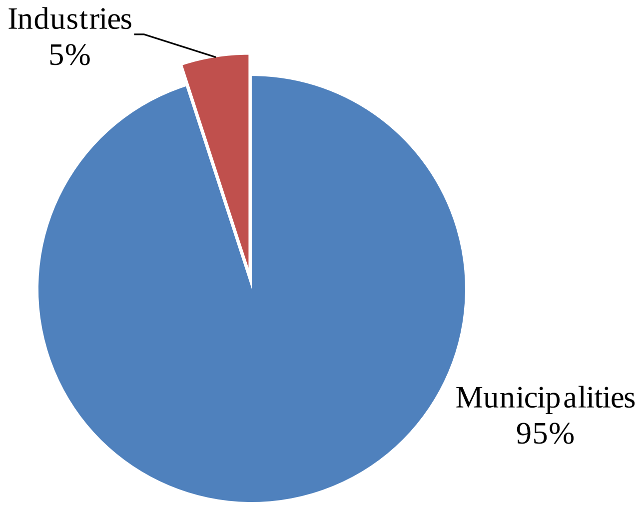


Figure 3.8: Water withdrawal by Sector in Maldives, 2008
(Total withdrawal 0.0059km^2)

Rainwater harvesting is common in most of the Islands of the Maldives, with the exception of Male. The water thus harvested is collected and stored in various types of tanks. All the islands have individual household as well as community tanks. However, the situation is different on the island Male, which is the capital and where everyone has access to desalinated water distributed through a piped network. Groundwater, which is highly contaminated, is mainly used to flush toilets. Those who can, however, often prefer to collect rainwater for drinking to save money. Those who cannot afford to have house connections can collect limited quantities of water for free from tap bays located in 15 places around the island (Ibrahim et al., 2002).

In the tourist resorts, the desalinated water produced is generally used for cooking and bathing only, as guests are encouraged to buy bottled water for drinking. Rainwater is sometimes collected for staff to drink, and groundwater is sometimes used for irrigation of tiny areas, though neither resource is used to its full extent. On a few resorts treated wastewater is used for irrigation of food crops and some landscaping, but no data are available, though the amount must be very small (*ibid*.).

3.5.3 Water Management

There prevails institutional mechanism in Maldives for water management. Establishment of the Environmental Protection Agency (EPA) in 2009 was facilitated with the abolition of the Maldives Water and Sanitation Authority (MWSA), established in 1973, and the Environment Research Centre. The newly established EPA was linked to the Ministry of Housing, Transport and

Environment. It operates as a regulatory authority administered under a governing board (HCoM-UK, 2009). Male Water and Sewerage Company (MWSC), established in 1995, is responsible for the operation and management of water supply and sewerage services in Male. Ibrahim et al. (2002) have argued that the development of sustainable water supplies should rely on a combination of developing groundwater resources and rainwater harvesting. Undoubtedly, desalination is considered an expensive alternative in the Maldives; nevertheless, it is necessary on some islands and it is widely used in the 87 tourist resorts because it is regarded as an affordable option in view of substantial revenue being generated from the tourists.

Groundwater resources management requires improved land-use planning, assessment of groundwater conditions before development, and the designation of groundwater protection zones. The need for groundwater quality protection through improved sewage treatment and disposal of wastewater is recognized. Trials are to begin on use of gravel bed hydroponics (GBH) or constructed wetlands for sewage treatment to protect the groundwater from pollution. The kulhis (freshwater ponds) could be developed as a water resource, though studies have yet to be undertaken to explore this feasibility (Ibrahim et al., 2002).

The government of Maldives has adopted a policy which is designed to ensure that all inhabited islands have water supplies that meet basic requirements. Except for Male, current investment on the islands is for rainwater collection to develop a consistent supply of safe water for drinking and cooking. The Government's objective, according to the Health Master Plan 1996–2005, was to provide access to 10 litres/person per day of safe water for drinking and cooking for the entire population and, on islands where groundwater is not potable, to provide 40 litres/person per day. In 2006, MWSA presented the five-year activity plan, with the following activities: water resources assessment and monitoring, water supply and sanitation guidance and regulation development, and water and wastewater quality compliance monitoring (MWSA, 2006). The Health Master Plan 2006-2015 promised to provide access to safe drinking water to 85% of the population by 2010 which would be extended to above 90% of the population by 2015 (MoH, 2006).

With a view to facilitate the sustainable development of water resources, the following policies were set out in the context of the Health Master Plan 1996–2005 and the Second National Environmental Action Plan 1999:

- To increase collection and storage of rainwater at household level. This will include the sizing of rainwater tanks at the household level to have sufficient capacity to store rainwater to last the whole year through.

- To improve community collection and storage by increasing the storage capacity, renovating existing tanks, increasing catchment areas and conducting information, education and communication (IEC) activities to ensure rainwater is collected safely. This will include the building of underground rainwater tanks during construction of community buildings, and will encourage directing rainwater into household wells where rainwater tanks are not available.
- To pilot new schemes such as community groundwater systems (infiltration galleries) in areas of low salinity with a low risk of pollution, as a means of supplementing rainwater supplies where necessary.
- In order to protect groundwater resources from becoming saline, to discourage the use of electric pumps (Frenken, 2012).

3.5.4 Environment and Health

Massive increase in the quantity of water withdrawn from Male's aquifer during the 1970s was followed by tremendous disposal of sewage into the ground which culminated in making groundwater more vulnerable to pollution. The resultant outcome was the start of spreading of water-borne diseases such as diarrhoea, cholera, shigella and typhoid etc because of the poor sanitary conditions. In response to this problem, a special office was established in 1973, the Maldives Water and Sanitation Authority (MWSA). A study carried out by MWSA in Male revealed about 1.3 million litres of water were being used from the aquifer daily, the thickness of the freshwater lens had reduced to about 12 m and there was rapid deterioration of the groundwater quality. This was because of a larger population and poor sanitary conditions.

According to Ibrahim et al. (2002), developments like outbreaks of cholera in 1978 and shigella in 1982 led to the implementation of the Male Water Supply and Sewerage Project in 1985 with assistance from external donors. Under this project, lot of work was carried out in Male between 1985 and 1988, which *inter alia* included: drilling of boreholes, installation of large steel tanks for storage of rainwater, installation of household tanks and the construction of a sewage scheme for the entire island of Male etc. Growth in Male's population during the 1990s led to increased withdrawal of groundwater without matching recharge of aquifers, as a result of which, the salinity of the aquifer increased sharply, limiting its usefulness as a resource. In the wake of these developments, desalination became one of the few options available for providing sufficient safe water to Male. In the aftermath of the installation of first desalination plant in 1988, more such plants have been installed to satisfy growing demand for water (*ibid*.).

The December 2004 tsunami that hit the Maldives had affected nearly one-third of the country's inhabitants and also destroyed much of the infrastructure. The post-tsunami period saw the islands' residents rely on groundwater as their main source of water for domestic activities such as cooking, cleaning and washing (ARC, 2006). An Asian Development Bank (ADB) grant for environmental management focuses predominantly on environmental health and awareness. It designed a strategy for reconstructing the water and sanitation sector following the tsunami and improving the country's environmental assessment capability. It also tests innovative environmental public awareness programmes and promotes community management of sanitation and solid waste systems (ADB, 2016).

3.6 Water Security in Nepal

Nepal is located entirely in the Ganges basin and is bordered by India in the east, south and west and by China in the north. With fifteen peaks higher than 7 000 m, including the world's highest peak Mount Everest at 8 848 m, Nepal is one of the highest countries in the world. Nepal's recent achievements in bringing water to a growing percentage of the population have not benefited all segments of the Nepalese society because many people are still unable to have access to clean water sources. In the Terai plains of Nepal, where water sources are easier to access, the water may not be safe to drink or cook with, because of contamination by industrial and agricultural chemicals. And in Nepal's large cities, including Kathmandu, high rates of urbanization are over-saturating the existing water supply systems. The people belonging to marginalized segments, lower castes and indigenous communities have reportedly no easy access to water. And as fetching water is often considered a woman's job, the lack of access to water has a disproportionate impact on women and girls (Rousselot, 2015).

3.6.1 Water Resources

There are more than 6 000 rivers in Nepal, which provide a dense network with steep topographic conditions and all these rivers drain into the Ganges river. Nepal's average annual precipitation is estimated at 1 500 mm (Table 3.14). The country is divided into five river basins, which are spread from west to east. Mahakali river basin, which is shared with India, with an average flow from the Indian tributaries into the border river, entails outflow of around 15 km^3/year and some 3.4 km^3/year from the Nepalese tributaries. Karnali river basin has an average outflow of about 43.9 km^3/year. The average outflow of Gandaki river basin is roughly 50.7 km^3/year; and Kosi river basin's average outflow is estimated at 47.2 km^3/year, which receives a contribution of some 12 km^3/year from the upper catchment area located in China. Nepal's southern river basins produce some 65 km^3/year of water that flows into India.

Table 3.14: Renewable Freshwater Resources in Nepal

Category	Quantity	Frequency
Precipitation (long-term average)	1500	mm/yr
	220, 770	million m^3/yr
Internal renewable water resources (long-term average)	198, 200	million m^3/yr
Total actual renewable water resources	210, 200	million m^3/yr
Dependency ratio	5.71	%
Total actual renewable water resources per inhabitant in 2009	7, 142	m^3/yr
Total dam capacity in 2009	85.3	million m^3

Source: FAO-Aquastat-Nep, 2012.

In Nepal, the seasonal distribution of water flow is extremely variable. It might be as low as 1.5-2.4 percent of the total runoff in January, February and March, and as high as 20-27 percent in July and August for snow-fed rivers, while the corresponding figures for purely rain-fed rivers are 0.5-3 percent from March to May and 19-30 percent in July and August. The surface water resources produced internally are estimated at 198.2 km^3/year. Undoubtedly, the groundwater resources of Nepal have not been fully assessed; nevertheless, it becomes discernible from ongoing studies that a good potential for groundwater extraction exists, especially in the southern Terai lowland plains and inner valleys of the hilly and mountainous regions. Large part of the Terai physiographic region and some parts of Siwalik valleys are underlain by deep or shallow aquifers, many of which are suitable for exploitation as sources of irrigation water (Frenken, 2012).

FAO-Aquastat in its report on Nepal has suggested that a rough estimate can be made by assuming a groundwater resource equivalent to 10 percent of surface water, i.e. approximately 20 km^3/year, which corresponds to the base flow of the rivers; then total internal water resources would therefore amount to 198.2 km^3/year. Chinese statistics, as referred to in FAO report, mention an average outflow to Nepal of 12 km^3/year, which brings the total renewable water resources of Nepal to 210.2 km^3/year. It is assumed that all the renewable water resources of Nepal flow out of the country to India. In 2009, the total dam capacity was 85 million m^3, although the potential exists for at least 138 km^3 (FAO-Aquastat-Nep, 2012) .

3.6.2 Water Use

Total water withdrawal in Nepal during 2005 was an estimated 9 787 million m^3, all freshwater withdrawal, of which 98.2 percent was utilized for agricultural purposes, 1.5 percent for municipalities and 0.3 percent for industry (Table 3.15 and Figure 3.9).

Table 3.15: Water Withdrawal and Use in Nepal

Water withdrawal	Year	Quantity	Frequency
Total water withdrawal	2005	9, 787.1	million m3/yr
-irrigation+ livestock	2005	9, 610	million m3/yr
-municipalities	2005	147.6	million m3/yr
- industry	2005	29.5	million m3/yr
*per inhabitant	2005	359	m3/yr
Surface water and groundwater withdrawal	2005	9, 787.1	million m3/yr
*as of % of total actual renewable water resources	2005	4.7	%
Non-conventional sources of water			
Produced wastewater	-	-	million m3/yr
Treated wastewater	-	-	million m3/yr
Reused treated wastewater	-	-	million m3/yr
Desalinated water produced	-	-	million m3/yr
Reused agricultural drainage water	-	-	million m3/yr

Source: FAO-Aquastat-Nep, 2012

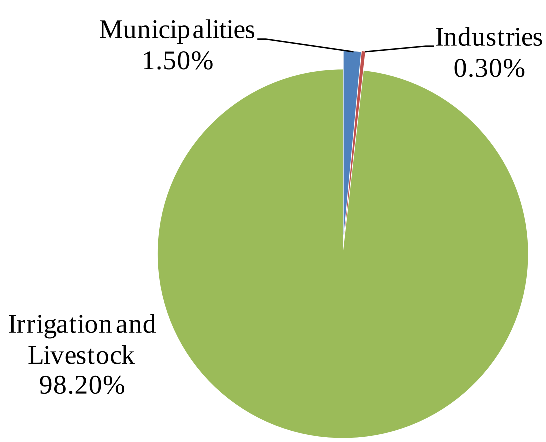


Figure 3.9: Water withdrawal by Sector in Nepal, 2005 (Total withdrawal 9.787 km^2)

Water withdrawal for the domestic sector is from different types of sources such as springs, open wells, tube-wells, rivers or streams, traditional stone taps and modern piped systems.

3.6.3 Water Management

Nepal's Ministry of Irrigation (MOIR) is the major government institution, currently involved in the water resources and irrigation sectors, which is responsible for the utilization and management of water resources. It prepares plans and policies and their implementation regarding irrigation development. The MOIR includes the Department of Water-Induced Disaster Prevention and the Department of Irrigation. Other institutions having direct links to the irrigation sector in Nepal, *inter alia*, include: Ministry of Agriculture and Cooperatives (MOAC), National Planning Commission (NPC), Water and Energy Commission Secretariat (WECS), and the Department of Hydrology and Metrology of the Ministry of Environment.

The focus of the traditional water resources management in Nepal has thus far been on the supply side where only technical solutions were considered to meet the growing demand for water. Isolated projects for irrigation, drinking water supply and sanitation, hydropower, flood control and other uses were developed. Economic criteria formed the basis of evaluation, while the environmental and social impacts were hardly considered. Control over these projects by independent sector authorities on the basis of command and control has often led to unsatisfactory results, frequently leading to inter-sectoral, inter-regional and riparian conflicts WECS, 2002).

The Water Resources Strategy (WRS) was based on certain identified policy principles involving integrated water resources management (IWRM). Two of the stated policy principles relevant to river basin management (RBM) are: (a) Development and management of water resources shall be undertaken in a holistic and systematic manner, relying on IWRM; (b) Water utilization shall be sustainable to ensure conservation of resources and protection of the environment. Each river basin system shall be managed holistically.

WECS formulated the National Water Plan (NWP) in 2005 to implement the Water Resources Strategy (WRS) in consultation with relevant sectoral ministries. The plan states the importance of IWRM principles and the notion of river basin management to ensure that water resources development is done in an effective and sustainable manner. The broad objective of the NWP is to contribute to the overall national goals of economic development, poverty alleviation, food security, public health and safety, decent standards of living for the people and protection of the natural environment. The NWP provides a framework to guide, in an integrated and comprehensive manner, all stakeholders in developing and managing water resources and water services. A set of specific short-, medium- and long-term action plans has been developed for the water sector, including for programme and project activities, investments and institutional aspects (WECS, 2005).

Initially, the Ministry of Water Resources (MoWR) and WECS were identified as the main government institutions responsible for promoting IWRM implementation. In 2009, however, MoWR was split (mainly for political reasons) into two ministries: the Ministry of Irrigation (MoI) and the Ministry of Energy (MoE). Though other ministries are actually involved in water resources management, MoWR and later MoI and MoE continue to be the most powerful ministries in water resources management. For this reason, WECS is also located under MoWR and later under MoE (Suhardimana, *et al*., 2015).

3.6.4 Environment and Health

Water pollution is fast emerging as a matter of serious concern in Nepal, especially its capital, Kathmandu, because of its adverse impact on the health of the people. It is estimated that Kathmandu produces 150 tons of waste each day, nearly half of which is dumped into the river. More than 40 million liters a day of wastewater is generated in Kathmandu and a whopping over 80 percent of this is generated by households (Manandhar, 2001). A report by international consultants concludes, "Kathmandu's drinking water is hosting disease-causing microbes and hazardous chemicals." According to the same study, when tap water from representative locations of Kathmandu's urban areas was analyzed in the laboratory, almost 90% of the sample was not potable (Adhikari, 1998).

Most rivers in Nepal's urban areas are polluted and their waters unfit for human use. The latest UN report presented at the ongoing 3rd World Water Forum in Japan says that the drinking water in Kathmandu Valley has been found to contain coliform bacteria, iron, ammonia and other contaminants (Budhathoki, 2003). Many rivers and water bodies are becoming saturated with organic compounds from industrial effluents, posing a major threat to both human health and aquatic life (UNICEF, no date). Bagmati and Vishnumati rivers in the Kathmandu valley which must be the most polluted rivers in Nepal also serve as a source of water for drinking, washing, bathing and irrigating. Both the Bagmati and Vishnumati receive raw sewage from the metropolitan area, untreated effluents from industrial estates, hospital wastes, toxic chemicals and acid from carpet washing plants, pesticides and chemical fertilizers washed by rainwater from the field, and the detritus of cremation. Around 68 industries and nearly 2 million people pour industrial effluent and human waste directly into the holy river, which is the backbone of the civilization of the Kathmanduites and not just a river of religious, cultural and social importance (*Kathmandu Post*, 2001)).

3.7 Water Security in Pakistan

Pakistan is reportedly heading toward a serious water crisis and by 2030, experts expect this semi-arid country to decline from being water stressed to water scarce (Chellaney, 2011). Because of overuse and misuse, the country is facing declining water availability and quality, growing water pollution, and overall environmental insecurity. In addition, its water and security nexus—which in this report refers primarily to human and socioeconomic security—is complicated by institutional inadequacies, a monochromatic supply-side vision, and a lack of substantive public participation in defining and solving problems. Water shortages may well pose the greatest future threat to the viability of Pakistan's economy. Water is essential, whether for livelihoods, health, food security, or general economic development. In Pakistan, as in many parts of Asia, population growth, elite capture of public benefits, rapid urbanization, and shifts in production and consumption patterns have placed unprecedented stress on water resources (*ibid*). Increasing pressure over water use and misuse, along with institutional, operational, and governance failures, is fostering domestic discord.

3.7.1 Water Resources

Pakistan's water resources can be divided into three hydrological units - the Indus basin, the Karan desert and the arid Makran coast. The Indus basin, comprising about 65 per cent of the territory, consists of all the provinces of Punjab, Sindh and Khyber Pakhtunkhwa and the eastern part of Balochistan. The two main tributaries of the Indus river are the Kabul river and the Panjnad, the flow of which results from five main rivers – the Jhelum and Chenab, known as the western rivers, and the Ravi, Beas and Sutlej, known as the eastern rivers. The Karan desert, in the west of Balochistan covering 18 percent of the territory, has two main rivers – the Mashkel and Marjen rivers – which are the principal source of water in the basin. The arid Makran coast, along the Arabian Sea, covering 17 percent of the territory in its southwestern part, has the Hob, Porali, Hingol and Dasht as the principal rivers in this coastal zone (Frenken, 2012).

The flow of water in the river basins outside the Indus Basin Irrigation System (IBIS), the Makran coast and the Karan closed basin, are flashy in nature and do not have a perennial supply. They account for a total flow inferior to 5 km^3 per year. The long-term average annual precipitation for Pakistan is 494 mm, representing 393.3 km^3 (Table 3.16). Precipitation in 2008 was 278 mm. Internally-produced surface water is 47.4 km^3/year, whereas internally generated groundwater is 55.0 km^3/year. Some of the groundwater drains directly into the sea, while the rest feeds the base flow of the river system, which is an estimated 47.4 km^3/year. Taking into account this overlap of 47.4 km^3/year between surface water and groundwater, the internal renewable water resources (IRWR) are an estimated 55 km^3/year (FAO-Aquastat-Pak, 2012).

Table 3.16: Renewable Freshwater Resources in Pakistan

Category	Quantity	Frequency
Precipitation (long-term average)	494	mm/yr
	393, 300	million m^3/yr
Internal renewable water resources (long-term average)	5, 000	million m^3/yr
Total actual renewable water resources	246, 800	million m^3/yr
Dependency ratio	78	%
Total actual renewable water resources per inhabitant in 2009	1, 474	m^3/yr
Total dam capacity in 2005	23, 360	million m^3

Source: FAO-Aquastat-Pak, 2012.

The total drainage area encompassing the Indus river basin is about 1.1 million km^2, of which 47 percent lies in Pakistan, and the other 53 percent in China, Afghanistan and India. The mean annual inflow into the country through the Indus river system is an estimated 265.08 km^3, of which 21.5 km^3 is from the Kabul river and other tributaries of the Indus river flowing from Afghanistan, 11.1 km^3 from the eastern rivers of the Indus basin and 232.48 km^3 from the western rivers, both flowing from India. Under the Indus Water Treaty (1960) between India and Pakistan, it is estimated that 170.27 km^3/year is reserved for inflow from India into Pakistan in accordance with the following rules as envisaged in the treaty:

- *Eastern Rivers:* All the waters of the eastern tributaries of the Indus river originating in India, i.e. the Sutlej, Beas and Ravi rivers taken together, shall be available for unrestricted use by India. Pakistan shall be under an obligation to let flow, and shall not permit any interference with, the waters (while flowing in Pakistan) of any tributary which in its natural course joins the Sutlej main or Ravi main before these rivers have finally crossed into Pakistan. This average annual flow in India before crossing the border is an estimated 11.1 km3. All the waters, while flowing in Pakistan, of any tributary which in its natural course joins the Sutlej main or the Ravi main after these rivers have crossed into Pakistan shall be available for the unrestricted use of Pakistan.
- *Western Rivers:* Pakistan shall receive for unrestricted use all those waters of the western rivers, i.e. Chenab and Jhelum, which India is under obligation to let flow, except for restricted uses, related to domestic use, non-consumptive

use, agricultures use and generation of hydroelectric power of which the amounts are set out in the Treaty. Annual flow from China to India in the Indus basin is 181.62 km3 and it is estimated that the flow generated within India is 50.86 km3, resulting in a flow from India to Pakistan in this part of 232.48 km3, of which 170.27 km3 reserved for Pakistan and 62.21 km3 available for India (MEA-India, 1960).

3.7.2 Water Use

Pakistan's total water withdrawal in 2008 was approximately 183.4 km^3, of which surface water withdrawal accounted for 121.8 km^3 (66.4 percent) and groundwater withdrawal accounted for 61.6 km^3 (33.6 percent). This mainly refers to the IBIS, the withdrawal outside the IBIS being extremely small (GoP, 2008a) (Table 3.17 and Figure 3. 10).

Table 3.17: Water Withdrawal and Use in Pakistan

Water withdrawal	Year	Quantity	Frequency
Total water withdrawal	2008	183, 421	million m3/yr
-irrigation+ livestock	2008	172, 371	million m3/yr
-municipalities	2008	9, 650	million m3/yr
- industry	2008	1, 400	million m3/yr
*per inhabitant	2008	1, 096	m3/yr
Surface water and groundwater withdrawal	2008	183, 421	million m3/yr
*as of % of total actual renewable water resources	2008	74	%
Non-conventional sources of water			
Produced wastewater	2000	12, 330	million m3/yr
Treated wastewater	2000	145	million m3/yr
Reused treated wastewater	-	-	million m3/yr
Desalinated water produced	-	-	million m3/yr
Reused agricultural drainage water	-	-	million m3/yr

Source: FAO-Aquastat-Pak, 2012.

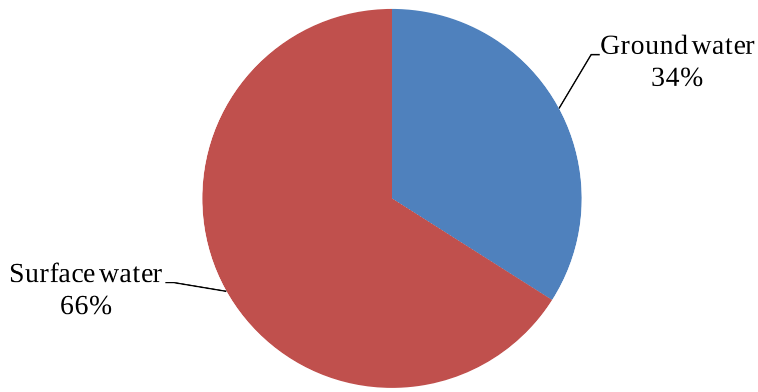


Figure 3.10: Water withdrawal by source in Pakistan, 2008

The amount of water withdrawal by the agriculture sector in Pakistan in 2008 amounted to an estimated 172.4 km^3, or 94 percent of the total water withdrawal, while municipal and industrial water withdrawal was an estimated 9.7 km^3 and 1.4 km^3, respectively (Figure 3.11) (GoP, 2008a; Zakria, 2000).

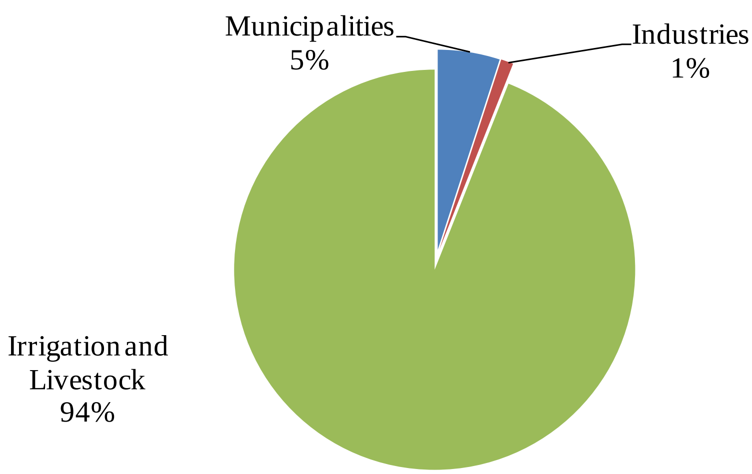


Figure 3.11 Water withdrawal by Sector in Pakistan 2008

Rapid runoff of torrential showers makes most of the summer rains unavailable either for crop production or recharge to groundwater. The overall irrigation efficiency in the IBIS is 40 percent (canal efficiency 75 percent, conveyance efficiency 70 percent and field application efficiency 75 percent). The water lost during conveyance and application largely contributes towards recharging groundwater. In some areas, development appears to have reached the point where groundwater is being mined. Most urban and rural water is supplied from groundwater. Over 50 percent of the village water supply is obtained from hand pumps, which are installed by private households. In saline groundwater areas, irrigation canals are the main source of municipal water.

Pumping of groundwater is facilitated through pumps using electricity and diesel fuels. According to Ahmad, (2008b), there were one million tube-wells in Pakistan in 2008, of which 87 percent were operated by diesel. Power failures, extended load shedding and poor electricity supply were regarded as the main reasons for the slow growth of electric tube-wells compared to diesel-operated tube-wells. Undoubtedly, there is lack of authentic information on the use of treated wastewater and desalinated water; nonetheless, it seems to be a minor fraction of the total. Sewage water from urban areas is used by farmers in the peri-urban areas to irrigate fodder crops and vegetables. Farmers also reuse drainage water during periods of water scarcity to supplement canal water supplies, but data are not available.

3.7.3 Water Management

Water being a federal subject in Pakistan, its management is being looked after by various federal institutions. The Ministry of Water and Power is responsible for the development of water projects including hydropower dams, main canals and inter-provincial works. The Ministry is supported by the Office of the Chief Engineering Advisor, the Chair of the Federal Flood Commission and the Chair of the Indus River System Authority (IRSA). The IRSA is responsible for the distribution of water among the provinces and assists provinces to share shortages according to the Apportionment Accord of 1991.

The Water and Power Development Authority (WAPDA), a semiautonomous body, is the functional arm of the Ministry of Water and Power and is responsible for the development of hydropower and water development projects. The Ministry of Food and Agriculture is responsible for water management at the watercourse command level and farm level irrigation and water productivity. Pakistan Council of Research in Water Resources, which operates under the federal Ministry of Science and Technology, is also involved in some areas of water research related to agriculture and its activities are related to water for domestic use, water quality and control of desertification.

Pakistan's Water Vision 2025 is regarded as a comprehensive integrated water resource hydro-power plan, which envisages that by 2025, Pakistan should have adequate water available through conservation, development and good governance. It further emphasizes on the fact that water supplies should be good quality and meet the needs of all users through an efficient and integrated management., institutional and legal system that would ensure sustainable utilization of the water resources and support economic and social development with due consideration to the environment, quality of life, economic value of resource, ability to pay and participation of all stakeholders (PDF, 2013).

Pakistan's National Water Policy 2005 prescribes an Integrated Water Resources Management (IWRM) regime that envisages the following aims:

- Providing adequate and safe drinking water for all;
- Providing food security for all in Pakistan and feed security for livestock;
- Providing hygienic sanitation facilities for urban and rural population;
- Maintaining water quality and protecting water resources by preventing their pollution;
- Treatment and possible reuse of waste water – domestic, agricultural and industrial;
- Restoring and maintaining the health of the environment and ecology;
- Flood management to mitigate floods and minimize flood damages;
- Hydropower development for economic growth;
- Security of benefit streams of the water related infrastructure for sustained provision of services,
- Conservation and optimizing water use efficiency (PWR, no date).

Since 2005, the Draft National Water Policy is still in the process of being approved. The Pakistan Water Strategy was prepared during 2001, which is the basic document for water development and management. Media reports appearing in December 2015 have indicated that the government of Pakistan is contemplating to announce new National Water Policy, which will protect the drinking water sector as a fundamental right of citizens. The proposed policy also promises plans and initiatives to progressively provide access to clean and safe drinking water and sanitation facilities to the entire urban and rural population. Effective safety-nets will be provided to poor communities (Kiani, 2015).

3.7.4 Environment and Health

Undoubtedly, water quality of the Indus river and its tributaries is excellent while at upstream where total dissolved solids (TDS) range between 60-374 ppm (parts per million), which is safe for multiple uses (Bhutta, 1999; PWP, 2000). TDS in the upper reaches range between 60 ppm during high-flow to about 200 ppm during low-flow. However, water quality deteriorates downstream but remains well within permissible limits, with TDS in the lower reaches of the Indus (at Kotri Barrage) ranging from 150 to 374 ppm. TDS of some of the tributaries such as Gomal River at Khajuri, Touchi River at Tangi Post and Zhob River at Sharik Weir range between 400 to 1 250 ppm (IWASRI, 1997). The quality of the groundwater is marginal to brackish in 60 percent of the IBIS aquifer. The groundwater quality in the area outside the IBIS varies, depending on recharge (Ahmad, 2008a; Ahmad, 2008b).

Disposal of effluents, including agricultural drainage water, municipal and industrial wastewater, into rivers, canals and drains in an indiscriminate and unplanned manner is causing deterioration of water quality downstream. In 1995 around 12.435 km^3/year (9 000 million gallons/day - 1 gallon = 4.5 litres) of untreated water were being discharged into water bodies (Ahmad, 2008b). It was estimated that 0.484 and 0.345 km^3/year (350 and 250 million gallons/day) of sewage was produced in Karachi and Lahore metropolitan areas and most of it was discharged untreated into water bodies. The polluted water is also being used for drinking in downstream areas causing numerous water-borne diseases.

Wide variations pervade the quality of groundwater, ranging from < 1 000 ppm to > 3 000 ppm. Around 5.75 million ha have underlying groundwater affected by salinity < 1 000 ppm, 1.84 million ha with salinity ranging from 1 000 to 3 000 ppm and 4.28 million ha with salinity > 3 000 ppm. In addition to TDS, water quality concerns are related to the sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) (WAPADA 2006). Use of pesticides and nitrogenous fertilizers seriously affects shallow groundwater and entry of effluents into rivers and canals is deteriorating the quality of freshwater. Almost all shallow freshwater is polluted with agricultural pollutants and sewage (Ahmad, 2008a; Ahmad, 2008b).

Adverse impact of the ongoing process of climate change is increasing becoming apparent on the limited availability of fresh water resources in Pakistan. Given the already scant water resources in Pakistan, it has been argued that, the near and long term effects of climate change on Pakistan’s water resources will further challenge the country’s water security, resources and aggravate inter and intra-regional ethnic tensions (Vaughn *et al.*, 2010). Climate change can influence the quantity of water available, thus impacting the existing food, water and energy security in the long term. Additionally, the impact of climate change combined with mismanagement of water resources and fossilised institutional practices, will further strain water supply options in Pakistan. These in the long term can have national and regional implications. The Task Force on Climate Change identified certain effects climate change, which are as follow:

- Increased variability of monsoon;
- Rapid recession of HKH glaciers threatening water inflows into the Indus River System;

- reduction in capacity of natural reservoirs due to glacial melt and rise in snow line;
- Increased risk of floods and droughts;
- Increased siltation of major dams resulting in greater loss of reservoir capacity;
- Severe water-stressed and heat-stressed conditions in arid and semi-arid regions, leading to reduced agricultural productivity and power generation;
- Increased upstream intrusion of saline water in the Indus delta, adversely affecting coastal agriculture, mangroves and breeding grounds of fish; and
- Threat to coastal areas including the city of Karachi due to sea level rise and increased cyclonic activity due to higher sea surface temperatures (MOE, 2011).

3.8 Water Security in Sri Lanka

Sri Lanka is a tropical island having three-quarters of the land consisting of a broad first peneplain with an average elevation of 75 m above sea level. A second peneplain rises to 500 m, and towards the south, a third peneplain rises steeply to form a mountain massif that reaches an elevation of 2 500 m. Sri Lanka is regarded a country of abundant water resources; however, there are frequent water scarcities in many parts of the country as a result of spatial and temporal variations in rainfall and of changing weather patterns. Water related needs of the people of Sri Lanka are fulfilled basically by country's fresh water mainly drawn from surface and ground water resources which are replenished through precipitation during monsoon and inter-monsoon periods.

3.8.1 Water Resources

Sri Lanka is endowed with a radial network of rivers, which begins in the central highlands and there are about 103 distinct river basins covering 90 percent of the island. The southwestern part of the island has seven major basins with catchment areas ranging from 620 to 2 700 km^2. They are, from north to south: Maha river (1 528 km^2), Attanagalu river (736 km^2), Kelani river (2 292 km^2), Kalu river (2 719 km^2), Bentota river (629 km^2), Gin river (932 km^2) and Nilwala river (971 km^2). An exception to the radial pattern is the largest basin, that of the 335 km long Mahaweli river, which has a catchment area of 10 448 km^2. After leaving the central highlands, it runs almost north for 90 km from Minipe to Manampitiya and then a further 70 km through several distributaries as far as Verugal and Mutur on the east coast. Most Sri Lankan river basins are small. Only 17 of the 103 basins exceed 1 000 km^2 (Frenken, 2012).

Besides the Mahaweli basin, four other basins exceed 2 500 km^2. Three of these (Deduru river, Kalu river and Malvathu river) have their entire catchment area in the dry zone, and only Kalu river is in the wet zone. The total runoff in Sri Lanka is an estimated 52 km3/year (Table 3.18). Considering 75 and 50 per cent dependability rainfall, annual runoff estimates are 42 and 49 km3 respectively (Amarasinghe, 2009).

Table 3.18: Renewable Freshwater Resources in Sri Lanka

Category	Quantity	Frequency
Precipitation (long-term average)	1, 712	mm/yr
	112, 300	million m^3/yr
Internal renewable water resources (long-term average)	52, 800	million m^3/yr
Total actual renewable water resources	52, 800	million m^3/yr
Dependency ratio	0	%
Total actual renewable water resources per inhabitant in 2009	2, 555	m^3/yr
Total dam capacity in 1996	5, 942	million m^3

Source: FAO-Aquastat-Lka, 2012

Six types of aquifers are found in Sri Lanka, which include the shallow karstic aquifer of the Jaffna Peninsula, deep confined aquifers, coastal sand aquifers, alluvial aquifers, the shallow regolith aquifer of the Hard Rock Region and the southwestern lateritic (cabook) aquifer (WRB, 2005). Sri Lanka's largest aquifer extends over 200 km in the northwestern and northern coastal areas. The internal renewable groundwater resources are estimated at 7.8 km3, most (estimated as 7 km^3/year) returning to the river systems and being included in the estimate for surface water resources. Therefore the total renewable water resources are an estimated 52.8 km^3/year (FAO-Aquastat-Lka, 2012).

The five river basins – Kalu, Kelani, Gin, Bentota, and Nilwala river basins – cover only 13 percent of the land area, but are where 30 percent of the population live and where 38 percent of the total renewable water resources (TRWR) are located. The basin of the Mahaweli river, the longest river, covers 17 percent of the total area of the country, supports 17 percent of the population and carries 19 percent of TRWR. The basin of the eastward flowing Gal river, known for its irrigated rice production, covers 3 percent of the land area and has 2 percent of TRWR (Amarasinghe, 2009).

Sri Lanka is usually regarded as a country with either little or no water scarcity or moderate water-scarcity conditions. However, Sri Lanka's spatial and temporal variation of water availability makes it experience high seasonal and spatial variations in rainfall as a result of the bi-monsoonal climatic pattern (northeast monsoon from October to March and southwest monsoon from April to September). Large areas of the country are drought prone. Droughts occur to different degrees in both semi-arid and humid zones (Matin et al., 2009). Dry-zone districts, comprising 75 percent of the country, contribute to only 49 percent and 29 percent of the maha and yala season runoff. Thus, storing water for irrigation in the yala season (April to September) is essential in many river basins (*ibid.*).

A major water treatment project has been constructed at the greater Ratnapura area of Sabaragamuwa Province and this project is composed of raw water intakes located in the Kalu river, raw water transmission lines between the intakes and the treatment plant, the construction of one reservoir with a capacity of 2 500 m^3, the construction of a water treatment plant in Muwagama with a capacity of 13 000 m^3/day and transmission pipelines from the treatment plant to different reservoirs (Befesa Agua International News, 2009). This project, designed to meet the estimated water demand for the horizon year 2025, will ensure the provision of potable water to Ratnapura city and its environs, which will benefit a population of 100 000 inhabitants (Infoagua, 2010).

3.8.2 Water Use

Recent decades have witnessed rapid progress in the development of large-scale water resources for irrigation and hydropower in Sri Lanka. In 2005, The total water withdrawal in 2005 stood approximately at 12.95 km^3, of which about 11.31 km3 (87.4 percent) was for agriculture, 0.81 km^3 (6.2 percent) for municipalities and 0.83 km^3 (6.4 percent) for industries (Table 3.19 and Figure 3.12). Irrigation withdrawal for rice represented 10.63 km^3. The Eastern, North-Western, and North-Central provinces and Hambantota in the Southern Province account for 76 percent of the total withdrawals (Amarasinghe, 2009).

Table 3.19: Water Withdrawal and Use in Sri Lanka

Water withdrawal	Year	Quantity	Frequency
Total water withdrawal	2005	12, 950	million m3/yr
-irrigation+ livestock	2005	11, 314	million m3/yr
-municipalities	2005	805	million m3/yr
- industry	2005	831	million m3/yr
*per inhabitant	2005	653	m3/yr
Surface water and groundwater withdrawal	2005	12, 950	million m3/yr
*as of % of total actual renewable water resources	2005	24.5	%
Non-conventional sources of water			
Produced wastewater	-	-	million m3/yr
Treated wastewater	-	-	million m3/yr
Reused treated wastewater	-	-	million m3/yr
Desalinated water produced	-	-	million m3/yr
Reused agricultural drainage water	-	-	million m3/yr

Source: FAO-Aquastat-Lka, 2012

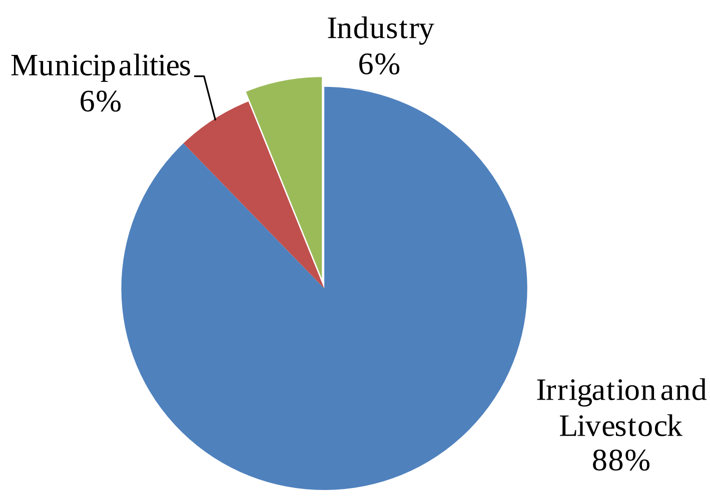


Figure 3.12 Water withdrawal by sector in Sri Lanka, 2005

Extensive use of groundwater resources is made in Sri Lanka for domestic, commercial and industrial purposes as well as small-scale irrigation. Bulk of rural domestic water supply needs, about 80 per cent, is met by groundwater from dug wells and tube-wells. Dependence on groundwater for industrial and commercial uses increases in areas where surface water systems are not fully reliable. Most industries in Sri Lanka are heavily dependent on deep wells where groundwater is safe and of good quality, and can be self-managed. A steady increase in the demand for groundwater is taking place in Sri Lanka, especially for urban and rural water supplies, irrigated agriculture, industries, aquaculture, small and medium enterprises and urban housing schemes. The rapid expansion of these projects is exerting much pressure on available groundwater resources (WRB, 2005).

A wide network of artificial lakes and ponds, known locally as ‘tanks’, is spread over Sri Lanka. Some are truly massive, many are ancient and almost all represent a high degree of sophistication in their construction and design (Goldsmith *et al.*, 1984). A significant rise in the numbers of water pumps and ‘agro-wells’ (wells used mainly for agriculture) sunk over the past few decades has been revealed in a recent study undertaken by the International Water Management Institute (IWMI) in Sri Lanka’s dry zone, where groundwater use for farming is greatest. The study further reveals that there are close to 50 000 agro-wells in the dry zone and the number of pumps is higher, around 100 000, as it includes those used to pump water from rivers, irrigation canals and tanks, and not just those fitted to agro-wells. According to IWMI report, this boom in agro-well construction took place partly because a government subsidy programme for brick and concrete-lined wells was introduced in 1989, but also because many aquifers are quite close to the surface, which makes digging shallow wells and drilling tube-wells relatively cheap (IWMI, 2005).

Supply of safe water to almost 90 percent of the urban population, and protected wells to approximately 60 percent of the rural population in Sri Lanka is facilitated through piped water systems. The National Water Supply and Drainage Board (NWSDB) distributes the major portion of the, mostly urban, water requirement of the country, over 310 million m^3 per year to cater for a population of over 5.3 million. Many of the large urban centres along the coast get their water supply from river systems. They are experiencing water supply interruptions as a result of salinity intrusions in the lower reaches of these rivers (WRB, 2005).

3.8.3 Water Management

Undoubtedly, there are more than 50 government and semi-government institutions dealing with subjects relating to water in Sri Lanka; nonetheless, there is little coordination between and amongst these institutions. Among the major institutions looking after water management in Sri Lanka are: Irrigation

Department (ID), Mahaweli Authority of Sri Lanka (MASL), National Water Supply and Drainage Board (NWSDB), Water Resources Board (WRB), and Central Environmental Authority (CEA).

Irrigation Department (ID), established in 1900, is the principal organization responsible for the regulation and control of inland water. Mahaweli Authority of Sri Lanka (MASL), established in 1979, is responsible for water and related infrastructure development in designated basins, not only in Mahaweli project. National Water Supply and Drainage Board (NWSDB): is the regulator for drinking water and operator of integrated urban and small town schemes. Water Resources Board (WRB), established in 1968, is responsible for hydro-geological investigations. Central Environmental Authority (CEA) is responsible for environmental quality standards and environmental impact assessment procedures (tolerance limits for discharge of effluents into inland waters) (Nanayakkara, 2009). Freshwater resources in Sri Lanka remain a free public good, with the State acting as the trustee and custodian of the resource. Water rights are linked to land ownership and, as such, landowners are regarded as owning the water underneath their land and have the right to pump all the water from the common aquifer, lowering the water table. Furthermore, they may use or abuse all the rain that falls on their land. However, all the streams that flow across private land fall within the public domain (*ibid*.).

Completion of the Institutional Assessment for Comprehensive Water Resources Management Project in 1994 led to its execution by the National Planning Department of Sri Lanka in association with more than 30 agencies and organizations concerned with water resources development and management. In July 1995, the Government approved the implementation of the strategic framework and action plan together with the establishment of the Water Resources Council to oversee the implementation of the action plan. However, no effective systems for groundwater planning or management have been put in place. Developing such systems is a challenge because a large number of scattered farmers are involved, and because there are seven different types of aquifer on the island, five of which are in the dry zone, each with its own constraints and opportunities. Certainly, much more detailed information on each particular resource and how it is being used are needed. Even very basic information, such as the actual number of agro-wells throughout the country is currently unavailable. Data on groundwater collected by some agencies are inconsistent, unreliable, and lack sufficient coverage (IWMI, 2005).

Over the years, Sri Lanka continues to remain a country without a comprehensive water policy. In March 2000 a water development policy document prepared by experts in the field was presented to the cabinet ministers, but due to heavy criticism from certain parties, it was never implemented. This has both direct and indirect costs including economic, social and environmental costs. Due to water related issues of which some countries have already reached crisis proportion, Sri Lanka cannot continue any longer as a country without a comprehensive water policy, which is essential to lay down guidelines for the preservation of fresh water ecosystem, delivering clean water for household and agricultural purposes, replenishing ground water, help prevent soil erosion and protect against floods (*Sunday Times*, 16 January 2016).

3.8.4 Environment and Health

Sri Lanka is beset by climate change problems. The most notable one is a change in rainfall patterns. There were more floods and more droughts. The intense rain is due to climate change; but its impact is high because of human activities. People have cleared forests and started building houses very close to rivers. Dry areas of the country have become drier and wet areas wetter, leading to floods in some areas and drought in others. Rural areas are expected to experience major impacts on water availability and supply. Some experts feel that climate change impacts are projected to slow down economic growth; make poverty reduction more difficult; further erode food security; and prolong existing and create new, poverty traps, particularly in urban areas and emerging hotspots of hunger for Sri Lanka (Wipulasena and Sathisraja, 2015).

Contamination of surface and groundwater resources and the consequential spread of vector-borne and water-borne diseases have been the cause of great concern in Sri Lanka. It is believed that contamination of water sources, by industry and through agricultural waste and fertilizers, is the main cause of the growing water-related health problems being reported in the country. It is understood that contamination of Sri Lanka's water by lead and uranium is also a significant problem, with evident health repercussions. Large-scale use of fertilizers and pesticides cause toxic chemicals enter the county's water system and are delivered to other parts of the country. The recent increase in the number of persons suffering from renal disease is one of the major health problems in Sri Lanka. Since 1994, a new form of chronic kidney disease, known as CKDu, has been identified in Sri Lanka, which has causes that are not yet understood. According to the Annual Health Bulletin 2005, the hospital mortality rate for diseases of urinary system (which includes kidney diseases) doubled during the period 1980-2005, from 3.1 to 6.5 deaths per 100,000 persons. At the national level, such diseases were the 11th leading cause of hospital deaths in 2005 (ALRC, 2010).

Conclusion

Almost all the countries of the SAARC region are water stressed. Undoubtedly, Bhutan and Nepal are endowed ample water resources; nevertheless, these countries also face water problems during the dry season. Being water stressed countries, these countries water insecure countries. The growing demand for water in the wake of burgeoning population, urbanization, industrialization and increased food production is exerting mounting pressure on the finite water resources. The fresh water resources, both surface and ground, are shrinking. The surface water resources in the form of rivers are getting polluted at a fast pace and groundwater resources are getting depleted as well as contaminated simultaneously. These are the common problems confronting the countries of South Asia. There is almost negligible progress in recycling the wastewater for reuse, especially in agriculture sector.

Besides, some countries of South Asia lack well-defined national water policies and effective institutional mechanism to implement reformative water related policies efficiently. There is also lack of coordination, cooperation and convergence between different national institutions dealing with water sector and this absence of synergy culminates in formulation of water related policies in a haphazard manner without yielding any tangible outcome. Absence of trans-boundary cooperation in water sector in the wake of 'national sensitivities' on water-related issues are instrumental in contributing to water insecurity in this part of the globe.

Chapter-4

Energy Security in South Asia

The uneven spatial distribution of natural resources in South Asia has envisaged a wide variation in commercial energy resource endowments and commercial energy demand among the SAARC countries. Undoubtedly, India, Pakistan and Bangladesh account for the major share of natural gas and coal resources in the region; nevertheless, these countries are also large in terms of area as well as population and thus, the higher resource base does not necessarily indicate sufficiency to meet energy needs. On the other hand, Bhutan and Nepal possess hydropower potential in excess of their demand for electricity over the foreseeable future and offer the best prospects for intra-regional electricity export. Besides, neighboring regions, particularly Central Asia and Western Asia, have inter- regional energy export capability to South Asia.

Viewed in a broader perspective, countries of South Asia are already energy-deficient and in the wake of exponential growing energy demand, these countries are faced with a number of energy challenges like energy poverty, lack of adequate supplies, poor energy infrastructure and transport facilities, and environmental externalities of energy production and use. According to *World Energy Outlook 2011*, in 2009, of the total 1.3 billion people globally without access to electricity, about 449 million lived in Bangladesh, India and Pakistan. Undoubtedly, energy policies geared towards efficient use of energy can help curb demand; nevertheless, it is clear that maintaining growth rates, as developing economies undergo structural changes and strive to meet welfare objectives, will necessitate increase in energy use (ESCAP, 2013).

High population growth as well as economic advancement through industrialization and urbanization has proved instrumental in increased demand for energy in South Asia. The total primary energy consumption in South Asia, which stood at 1.7% of the total world energy consumption in 1980, had grown to 2.36% in 2006 (EIA, 2010). Undoubtedly, the South Asian region has registered drastic increase in the energy consumption; nonetheless, it still remains in the lowest per capita energy consumption region of the world (EIA, 2004). Bulk of the rural population in South Asia is making use of non-conventional form of energy and a significant number of them depend on biomass. In 2008, biomass was used for meeting 80% residential energy needs and it is also expected to remain 70% in 2020 (EIA, 2010).

4.1 Commercial Energy Mix in South Asia

Broadly speaking, commercial energy mix in South Asia may vary from country to country; however, the pattern of this variation is almost similar. Coal is the dominating fuel along with petroleum and others sources of energy, which are mostly non-renewable as shown in Figure 4.1. The contribution of renewable energy is very negligible in the mix. In recent years, South Asia is facing a rising energy demand because of both inadequate energy sources and growing population. The energy crisis affects the electricity generation, which in turn renders a large number of people to remain without electricity and it also affects the pattern of economic growth.

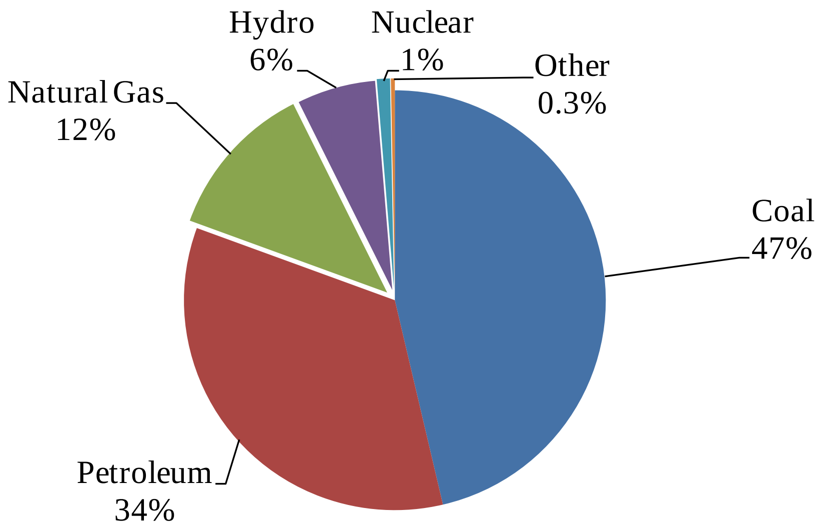


Figure 4.1: Commercial Energy Mix in South Asia.

The usage of commercial mix in South Asia, as shown in Fig. 3 above, shows that coal's contribution in providing energy is 46%, followed by oil (Petroleum) 34%, natural gas 12%, hydropower 6%, and nuclear energy 1%. The contribution of renewable energy is almost minimal.

The specific details of the commercial energy supply mix for the SAARC in 2010 are shown in Table 4. 1. It is important to note that commercial energy demand in a major part of the South Asia region (Afghanistan, Bangladesh, India, Nepal and Pakistan), during the latter part of the first decade of the 21st century was supply-constrained, and that constraint continues. Hence, the figures reported are best estimates based on actual limits in some cases, and supply limits, in other cases. They range from as low as 0.3 million tons of oil equivalent (mtoe) for the Maldives to as high as 554 mtoe for India.

Table-4.1 Commercial Energy Supply of the SAARC Countries in 2010 (mtoe)

Country	Petroleum	Natural Gas	Coal	Hydro-Electricity	Nuclear	Total
Afghanistan	0.27	0.03	0.03	0.7*	0	1.0
Bangladesh	4.9	16	0.7	0.4	0	22.0
Bhutan	0.2	0	0	0.5	0	0.7
India	155	75	290	29	7	554
Maldives	0.3	0	0	0	0	0.3
Nepal	1	0	0.3	0.9**	0	2.2
Pakistan	22	27.5	4.5	7.4	0.8	62.2
Sri Lanka	4.8	0	0.1	1.4	0	6.3
Total	208.5	98.5	295.6	40.2	5.8	648.7

*Imports from neighbouring countries, **Includes net electricity imports from India.

mtoe = million tons of oil equivalent.

Source: Wijayatunga and Fernando (2013).

It is also evident from Table 4.1 that while India and Pakistan have certain levels of diversity in their energy supply sources; Bangladesh is heavily reliant on natural gas and Sri Lanka to a large extent, on petroleum sources. Besides, while Bhutan and Nepal are largely self-reliant on their existing hydroelectricity, Afghanistan's energy supply is dominated by electricity imports from neighbouring Central Asian countries. Such restricted energy supply dependence not only limits the options to meet energy demand but also increases energy security concerns. The three larger SARCC countries (India, Pakistan and Bangladesh) accounted for more than 98% of the total SAC energy supply of 649 mtoe in 2010.

Table 4.2: Electricity Supply and Demand in SAARC Countries (2013/14)

Country	Installed Generation Capacity (MW)	Peak Demand (MW)	Generation (GWh)	Demand (GWh)
Afghanistan*	620	700	800	3890
Bangladesh	9821	9268	42195	36233
Bhutan*	1510	282	6750	1640
India	237742	129815	957734	802567
Maldives	141	N/A	290	270
Nepal	787	1200	3558	3448
Pakistan*	22860	23953	92860	76860
Sri Lanka	3362	2164	11962	10632

* Data in the year 2011/12

Source: Wijayatunga, Chattopadhyay and Fernando (2015: 2).

It is revealed from Table 4.2 that demand for hydropower has grown manifold from the installed hydropower generation capacity in almost all SAARC countries with the exception of Bhutan. Nevertheless, power generating capacity additions in India, although significant, have been falling behind planned activities. The planned capacity addition for India's Eleventh Five Year Plan (2007-2012) was set at 21 GW but less than half of that was achieved at the start of 2011. Part of the issue has been an overreliance of the system on coal. The 2012 installed coal based power generating capacity of 104 GW, requires a massive 355 million tons of coal per year and the impending coal shortage is a major challenge to the system. The Pakistan and Bangladesh power systems have also experienced power shortages due mainly to over reliance on natural gas-based power generation. Pakistan, with an installed power generating capacity of 20 GW had a 25% peak shortage in 2010, while Bangladesh, with an installed power generating capacity of 7 GW had around a 20% power shortage.

In order to have a better comprehension of the overall energy situation in the SAARC region, an overview of energy situation of each country of the region deems appropriate.

4.1. Afghanistan

Hydropower is the major source of power in Afghanistan. Having one of the lowest rates of electricity usage in the world, Afghanistan is in the bottom 10 percent globally (around 100 kilowatt hours per year per capita consumption). As of 2012, approximately 33% of Afghan population has access to electricity. According to a news report by Reuters (9 January 2012), Afghanistan generates around 600 megawatts (MW) of electricity mainly from hydropower followed by fossil fuel and solar and it is estimated that by 2020 it will require around 3,000 MW to meet its needs. Some of the hydroelectric power plants of Afghanistan are located in Sarbobi in Kabul province, Naghlu, Darunta and the Breshna-Kot Dam in Nangrahar province, Kajaki in Helmand province etc.

Afghanistan is reported to have oil reserves totaling 2.9 billion barrels; however, a very small amount of crude oil is produced at the Angot field in the northern Sar-e-Pol province and another small oilfield at Zomrad Sai near Sheberghan. Afghanistan mostly imports its petroleum products such as diesel, gasoline and jet fuel mainly from neoghbouring Pakistan and Central Asian nations.

Under the North East Power System (NEPS), Afghanistan imports 150 MW from Uzbekistan, supplemented by 150 MW from Tajikistan during the summer. The total current transmission lines capacity is: 326MW from Uzbekistan, 164 MW from Iran, 433 MW from Tajikistan and 77 MW from Turkmenistan. Discussions on electricity supplies began back in 2006 and the construction of a 442-kilometre high voltage transmission line from Uzbekistan to Afghanistan was completed by October 2008.

Prospects of solar and wind power are being explored in Afghanistan. The use of solar power is becoming widespread in Afghanistan. Solar-powered street lights are seen in several Afghan cities and towns, including the capital Kabul (the9billion.com, 19 Jan 2011). Many villagers in rural parts of the country are also buying solar panels and using them. At least one wind farm was successfully completed in Panjshir province in 2008, which has the potential to produce 100 kW of energy. United States Agency for International Development (USAID) has teamed up with the United States National Renewable Energy Laboratory to develop a wind map of Herat province. They have identified approximately 158,000 megawatts of untapped potential wind energy. Installing wind turbine farms in Herat could provide electricity to much of western Afghanistan (sada-e-azadi.net, no date).

4.2. Bangladesh

Natural gas and solid biomass and waste account for the bulk of Bangladesh's total primary energy consumption with the remainder being oil, coal, and hydro. In 2012, Bangladesh's primary energy consumption was an estimated 55% natural gas, 27% traditional biomass and waste, 15% oil, 3% coal, and less than 1% hydropower and solar (EIA 2015). Bangladesh's power system as prevalent in 2010 is shown in Table 4.3.

Table 4.3 Bangladesh's Power System 2010

Installed capacity	5,376 MW
Present operable capacity	4,714 MW
Present peak demand	4,300 MW
System loss (T&D)	22.06 percent
Generation mix	
Gas	89.4 percent
Hydro	4.5 percent
Liquid fuel	6.1 percent
Electricity growth	7.0 percent on average since 1990
Per capita generation	220 kWh
Access to electricity	47 percent

Source: Compiled from USAID (2009); Bangladesh Power Development Board (2010).

It is evidenced from Table 4.3 that operable power generation capacity in Bangladesh was less as compared to the installed capacity in 2010. Besides, thermal component of power generation accounted for the bulk while contribution of the hydropower was minimal. Undoubtedly, over a period of two decades since 1990, Bangladesh recorded an average growth of electricity at 7%; nonetheless, by 2010, about 47% of population had access to electricity. As can be seen from Figure 4.2, the contribution of hydropower to the total power generation in Bangladesh prior to 2010 was about 7% while thermal component accounted for 93% and it shows that by 2010, the contribution of hydropower had recorded a decline.

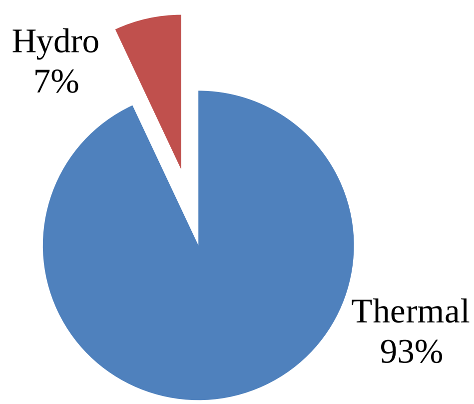


Figure 4.2. Source wise electricity production in Bangladesh

Bangladesh is a net importer of crude oil and other hydrocarbons. The production of crude oil and other liquids in Bangladesh stood in 2014 at 4,800 barrels per day (bbl/d) whereas consumption was more than 124,000 bbl/d. Because oil consumption has been increasing after 2010 to make up for the shortage of natural gas especially in the power sector, Bangladesh continues to increase its crude oil and oil product imports. In 2014, Bangladesh had emerged as the eighth largest natural gas producer in the Asia Pacific region and produced 833 billion cubic feet (Bcf/y), all of which was domestically consumed. However, Bangladesh still faces acute natural gas supply shortages especially in the electricity sector (EIA 2015).

An annual average increase of 9% in gross electricity generation has been recorded by Bangladesh from 2004 to 2014. Bangladesh's share of gas-fired capacity accounted for 70% of total installed electricity capacity which reached 10.6 GW by 2014. It plans to more than double power generation capacity to 24 GW by 2021, primarily through the use of coal and natural gas. According to the government of Bangladesh, about 62% of the population has access to electricity. As a result, 38% of the population mainly relies on traditional biomass and waste for cooking and heating (EIA, 2015). This amply demonstrates that Bangladesh is an energy-deficient country.

4.3 Bhutan

Bhutan is the only power-surplus country in the SAARC region. Hydropower aside, the country has no proven gas, oil or coal reserves. This means Bhutan is importing all of its petroleum product requirements (ADB 2009: 123). Power generation in Bhutan relies almost exclusively on hydropower. The total installed capacity of existing hydropower plants is 1,488 megawatts (MW). In the wake of the fact that all of the existing plants are run-of-the-river types, the total power generation drastically drops to about 300 MW during the winter dry season (December–March) due to low water levels. This falls short of meeting peak system demand during winter dry seasons. In order to deal with the seasonal power shortage, Bhutan, apart from curtailing industrial loads during the winter months, also imports power from India, especially in the winter.

During the wet season, Bhutan's existing hydropower plants can generate enough electricity to meet the domestic and industry demands and also export power. Bhutan exports around 70% of the total power it generates each year to India, after meeting its domestic consumption requirements. The power sector is the largest source of the government revenue and the premier contributor to the country's gross domestic product. Bhutan's rapid economic growth has been underpinned by hydropower development and exports and generated government resources for social and other investments, making an acceleration of hydropower development for exports strategically important.

Table 4.4: Bhutan-India Power Trade

Export	Transmission lines	Power Transfer
Bongaigon (Assam)	66 kV	-
Rongia (Assam)	33 kV	-
Siliguri (West Bengal)	220 kV	-
Export	-	1,764 GWh
Import	-	25 GWh

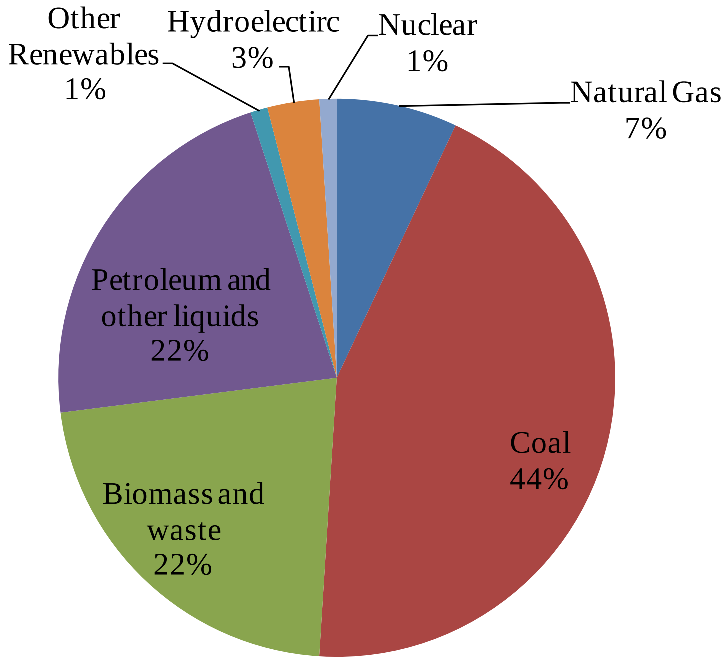
Source: USAID (2009)

Bhutan's export of hydropower to India is facilitated through transmission lines which pass through Assam and West Bengal states of India, as shown in Table 4.4. Bhutan exports 1, 764 GWh of hydropower to India, while during the dry season its imports 25 GWh power from India. It is interesting to note that all of the power deals with India happen on a government-to-government basis through the Power Trading Corporation India (PTCI) and the Bhutan Power Corporation. Indian investment is omnipresent in the Bhutanese power sector. In 2006, a joint venture between Tata Power and Power Grid Corporation of India was completed, which constructed a 400 kV double-circuit line of 1,200 km with a transfer capacity of 3,000 MW. At the same time, Bhutan still faces problems with electricity distribution. Of its 1,488 MW installed capacity, 80 percent are being exported to India (USAID 2009).

With a view to ensure energy security, the Government of Bhutan issued the *Alternative Renewable Energy Policy, 2013,* which aims at promoting alternative renewable energy sources other than large hydropower and diversify the energy supply base through the use of wind, solar, biomass, and small and micro hydropower systems. Wind power projects entail the potential to generate clean energy in the dry winters, thereby supplementing the diminished hydropower supply during these months and alleviating seasonal power shortages (ADB 2014).

4.4. India

Currently India is the fourth largest energy consumer and is slated to become the third largest by 2020. This implies that India needs to increase the energy supply by three to four times over the next two decades (*Business Standard*, 13 January 2014). According to the Central Electricity Authority, India's peak demand requirement for 2013-2014 was 136 gigawatts, of which it could only meet 130 gigawatts for a deficit of about 4.5 percent (Central Electricity Authority, May 2014). However, the deficit is actually greater than the official assessment. India's energy consumption is shown in Figure 4.3.



Source: Energy Information Administration (2014). *India Country Report*. Washington: U.S. Department of Energy. Available at http://www.eia.gov/countries/analysisbriefs/India/india.pdf.

Fig. 4.3: Total Energy Consumption in India in 2012

Coal is the largest source of energy for India by a wide margin and accounts for 44%, as shown in Fig. 4.3. The solid biomass, comprising chiefly non-commercial wood, dried dung and waste, accounts for 22% and plays a notable role in the Indian energy mix. In quantitative terms this solid biomass is as important to the energy mix as petroleum. Coal and biomass provide India with almost two thirds of its energy. The implications of Indian reliance on these two inefficient and polluting sources of energy are important for the future of India energy. Natural gas constitutes only about 7 percent of India's energy mix and hydroelectric even smaller at about 3 percent. While expanding rapidly, renewables and nuclear are a very small part of the contemporary Indian energy picture.

The pattern of consumption of conventional sources of energy in India has registered substantial increase in recent years as shown in Table 4.5.

Table 4.5: Trends in Consumption of Conventional Sources of Energy in India

Year	Coal#	Lignite	Crude Oil**	Natural Gas***	Electricity*
1	2	3	4	5	6
	Million Tonnes		MMT	Billion cubic meters	GWb
2005-06	407.04	30.23	130.11	26.86	411.887
2006-07	430.83	31.29	146.55	26.77	455.748
2007-08	457.08	33.98	156.10	26.97	510.899
2008-09	492.76	32.42	160.77	27.06	562.888
2009-10	532.04	34.07	192.77	40.83	620.251
2010-11	532.69	37.73	196.99	46.04	684.324
2011-12	535.88	41.88	204.12	41.03	755.847
2012-13(p)	570.23	46.41	219.21	34.30	835.513
Growth rate of 2012-13 over 2011-12 (%)	**6.41**	**10.81**	**7.39**	**-16.39**	**10.540**
CAGR 2005-06 to 2012-13 (%)	**4.30**	**5.51**	**6.74**	**3.11**	**9.240**

(p): Provisional

GWh=Giga Watt hour=106x Kilo Watt hour

* Includes thermal, hydro & nuclear electricity from utilities

** Crude oil in terms of refinery crude throughput

*** Gas available for sale, which is derived by deducting internal user of gas by producing companies from Net Availability

Does not include Lignite and imports

Source: Ministry of Statistics and Programme Implementation (May 2015). *Energy Statistics 2014*. New Delhi: Government of India: 42. Available at http://mospi.nic.in/mospi_new/upload/Energy_stats_2014.pdf.

It is observed from Table 4.5 that coal consumption in India which stood at 407.04 million tonnes in 2005-06 had increased to 535.88 million tonnes by 2011-12. The consumption of lignite recorded increase from 30.23 million tonnes in 2005-06 to 41.88 million tonnes in 2011-12. The consumption of crude oil which stood at 130.11 MMT in 2005-06 had increased to 204.12 MMT in 2011-12. Notable increase in the consumption of natural gas has also been reported. In 2005-06, the total consumption of natural gas stood at 26.86 BCM (billion cubic meters) and by 2011-12 it increased to 41.03 BCM. Consumption of electricity also increased during this period by recording an increase from 411.887 GWb in 2005-06 to 755.847 GWb in 2011-12.

The power supply/demand gap in India is much greater as compared to developed countries and China. India's per capita electricity consumption in 2011 stood at a paltry 684 watts, whereas the per capita 2011 consumption numbers for other prominent countries were much higher: United States-13,246; Germany-7,081; Japan-7,848; China-3,298; Brazil-2,436; and Russia-6,486 (World Bank, no date). Broadly speaking, enhancing India's per capita consumption to only China's level implies an increase of almost 500 percent.

4.4.1 India's Present Sources of Energy

Amongst the existing energy sources of India, coal is the largest source of energy for India by a wide margin. The solid biomass (chiefly non-commercial wood, dried dung and waste) also plays the outsized role in the Indian energy mix. In quantitative terms this solid biomass is as important to the energy mix as petroleum. Coal and biomass provide India with almost two thirds of its energy. The implications of Indian reliance on these two inefficient and polluting sources of energy are important for the future of India energy. Natural gas constitutes only about 7 percent of India's energy mix and hydroelectric even smaller at about 3 percent. While expanding rapidly, renewables and nuclear are a very small part of the present Indian energy picture. A brief overview of these sources of energy is called for here.

4.4.1-a. Coal

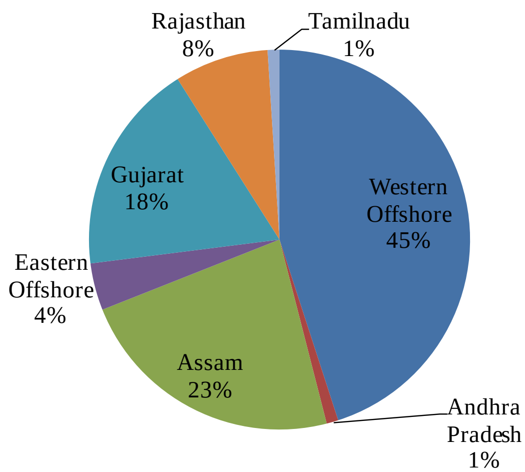
India has the fifth largest coal reserves in the world and is the world's third highest consumer and its coal consumption is expected to double in the next two decades. India had about 60 billion metric tons of coal reserves in 2012 (India, *Energy Statistics 2013*: 43). Consumption was about 600 million metric tons per annum (Ebinger, 2011: 34-35). These numbers place India fifth in the world in reserves and third in consumption. At 2012 rates of consumption, it appears that India would have enough coal for approximately 100 years. However, the IEA predicts that Indian coal consumption will double by 2035 over its 2008 level and India's 2006 Integrated Energy Policy Report estimated that "extractable coal resources will be exhausted in about 45 years."29 Still this is a large domestic coal resource. Broadly speaking, many factors inhibit coal production in India, which, *inter alia*, include: a highly inefficient and often corrupt coal sector that is largely state controlled; infrastructure deficits and Maoist insurgency in areas where coal deposits are available that inhibit coal exploitation (Vickery, 2014).

The lack of domestic actual availability is indicated by coal imports. Imports rose from 64.51 million metric tons for the fiscal year ending March 31, 2010 to 100.82 metric tons for the fiscal year ending March 31, 2011, an increase of 56.29 percent in a single year. Most Indian imports of coal come from Indonesia (61 percent). India also imports major quantities from Australia (17 percent) and

South Africa (14 percent). In 2012, coal imports were about 17 percent of total Indian coal used (India, *Energy Statistics 2013*:36). With the difficulties in domestic production, imports have risen rapidly. In 2012 they were up almost 50 percent, and in the first half of 2013, imports rose 28 percent year on year. With the drop in value of the rupee, this drove the total rupee value of the imported coal to unprecedented heights (Menon, 2013). For the fiscal year ended March 31, 2014, imports rose 16 percent compared with the previous fiscal year (Yep & Chaturvedi, 2014).

4.4.1-b. Oil

India has about 5.5 billion barrels of proven reserves and it ranks 19th in world proven reserves, 24th in world production, but 4th in oil consumption and 4th in importation. India's overwhelming reliance on imports still continues to the most salient feature of its oil supply and demand situation. The total crude oil production in India during the 12th Plan (2012-2017) is estimated at 216 million metric tons whereas the total demand for petroleum products in for the same period is estimated at 845 million metric tons. This ratio of 4 to 1 matches closely the almost 80 percent imports presently estimated as India's total reliance on petroleum imports. The limited physical availability of oil from within the country makes India heavily dependent on imports. may be very limited. The 12th Five Year Plan (2012–2017) estimates that domestic crude oil production has peaked. According to the Plan, production is expected to decline in the years 2015 through 2017. Apparently this predicted decline is predicated on lack of new discoveries. Estimated crude oil reserves in India by March end 2013 are shown in Fig. 4.4.

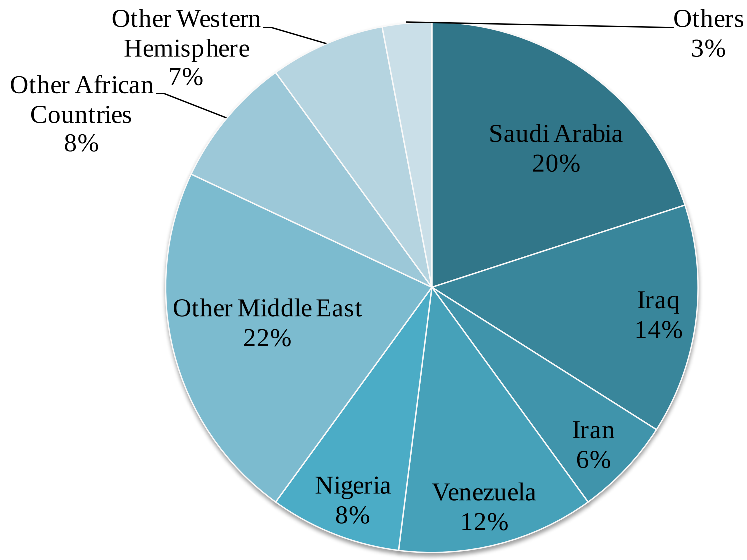


Source: Ministry of Statistics and Programme Implementation, Energy Statistics 2014 p.2
http://mospi.nic.in/mospi_new/upload/Energy_stats_2014.pdf?status=1&menu_id=229 .

Figure 4.4: Estimated Reserves of Crude Oil in India as on 31.03.13

The extent of India's oil reserves, as shown in Fig. 4.4, present a comparative scenario of offshore oil reserves and on land oil reserves. India's offshore oil reserves account for 45% in the Western offshore and 4% in the Eastern offshore. Of the on-land oil reserves, Assam accounts for 23%, followed by Gujarat 18%, Rajasthan 8%, Andhra Pradesh and Tamil Nadu 1% each.

India imports about 80% of crude oil from different destinations of the globe to meet its energy requirements, as shown in Fig. 4.5. Bulk of India's crude oil comes from the Middle East and of the total crude imports from the Middle Eastern countries, Saudi Arabia accounts for 20%, followed by Iraq 14%, Iran 6% and other Middle Eastern countries account for 22%. Besides, India imports 12% crude oil from Venezuela, 8% from Nigeria, and 8% from other African countries.



Source: Vickery (2014).

Figure 4.5: India Petroleum and other liquids imports by source, 2013

India's heavy dependence on oil imports, nearly 80 percent of its oil needs, brings with it a substantial concern with security of supply. Vickery (2014) opines that the security of foreign supply issue has many facets, of which two are most prominent: (1) security in terms of assured willingness and ability of countries to sell to India at affordable prices, and (2) the actual physical security of the lines of supply. India's import of over 40% of its oil from the countries of the Middle East adds serious dimensions to the energy security for India in the wake of fragile situation and political turmoil brewing up in some countries of that region. Besides, the expanding influence of the ISIS can also disrupt channels of oil supplies to India.

4.4.1-c. Natural Gas

Natural gas has a relatively small share (6%) in India's domestic energy mix. Buoyancy about the pace of expansion, fuelled by some large discoveries in the early 2000s, has failed to bear fruits in the wake of lower than expected output from offshore domestic fields. The main onshore producing fields are in the states of Assam, Gujarat, Tamil Nadu and Andhra Pradesh. Some of the most promising areas are offshore, including the Krishna Godavari basin off the east coast. The production record in recent years has been strongly affected first by the start of production at the much-awaited KG-D6 offshore field in 2009, and then by its faster than expected decline because of reported subsurface complexity. This has contributed to an overall decrease in Indian gas output since 2011. Production of conventional gas reached 34 bcm in 2013 and was supplemented by LNG imports via four re-gasification terminals. In addition to conventional gas resources, India also has large unconventional potential, both from coal-bed methane (CBM) and shale gas. Commercial production at scale is still some way off, although CBM activity is starting to gain momentum. However, upstream gas development in India continues to face a number of significant hurdles (IEA, 2015:34).

4.4.1-d Hydropower

India's total hydroelectric resource is estimated at 149 gigawatts of which only about 32 percent or 48 gigawatts is presently developed or under development. Undoubtedly, hydropower presently accounts for only about 3 percent of India's total energy needs; nevertheless, it is more significant in the generation of electricity. About 20 percent of India's generation capacity and 14 percent of actual generation came from hydro in 2012 (Planning Commission, India, 2012: 147). There exists ample scope for expanding hydropower in India and its current installed capacity represents a little under a third of the assessed resource and bulk of the remaining potential lies in the northern and northeastern parts of the country. Some plants with 14GW capacity are under construction and a few of these plants have been delayed in the wake of technical or environmental problems and public opposition. Hydropower development has often lagged well behind thermal generation capacity, leading to a consistent decline in its share of total electricity output. Capacity additions and generation have routinely fallen short of the targets set in successive five-year plans.

India's hydropower sector is faced with a vast array of difficulties like high upfront costs, lack of long-term debt facilities, absence of adequate and efficient project planning and supervision to evaluate and monitor environmental impacts etc. Small hydro projects up to 25 megawatt (MW) capacity are seen as potential source in overcoming some of these obstacles. As of 2014, 2.8 GW of small hydro (less than 10 MW) had been developed (MNRE, 2015).

4.4.1-e. Solar and Wind Power

Modern renewable energy, sans hydropower, is rapidly gaining ground in India's energy mix, especially in the wake of increasing emphasis being put in by the Government of India on renewable energy, including grid-connected and off-grid systems. Of the two major sources of renewable energy – solar and wind – solar power has seemingly played only a limited role in power generation thus far. The installed capacity of solar power in India has reached to 3.7 GW in 2014. Development of solar energy in India got impetus with the launch in 2010 of the Jawaharlal Nehru National Solar Mission, the target of which was dramatically upgraded in 2014 to 100 GW of solar installations by 2022, 40 GW of rooftop solar photovoltaics (PV) and 60 GW of large- and medium-scale grid-connected PV projects, as part of a broader 175 GW target of installed renewable power capacity by 2022, excluding large hydropower (IEA 2015: 36).

India's geographic location in the tropics makes it receive abundant energy from the sun. Currently the total installed solar power generation capacity of India stood at 4,878.88 MW as on December 11, 2015, Coal, of which Rajasthan has the largest solar power generation capacity of 1,256.7 MW, followed by Gujarat at 1,024.15 MW and Madhya Pradesh at 678.58 MW (*Economic Times*, 17 Dec. 2015). Broadly speaking, solar energy accounts for less than 1 percent of India's electricity generation capacity. Undoubtedly, India is endowed with abundant sunshine in geographic terms; nevertheless, the basic difficulty with solar power is not energy availability but the cost of turning the energy received into usable power, especially in view of considerably higher solar costs both for facilities construction and production than for any other renewable source. However, a major advantage of solar energy is that it is a highly secure source because it not only lessens the need for imported hydrocarbons, it also diminishes international security and geopolitical concerns associated with oil, gas and coal as well as it wields almost no significant adverse effects on the environment.

Wind power has made the fastest progress and provides the largest share of modern non-hydro renewable energy in power generation to date. India has the fifth-largest amount of installed wind power capacity in the world, with 23 GW in 2014, although investment has fluctuated with changes in subsidy policies at national and state level. Undoubtedly, during 2015 the Indian government has managed to create a buzz in the wind energy sector by drastically raising the capacity addition target to 60,000 megawatt (MW) from the present 24,000MW; nonetheless, against a potential of 18-22%, the sector registered a plant load factor, or PLF, of 15-17% over the past three years, the PLF has been on a downward trajectory since 2013 and projects in states that are best suited to generate wind energy— Tamil Nadu, Maharashtra and Rajasthan—are operating below their potential by a wide margin (Ram, 2015).

Wind energy entails the potential of tackling the issues of both domestic and international security of energy supply. However, quality control and supply issues pertaining to the wind equipment can make the reliability of the supply suspect. Wind energy has negligible environmental and health adverse effects. Availability of power from wind is faced with many constraints as well. The major constraint pertains to the remoteness and difficulty of terrain for many of the best locations of sites for wind generation equipment. This not only inhibits development by virtue of sites for the generation machinery, but also makes difficult the laying of transmission links to collection sites. Besides, much of the wind power installed capacity does not generate up to capacity and less than 2 percent of electricity is actually generated from wind, while wind accounts for about 1 percent of energy consumed. Thus, solar and wind energy is only a contributory factor in India's energy mix and a long-term alternative to hydrocarbon energy.

4.4.1-f. Nuclear Power

Currently, share of nuclear power in the generation mix in India is relatively small at 3%; India has ambitious plans to expand nuclear power in near future, including a long-term plan to develop more complex reactors. India has twenty-one operating nuclear reactors at seven sites, with a total installed capacity close to 6 GW. Another six nuclear power plants are under construction, which will add around 4 GW to the total. The operation of the existing nuclear fleet had been constrained in the past by chronic fuel shortages and this constraint was eased after India became a party to the Nuclear Suppliers' Group agreement in 2008, allowing access not only to technology and expertise but also reactor parts and uranium (DAE, 2015).

The nuclear industry in India is also subject to the broader challenges that are facing the worldwide nuclear industry, including project economics, difficulties with financing and the implications of the Fukushima Daiichi accident in Japan for public acceptance of new projects. India has struggled to attract the necessary investment and to gain access to reactor technology and expertise, with the Civil Liability Nuclear Damage Act of 2010 widely seen as deterring potential suppliers (especially Japanese and US companies). However, the United States and India reached an understanding on nuclear liability issues early in 2015 that may facilitate US investment in Indian nuclear projects (IAE, 2015).

Making nuclear energy as a significant part of India's energy mix requires manifold increase in India's installed capacity of nuclear power. As of September 2013, India's installed capacity of power stations was a mere 4.780 gigawatts, or only about 2 percent of total installed capacity and about 1 percent of total energy production (CEA, 2013). With the completion of seven additional power plants with a capacity of 5.3 gigawatts, which are under construction, India's nuclear energy is likely to be more than doubled. Besides, India's stated goal for nuclear is to have a total capacity of 63 gigawatts by 2032, a more than thirteen-fold increase from 2013. India's goal for 2050 is for 25 percent of its electricity to be generated from nuclear power plants, when 1094 gigawatts of base-load capacity is expected to be required (WNA, 2013).

Undoubtedly, India's commitments to nuclear energy are clear and ambitious and starting from an extremely small base, the growth required to meet those commitments is very large; nonetheless, the nuclear sector is also confronted the high costs of nuclear power plant construction. According to an IEA study, the nuclear option for India energy is considerably more expensive per kilowatt hour than coal, gas, or wind energy IEA, 2010). Other difficulties facing the nuclear sector, *inter alia*, include: lack of indigenous uranium milling capacity, the vulnerability of supply to international and domestic security concerns, and potential effects on the environment and health.

4.5. Maldives

Maldives is an island nation located in the Indian Ocean and is the smallest country in South Asia. Maldives consists of some 26 major atolls and 1190 tiny islands lying at the equator, of which only 199 are inhabited. Of these islands, only 33 have an area greater than one square kilometer. Maldives imports all its fuels in refined form and in very small quantities making petroleum products more expensive. The yearly consumption of fuel is growing rapidly, thus the proportion of hard earned foreign exchange spent on fossil fuels is increasing.

Total installed capacity was 106.2 MW in 2008. About 33% of the generation is through the State Electric Company (STELCO). In 2009, the company operated 15 power systems in 18 islands, providing electricity to 46% of the population. STELCO now has an installed capacity of 53 MW and over 70% of generation is consumed by the capital, Male. Outer islands account for 13.2% of the total capacity and are controlled by the Island Development Committees and some private producers. Power demand is expected to grow fast due to tourism, particularly in Male where it has been foreseen that demand will grow at more than 11% per annum (Maldives, 2010).

Electrification is estimated at 93% with 197 out of the 199 inhabited islands having access to electricity though only 82 in a continuous manner. The highly dispersed territory does not allow for the installation of a single national grid. The transmission and distribution systems experience high losses due to bad maintenance. The national utility and private power producers suffer from 13% and 24% losses respectively. STELCO also suffers from financial losses due to high oil prices and its transportation costs, and high costs for maintaining increasing staff in the islands. Energy demand in Maldives is rapidly growing with an annual growth rate of approximately 11% in the last decade. Power generation is unequally distributed among the islands. Male, the capital, alone accounts for approximately 72% of all the generated power for inhabited islands. 48.3% of the total generated electricity is produced in the tourist resorts which constitute the main source of income for the islands accounting for 28% of its GDP and more than 60% of its foreign exchange receipt (Ibid.).

The main supply of energy includes Diesel, Petrol, Liquefied Petroleum Gas (LPG), Kerosene, Jet A1 fuel and solar energy. Diesel import with 84% in 2010, 80% in 2011 and 70% in 2012, is the most imported fuel type. In Maldives the most significant energy conversion is from diesel energy to electricity. Nearly 100% of all electricity produced in Maldives in from diesel based systems. The thermal conversion efficiency range from 33% to 38% in the Greater Male' Region. The thermal conversion efficiency of 38% observed in Male' Power house is an extremely good conversion rate for a diesel generator. For the Other Atolls there are 189 power houses throughout the Maldives operated by different utility operators. The conversion rates from well-populated or development islands are considerably better than the rest. All tourist resort islands have their own private electricity production (MEA, 2012).

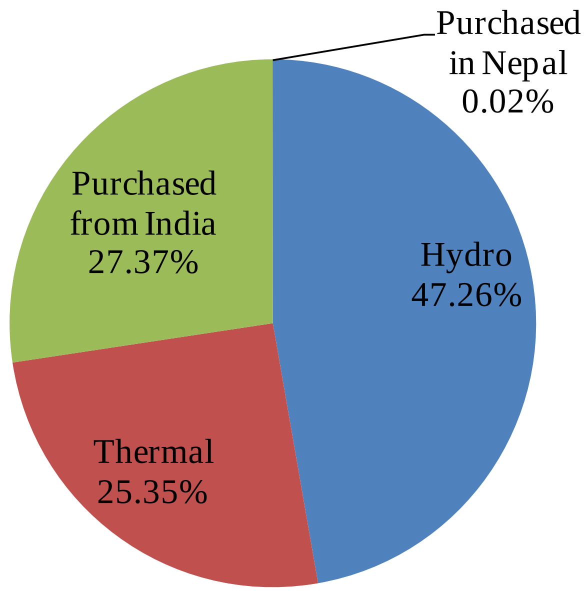
In pursuance of its National Energy Policy and Strategy adopted in 2010, the Government of Maldives has set for itself the ambitious goal of becoming a carbon neutral country by 2020 (Govt. of Maldives, 2010), and increased emphasis is being focused on renewable sources of energy, especially the solar energy. Due to several installations of solar PVs in Greater Male' Region and some areas in the Other Atolls, a huge increase in the solar energy production from 2011 to 2012 is observed.

4.6. Nepal

Biomass and hydropower constitute two indigenous energy sources in Nepal. Fuel wood supplies almost 80 percent of total energy demand and is extracted beyond the sustainable supply capability of the forests indicating a growth in deforestation. Electricity supplies only one percent of total energy consumption and only about 280 MW of 83,000 MW theoretical potential have been developed. Undoubtedly, Nepal has not made satisfactory advance in the technology related to alternative energy; nonetheless, the trend in this area is quite appreciable because technically biogas digesters, small hydropower, solar water heaters, etc are the most proven alternative energy sources (Upadhaya, 2008).

The annual peak power demand of the Integrated Nepal Power System (INPS) in fiscal year 2014-15 was 1, 291.80 MW. Out of the power actually supplied, 357.68 was contributed by NEA hydro, 124.71 MW by IPP hydro and the rest 224.41 MW was imported from India. Compared to the 2013-2014's figure of

1201 MW, the annual peak power demand of the INPS registered a growth rate of 7.56% (NEA, 2015).



Source: NEA, 2015

Figure 4.6: Availability of Energy in Nepal in 2014-2015

Bulk of Nepal's energy, about 47.26%, came from hydropower in 2014-15, as shown in Fig. 4.6 and contribution of thermal power generation was almost miniscule. During this period, Nepal's purchase of power from India and IPPs accounted for 27.37% and 25.35% respectively.

4.6.1. Nepal's Sources of Energy

Traditional sources of energy like fuel wood, agri-waste and animal dung etc. constitute the major source of energy. The commercial sources of energy comprise coal, petroleum and hydropower. The consumption of these energy sources is shown in Table 4.6.

Table 4.6: Sectoral Energy Consumption in Nepal, 2010/11 to 2013/14 (in '000' GJ)

Fuel Type	2010/11	2011/12	2012/13	2013/14*
Traditional	**8,500**	**7,033**	**8,017**	**6,093**
Fuel-wood	7,606	6,274	7,153	5,436
Agri-waste	331	310	353	269
Animal dung	563	448	511	388
Commercial	**1,580**	**1,678**	**1,855**	**1,268**
Coal	293	348	415	277
Petroleum	1,058	1,083	1,182	820
Electricity	229	248	257	171
Others	**75**	**109**	**166**	**247**
Total	**10155**	**8820**	**10038**	**7608**

*Estimate of first eight months, Source: SPBN, 2014.

4.6.1a. Traditional Fuel

Traditional fuel, comprising fuel wood, agri-waste and animal dung, accounts for on an average 80% of the total energy consumed in Nepal. Forests, encompassing almost 5.6 million hectares of Nepal's land forms i.e. around 29% of the country area, are the main source of fuel wood in Nepal. Almost all Nepalese people's livelihood is run by the energy from forests. Fuel wood consumption in Nepal cannot be replaced in the near future and, therefore, the sustainability of forestry sector would remain a question until that time. Biogas, livestock manure, crop residues are some other sources of energy in Nepal. While talking about crop residue, there is a potential of about 14 million metric tons of crop residue among which Terai singly supply 9 metric ton. Many communities in Nepal are using livestock manure as a good source of heat energy. They are using manure for cooking purpose since long period of time (Upadhayaya, 2008). As shown in Table 4.6, fuel wood constitutes the major source of traditional fuel in Nepal followed by animal dung and agri-waste. However, it is observed that a gradual decline is taking place in the usage of fuel wood as well as other traditional fuels

4.6.1a. Electricity

Electricity generation takes place in Nepal both from hydro and thermal sources. Over the years, hydropower generation has witnessed a steady growth and thermal power generation has recorded a decline, especially between 2006 and 2015, as shown in Table 4.7. The hydropower generation which stood at 1,568.55 MW rose to 1839.53 MW in 2009 and by 2015 it reached to 2,365.64 MW. On the hand, thermal power generation has shown a continuous declining trend between 2009 and 2015. The thermal power generation which stood at 9.06 MW in 2009 showed a continuous declining trend till 2012 when it stood at 1.56 MW; however, in 2013 it took a quantum jump by reaching to 18.85 MW to decline by half in 2014 and in 2015 it further declined to 1.24 MW.

Table 4.7: Total Energy Available & Peak Demand in Nepal (2009-2015)

Particulars	2009	2010	2011	2012	2013	2014	2015*
Peak Demand (MW)	812.50	885.28	946.10	1,026.65	1,094.98	1,200.98	1,291.80
NEA Hydro Generation	1,839.53	2,108.65	2,122.08	2,357.43	2,273.11	2,288.23	2,365.64
NEA Thermal Generation	9.06	13.01	3.40	1.56	18.85	9.65	1.24
NEA Total Generation (GWh)	**1,848.59**	**2.121.66**	**2.125.48**	**2,358.99**	**2,291.96**	**2,297.88**	**2,366.88**
Power Purchase from India	356.46	658.68	694.05	746.07	790.14	1,318.75	1,369.89
Power Purchase from IPPs	925.74	591.43	1,038.84	1,073.57	1,175.98	1,070.47	1,268.93
Power Purchase Total (GWh)	1,282.20	1,230.11	1,732.89	1,819.64	1,966.12	2,389.21	2,638.81
Available Energy (GWh)	3,130.79	3,351.77	3,858.37	4,178.63	4,258.08	4,687.09	5,005.69

Note: Peak demand is for all areas covered by integrated system, including supply to India,

*Provisional figures. Source: NEA, 2015

Nepal’s power purchase from India has recorded a significant increase between 2006 and 2015 by showing continuous year-wise onward increase. In 2006, Nepal’s power purchase from India which stood at 266.23 GWh had more than doubled by 2010 by reaching to 658.68 GWh and by 2015 it stood at 1,369.89 GWh, thereby, registering more than five-fold increase as compared to 2006. Nepal’s purchase of power from IPPs also shows gradual increase during this period, by recording increase from 930.04 GWh in 2006 to 1,268.93 GWh in 2015.

4.6.1.b. Coal

Coal accounts for 2 % of the total energy consumption in Nepal and is almost exclusively consumed by the industrial sector, primarily for heating and boiling processes in brick, lime and cement production as well as in steel processing. Apart from some minor coal reserves, coal for industrial needs is imported from India. In the year 2008/09, Nepal imported about 293,000 tons of coal. As shown in Table 4.6, coal imports by Nepal continue to increase in subsequent years and in 2010-2011 it imported 348 metric tons of coal which further rose to 415 MTs in 2012-2013. However, Nepal's import of oil declined in 2013-2014.

4.6.1.c. Petroleum

Undoubtedly, Nepal is not producing petroleum products; nonetheless, it is highly depended on it and import is the only option for Nepal to meet the growing domestic demand for petroleum products. The demand and supply both are increasing day by day. Petroleum is the second largest energy fuel in Nepal after firewood and accounts for 8% of primary energy consumption in Nepal. All petroleum products are imported from India. The government has signed an agreement with the British company Cairns Energy PLC for petroleum exploitations but the exploitation works have not been initiated up to now.

Currently, the import of petroleum products takes place exclusively between the Nepal Oil Corporation (NOC) and the Indian Oil Corporation (IOC). About 75 % of the imports are diesel, kerosene and gasoline. Due to the high energy demand in the country the dependence on petroleum imports is increasing. In 2006, Nepal had to spend 53 % of its foreign currency for importing petroleum products and more than 62 % of the petroleum products are used in the transportation sector. Besides that, petroleum products constitute important energy sources for cooking purposes in households. As shown in Table 4.6, Nepal's import of petroleum products stood at 1,058 MTs in 2010-2011 which increased to 1,182 MTs in 2012-2013. However, Nepal's import of petroleum products recorded a decline when it stood at 820 MTs in 2013-2014 as compared to previous years.

4.6.1.d. Solar and Wind Energy

Nepal has great potential for at least four types of solar energy technology: grid-connected PV, solar water heaters, solar lanterns and solar home systems. Nepal receives 3.6 to 6.2 kWh of solar radiation per square meter per day, with roughly 300 days of sun a year, making it ideal for solar energy. The country also has a large market for solar water heaters, with 185,000 units installed and operating as of 2009 (REEP, 2012). The utilization of solar energy was started in Nepal only after the introduction of domestic solar water heaters. Solar energy as source of energy is being used in Nepal's rural areas by Nepal telecommunication, civil aviation and Nepal electricity authority. More than 348 KW of energy from sun is being used by various stakeholders within Nepal. Solar energy is very suitable for the country like Nepal and it the best option for the generation of energy. In Nepal the total installed photovoltaic capacity is about 350 KW. In 2010, over 900 medium-size solar PV units provided 1.2 MWp of electricity for the communications sector. Solar lanterns, popularly known as solar tuki, with 155,000 units were in use as of 2010 constituting 737 kWp of capacity. 225,000 of solar home systems were used throughout Nepal across 2600 villages with an output of 5.36 MWp (ibid.).

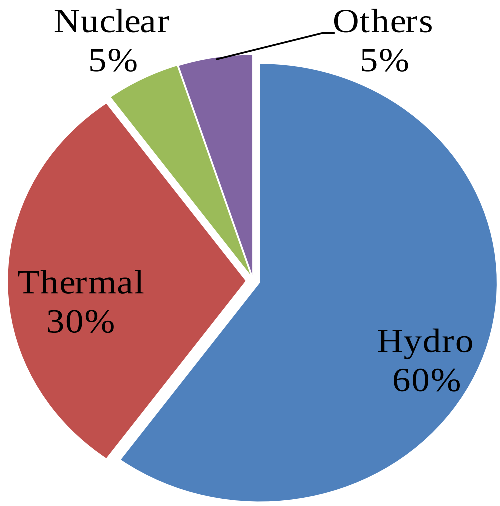
The first wind turbine generator of 20 kW capacity (10 kW each) installed Kagbeni of Mustang District in 1989 (Within the three months of operation, blade and tower of the wind generator were broken). Other, wind turbines were installed in Chisapani of Shivapuri National Park and the Club Himalaya in Nagarkot, both of which are not functional anymore. Within the Asian Development Bank Renewable Village Program, two 5KW wind turbines in Dhaubadi village of Nawalparasi District were installed. (Energypedia, no date). In the northern region of Nepal wind energy is available, but the exact potential is yet to be estimated due to lack of technical personnel. Wind power, of course, is a promising unconventional source of power. It is merely air in motion, set up and continually regenerated by small fraction of isolation reaction the outer atmosphere. It is estimated that nature is generating 1.67 X 1015 KW annually but lonely a small fraction of this can be harnessed for use in the other forms (ibid.).

This brief overview of energy situation in Nepal makes it discernible that Nepal is an energy deficient country and the only potential source of energy is hydropower which is currently underutilized. However, Nepal’s hydropower can be utilized with increased fiscal and technological inputs to augment regional energy cooperation.

4.7 Pakistan

Pakistan has been in the midst of severe energy crisis in recent years in the wake of growing demand for energy and inability of existing energy sources. Primary energy consumption in Pakistan has grown by almost 80% over the past 15 years, from 34 million tons oil equivalent (TOEs) in 1994/95 to 61 million TOEs in 2009/10. Nevertheless, since 2006/07 energy supply has been unable to meet the country’s demand leading to shortages. Meanwhile per capita energy consumption in Pakistan at under 0.5 TOEs/capita remains only one-third of world average. Indigenous natural gas is the largest source of energy supply in Pakistan contributing 27.7 million TOEs (45.4%) in 2009/10, followed by oil products, mainly imports, at 21.3 million TOEs (34.9%), hydel power at 7.5 million TOEs (12.3%), coal, mainly imports, at 3.7 million TOEs (6.1%) and nuclear power at 0.8 million TOEs (1.3%) (PIP, 2011).

Source-wise electricity production in Pakistan in 2014 is shown in Figure 4.7.



Source: HDIP (2014), *Pakistan Energy Yearbook 2014*

Fig.4.7. Electricity Generation in Pakistan 2014

Pakistan's maximum power generation capacity stands at 21,143 MW, but its maximum electricity production in 2014 was to the tune of 15, 643 MW and as such electric power shortfall amounted to 5, 500 MW in 2014, as shown in Fig. 4.7. Bulk of electricity in Pakistan comes from thermal sources which contribute about 60%, to be followed by hydro sources contributing 30%, nuclear sources 5% and the remaining 5% comes from other sources (HDIP, 2014). Source-wise availability of energy generation is Pakistan is briefly described below.

4.7.1. Pakistan's Sources of Energy

Pakistan's sources of energy comprise natural gas, petroleum, hydropower, coal and solar and wind energy. These energy sources are briefly analyzed here.

4.7.1a. Natural gas

Natural gas is the major energy source for Pakistan, which accounted for an estimated 32% of Pakistan's primary energy supply in 2012, second only to biomass and waste. Dry natural gas production has grown by more than 80% over the past decade, from 809 billion cubic feet (Bcf) in 2002 to 1,412 Bcf in 2013. However, according to a report by the Pakistan government, Pakistan faced a natural gas shortfall of 912 Bcf in 2013. Natural gas shortages have forced citizens to use firewood for heat, leading to vast deforestation issues (EIA, 2015). Pakistan is faced with natural gas shortage in the wake of its declining domestic natural gas reserves and lack of the infrastructure to import more gas. Pakistan holds sizeable shale gas reserves of 105 trillion cubic feet (Tcf), according to the

EIA's Technically Recoverable Shale Oil and Shale Gas Resources report published in 2013, and the Pakistani government has provided investment incentives for shale gas development (ibid.).

The Government of Pakistan has extended its support to the construction of the Turkmenistan-Afghanistan-Pakistan-India (TAPI) natural gas pipeline. The TAPI pipeline has the multilateral agreements and financial support necessary to move forward. However, the TAPI pipeline faces serious geopolitical and security concerns and the start construction is uncertain. Pakistan's demand for natural gas has been surpassing the supply for more than two to three years. According to officials the total gas demand on the system is 8 Billion Cubic Feet (BCF) against the total supply of 4 BCF, thus creating the shortfall of around 4 BCF. This gas shortfall has driven a severe power crisis leading to a tenacious shortfall of 5000-5500 MW as on 30th June, 2012 (PIP, 2012).

It is often observed that the contemporary energy crisis in Pakistan has been a self-inflicted problem resulting from years of poor policies and reckless attitude on the part of concerned authorities. In 2010-11, more than 40% of the primary energy needs are dependent on gas, the greatest as compared to any other source This excessive dependence on natural gas continued and in 2012 the natural gas share reached 49.5% while oil imports accounted for 30.8%, LPG 0.5%, Electricity (Hydro, Nuclear & imported) 12.5% and Coal 6.6% (HDIP, 2012).

4.7.1b. Oil

Pakistan is a net importer of petroleum and refined petro-products. From July 2013 to March 2014, Pakistan's crude oil imports grew by 11%. In 2014, Pakistan produced 98,000 barrels per day (b/d) of total oil, up from a below 70,000 b/d before 2012. Most of the increase in oil production stems from additional discoveries and production of condensates from the Tal block. Oil consumption has grown over time and averaged 437,000 b/d in 2013. Pakistan currently has six oil refineries, running mostly on imported crude oil, and a total crude oil distillation capacity of 186,000 b/d (EIA, 2015). The total oil resource potential is 27 million barrels with production of 66,032 barrels per day and currently 29% of the energy requirements are fulfilled through petroleum products (PMoF, 2014). Pakistan's transport sector constitutes the greatest share for oil consumption followed by power, industry and agriculture.

4.7.1c. Electricity

Undoubtedly, Pakistan's net electricity generation increased from 69 billion kilowatt-hours (kWh) in 2001 to 93 billion kWh in 2012; however, according to the Pakistani government, available capacity was only 85% of installed capacity in 2012, and utilization rates for power plants were less than 60%. According to the latest IEA estimates, less than 70% of the Pakistani population had access to electricity in 2012, with 56 million people without access to electricity. The electricity industry faces problems with power generation theft, insufficient collection rates, line losses, high natural gas subsidies, the high cost of furnace oil used in place of natural gas, and insufficient natural gas supply. These problems have resulted in the poor financial position of generation companies, leading to widespread power shortages (IEA, 2015).

Another issue that keeps the Pakistani government trapped in a system of circular debt pertains to electricity price subsidy. According to the Pakistani Ministry of Finance, depending on the fuel source the state utility may charge the consumer less than half of the cost of producing the electricity, which leaves the utility unable to pay for additional fuel. The fuel supply and payment issues have forced many of the power plants to run below peak capacity. White the installed capacity of Pakistan is 23,500 MW, the available capacity is a mere 14,000 MW which is far short of the 17,000 MW average annual electricity demand (ibid.).

4.7.1d. Coal

Pakistan ranks at sixth position across the world in terms of coal resources. Pakistan's total coal reserves are estimated at 185.5 billion tones and these coal resources available in Pakistan vary from lignite to sub-bituminous coal as largest coal reserve in Sind is characterized by high moisture content and low Btu value thus making it difficult to capitalize this resource potential for power generation. However, irrespective of the problems associated with the low quality coal, it has been used widely across the world for fulfilling the energy needs (Abbasi et al. 2014).

4.7.1d. Solar and Wind Energy

Pakistan's geographic location places at an advantageous position to harness solar energy. The mean global radiation falling on the horizontal surface of Pakistan is about 200-250 watt per m^2 in a day with about 1500-3000 sunshine hours in a year, with an annual mean sunshine duration of 8-8.5 hours of sunshine. The country receives on average global insolation of 19 mega joules per square meter of solar energy daily. The solar potential for most parts of Pakistan lies in the range of 150-300 KWh /m2/year. Pakistan can make use of this widely available solar energy for improving the socioeconomic conditions of the people living in these far-flung areas. It is estimated that approximately 40,000 remote villages can be electrified through solar energy. The solar radiation level in Pakistan has been mapped by NREL and total solar energy potential in Pakistan is estimated to be 2.9 million MW of which only a meager portion has been harnessed to date (Abbasi et al. 2014).

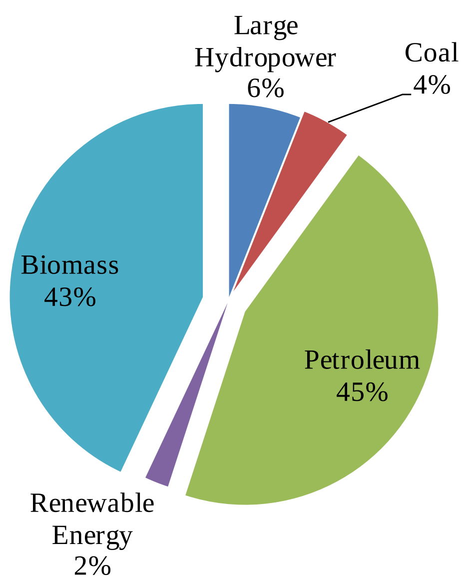
On May 29, 2012 Pakistan inaugurated its first ever solar power on-grid power plant in Islamabad. The Project includes the installation of 178 kilowatts (kW) photovoltaic (PV) systems and the entire setup amounts to a total generation capacity of 356 kW. This is the first on-grid solar PV project which has the arrangement of net-metering thereby allowing the beneficiaries to sell the surplus electricity to Islamabad Division. This project has been executed with the grant assistance from Japan (JICA, 2012). Beaconhouse installed the first-ever high quality, integrated solar energy system with a 10 kW power generation capacity capable of grid tie-in at Beaconhouse Canal Side Campus, Lahore. It was a pilot project for BSS, based upon feasibility by the US Trade and Development Agency (USTDA) and designed by the US Consultants (*Beaconhouse Times Online*, 3 Nov. 2011). In early July 2009, the Government of Pakistan announced that it had also set a target to add 5% approximately 10,000 MW electricity through renewable energies by year 2030 besides replacement of 5% diesel with bio-diesel by year 2015 and 10% by 2025 (GEO TV, 2 July 2009).

Pakistan has also contemplated to harness wind power to generate electricity especially in the wake of the fact that Pakistan is endowed with a great potential for the generation of energy through wind with the velocity of wind in certain areas of the country strong enough to run turbines and consequently generate power. Geographically, Pakistan lies in the region's trade wind corridor which presents a unique opportunity to utilize the priceless potential for energy generation through wind. The wind map of Pakistan developed by National Renewable Energy Labs(USA) identified that wind with good to excellent speed is available in many parts of Pakistan and estimated the total wind potential of about 340,000 MW(See Figure). However Pakistan has only recently ventured into the field of wind technologies and to date has no significant large scale wind generation project in operation. In 2010, the preliminary wind potential had been calculated as 346, 000 MW. Nevertheless, the energy generation through wind power in Pakistan in 2013 stood around 384,000KWh through Zorlu wind power project (Abbasi et al. 2014).

Media reports indicate that Pakistan is looking to increase the share of renewable energy in its overall energy mix substantially and in November 2015 it announced a roadmap that will see around 3.5 GW wind energy capacity operational by 2018. The Alternate Energy Development Board (AEDB) of Pakistan announced on 20 November 2015 that over 40 wind energy projects were in various stages of development and were likely to contribute around 2,050 MW capacity to the national grid by 2017-18. The Chief Executive Officer of the AEDB, Amjad A. Awan, stated that the total installed wind energy capacity in the country is currently 255.4 MW, but is expected to increase rapidly. Currently 28 projects with a cumulative capacity of 1,396.4 MW are under construction, of which nine have achieved financial closure and 14 are under various stage of project development (Mittal, 2015).

4.8 Sri Lanka

Biomass or fuel wood, petroleum and hydro are the major primary energy supply sources of Sri Lanka, which cater to the energy demands of this archipelago. Prior to 2008, biomass accounted for 47% to be followed by hydropower 8% and petroleum 45% as the main primary energy sources used (ADB, 2011). By 2012, biomass contributed 43%, petroleum 45%, large hydropower 6% to be followed by coal 4% and renewable 2% to the total energy consumption in Sri Lanka as shown in Fig. 4.9.



Source: Sri Lanka Energy Balance 2012 http://www.info.energy.gov.lk/

Figure 4.9: Primary Energy Consumption in Sri Lanka (11,524 KTOE in 2012)

The per-capita energy consumption in Sri Lanka was about 0.4 tons of oil equivalent (TOE) in 2014. Biomass or fuel wood, which is mainly a non-commercial fuel, at present provides approximately 45 percent of the country's total energy requirement. Petroleum turns out to be the major source of commercial energy, which covers about 40 percent of the energy demand (CEB, 2015). Undoubtedly, electricity and petroleum products constitute the major forms of commercial energy in Sri Lanka; nonetheless, an increasing amount of biomass is also commercially grown and traded. Hydropower, covering 8% of the total primary energy supply, is the main indigenous source of primary commercial energy in Sri Lanka. Estimated potential of hydro resource is about 2000MW, of which more than half has already been harnessed. Further exploitation of hydro resources is becoming increasingly difficult owing to social and/or environmental impacts associated with large-scale development.

Apart from these, wind power development entails a vast potential. The first commercial wind power plants were established in 2010 and the total capacity of wind power plants by end of 2014 is 124MW. 100MW wind farm at Mannar Island is at the initial development stage. Sri Lanka is heavily dependent on import of fossil fuel either as crude oil or as refined products to meet its energy requirements for transport, power generation, industry and other applications. Efforts are underway to explore potential oil and gas resources in Mannar basin, off shore from Kalpitiya Pennisula. In 2014 the primary energy supply consisted of Biomass (4911 ktoe), Petroleum (4595 ktoe), Coal (921 ktoe), Hydro (876 ktoe) and non-conventional renewable sources (297 ktoe) (CEB, 2015).

4.8.1: Sri Lanka's sources of Energy

Sri Lanka's leading sources of energy consist of biomass, petroleum and hydropower. Apart from these, coal, solar and wind energy also contribute to energy.

4.8.1a: Electricity

By the end of December, 2014, approximately 98% of the total population had access to electricity from the national electricity grid. When the planned electrification schemes are implemented it is expected that this will increase further. In early stages the electricity demand of in Sri Lanka was mainly supplied by hydro generation and the contribution from thermal generation was minimal. With the time, thermal generation has become prominent. Currently, thermal generation share is much higher than that of hydro. Electricity Generation during the last decade as summarized in Table 4.8.

Table 4.8: Electricity Generation in Sri Lanka, 2005-2014

Year	Hydro Generation		Thermal Generation		Self Generation		Total
	GWh	%	GWh	%	GWh	%	GWh
2005	3455	39.4	5314	60.6	0	0	8769
2006	4638	49.4	4751	50.6	0	0	9385
2007	3950	40.3	5864	59.8	0	0	9811
2008	4138	41.8	5763	58.3	0	0	9893
2009	3908	39.7	5975	60.6	0	0	9856
2010	5720	53.8	4994	47.0	0	0	10628
2011	4743	41.1	6785	58.9	2.9	0.03	11528
2012	3463	29.3	8339	70.7	1.4	0.01	11801
2013	7182	60.1	4773	39.9	0	0.0	11962
2014	4862	39.2	7556	60.8	0.0	0.0	12418

Note: Wind & small hydro generation is included in Hydro Generation Figure
Source: CEB 2015

It is observed from Table 4.8 that thermal power generation has maintained a steady lead in overall power generation in Sri Lanka between 2005 and 2014 with an exception in 2013 when thermal power accounted for about 40%. The thermal power generation that constituted 60% in 2005 almost maintained its lead over the subsequent years and in 2014 when the overall energy demand had registered substantial increase it continued to be 60% of the overall power generation. On the other hand, hydropower has continued to maintain its average share of over 40% in the overall power generation with slight fluctuations between 2005 and 2014 with the exceptions in 2012 when its contribution was 29% and in 2013 when its contribution accounted for 60%.

4.8.1b: Petroleum Products

In the present context, all fossil fuel-based thermal generation in Sri Lanka would continue to depend on imports, despite oil exploration activity presently on going in the Mannar basin (CEB, 2015). The domestic oil and gas industry in Sri Lanka is small, with no hydrocarbon production despite a refinery at Sapugaskanda with a processing capacity of 50,000 barrels of oil per day (bopd). The South Asian island-state, located off the southeastern coast of India in the Indian Ocean, is dependent on petroleum imports for its domestic needs. Oil consumption in 2013 reached 91,880 bopd, up from 90,000 bopd in 2012, data from the U.S. Energy Information Administration showed (Cheang, 2014). Sri Lanka is encouraging foreign investors to help the country develop its fledging upstream oil and gas sector as exploration and potential development of hydrocarbon resources is expected to reduce dependence on expensive petroleum imports.

4.8.1c: Coal

Coal, being commonly used as fuel option for electricity generation, was identified by CEB as an economically attractive fuel option for electricity generation in 1980s. Sri Lanka had been importing coal from abroad in small quantities to meet its minor energy requirements. However, no coal plants were built until 2011 due to several environmental and social issues. In the aftermath of the firs 900MW coal power plant coming into operation at Puttalam, which was built in two stages (CEB, 2015), the quantum of coal import has increased manifold. In 2007, Sri Lanka imported 74.96 thousand short tonnes (TST) and by 2009 it had reached to 110.23 TST. In the aftermath of coming into operation of the first coal-based power plant, the quantum of coal import in 2011 stood at 837.76 TST, which by 2012 stood at 1060.42 TST (Indexmundi, 2012) and subsequent couple of years have seen further increase in the quantity of coal imports by Sri Lanka.

4.8.1d: Solar Energy

Spatial distribution of Global Horizontal Radiation(GHI) in Sri Lanka varies from 1250 kWh/m2/year on the humid highlands to 2100 kWh/m2/year in high potential regions and taking into consideration the land availability the exploitable solar is estimated as above 6000 MW (MPE, 2014). Therefore, Sri Lanka is a region where substantial solar energy resources exist throughout much of the year in adequate quantities for many applications, including solar water heating, solar electricity, and desalination. Many applications of solar energy have currently been in use for meeting remote electrical loads throughout much of the non-electrified regions of Sri Lanka. The potential exists for significant expansion of the use of this renewable energy.

According to the study carried out by (Renné et al., 2003), annual solar resource in Sri Lanka ranges from 4.5 to 6.0 kWh/m2/day. This study further shows that ample resources exist throughout the year for virtually all locations in Sri Lanka for PV applications, such as solar home systems and remote power applications. The variability in global horizontal solar resources is relatively small across most of the country, despite the impact of terrain characteristics on cloud formation. The resource generally varies spatially at most 20% to 30% during any given season. The highest resources are in the northern and southern regions, and the lowest resources are in the interior hill country (Renné et al., 2003). A study carried out by DFCC Bank in 2007 under the RERED project has estimated that solar power generation will be increased up to 11.2 MW by 2015 (Boyagoda, 2007).

4.8.1e: Wind Energy

Availability of scant information on wind resource until the end of 2000 prevented Sri Lanka from harnessing wind power. With the advent of new technology backed by foreign financial aid, Sri Lanka commenced wind energy studies followed by pilot scale wind power projects. There are several comprehensive studies done extensively on the wind resource of Sri Lanka. The first one to emerge was the “Wind Energy Resource Assessment in Puttalam and Central Regions of Sri Lanka” as a result of a collaborative attempt of the Ministry of Power and Energy Sri Lanka, CEB, and UNDP/GEF Renewable Energy Project. The report elaborates the availability of wind resource, wind energy potential, and the reliability in terms of wind speed and consistency, etc. The study identified potential wind sites in the country along with the financial and economic viability of establishing wind driven power generation plants (MPE, 2015).

According to a study by Elliott et al. (2003), there is nearly 5,000 km2 of windy area with good to excellent wind resource potential in Sri Lanka out of which

4,100 km2 is in inland and 700 km2 is in the costal belt. Therefore, the land extent with wind energy potential is around 6% of the total land area (65,610 sq km2) of Sri Lanka. Based on a very conservative assumption of 5 MW per Km^2, it could accommodate around 20,000 MW capacity wind power plants. The total potential is as high as 24,000 MW if windy lagoons are also considered (ibid.). These values may be further enhanced with the future advancement in wind technology as it would be possible to utilize wind resource which is now at a moderate level. It would be equivalent to 16.7 % of the total area of the country (11,000 Km2 out of 65,610 Km2) having wind power generating potential. According to these approximations, Sri Lanka has an overall wind potential of more than 55,000 MW (Elliott et al. 2003).

Sri Lanka is looking to increase the installed renewable energy capacity by over four times over the next two decades, as the Ceylon Electricity Board (CEB) draws up a new long-term policy. Sri Lanka's installed power generation capacity at the end of 2014 was 3.9 GW, of which 442 MW is based on renewable energy capacity, dominated by mini-hydro power technology, which contributes 293 MW capacities, while wind energy technology represents 124 MW capacity. Renewable energy capacity has a share of over 11% in installed capacity as well as generation. Moving forward, the CEB plans to increase the renewable energy capacity to 972 MW by 2020, which would contribute 20% to the total power generation in the country. Renewable energy's share in power generation is expected to peak in 2025 at 21.4% with an installed capacity of 1,367 MW (CEB, 2015).

Between 2025 and 2034, share of renewable energy in power generation is expected to reduce marginally from 21.4% to 20.0%. Installed renewable energy capacity in 2034 is expected to reach 1,897 MW, with wind energy being the dominant technology. Wind energy is expected to overtake mini hydro in terms of installed capacity by 2023. Installed capacity targets for the four renewable energy technologies projected by the CEB are mini-hydro: 673 MW; wind energy: 719 MW; biomass-based power: 279 MW; and solar power: 226 MW. In order to boost the development of small-scale and rooftop solar power capacity in the country, the CEB will consider and approve a net metering policy. To boost power generation from large-scale wind energy and solar power projects, the CEB will also look to enhance resource potential mapping and forecasting of power generation (Mittal, 2015).

4.9. Conclusion

The energy situation in the SAARC region is critical at present juncture and almost all countries are energy-deficient on one count or the other. With the exception of Bhutan, the hydropower potential of other SAARC countries has remained under-utilized and as such much emphasis is placed on thermal power generation from coal and gas. However, like petroleum and petroleum products, coal and gas has to be imported by these countries for paucity of indigenous hydrocarbon resources. Besides, climate factors prevent from putting excessive reliance on petroleum product and coal for thermal power generation. However, in the wake of mounting demand for energy to continue to ride on the trajectory of economic growth, hydropower other renewable resources of energy are seen as entailing the potential for meeting the growing energy demands in each country of the SAARC region.

Nevertheless, the development of the renewable energy sources is at nascent stage for want of essential funds and appropriate technology. Besides, development of renewable energy sources, especially solar energy and wind energy are long-term projects contingent upon the availability of funds and technology, hydropower entails the potential of meeting the energy demands in bulk. There better prospects of bilateral and multilateral cooperation in developing hydropower potential in the non-island countries of the region. There already exists bilateral hydropower cooperation between India and Bhutan as well as India and Nepal. Prospects of hydropower cooperation between and amongst the countries of South Asia are analyzed in details in Chapter 6 of this report.

Chapter 5:

Food Security in South Asia

The concept of food security has been defined by the World Food Summit of 1996 as thus: "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life," (WFS, 1996). This definition of food security has come to be widely accepted and recognized all over the world, especially the UN agencies, including Food and Agriculture Organization (FAO).

Food security comprises following four key pillars:

- **Food Availability** – Sufficient availability of food with the nation through domestic production, net imports (commercial or food aid) and carry-over of stocks.
- **Food Access** – Individual's capability to purchase food and to be able to procure food through safety nets or availability.
- **Food Utilization**- Consumption of food by the household in a proper form. It also takes into account food preparation, storage and utilization, food safety and nutritional safety and dietary balance.
- **Food Vulnerability**- Vulnerability of the population to the food insecurity due to physiological, economic, social or political reasons (FAO, 2006).

Food security is an essential component of human development along with economic growth. Economic growth needs to be equitably distributed by the mechanism of progressive public policies to advance the well-being of people irrespective of gender, caste, religion and ethnicity. Accordingly, equitable economic growth facilitates not only alleviation of poverty and improves human development, but closing a virtuous circle, also accelerates the pace of economic growth in the long-run.

Undoubtedly, recent decades have seen South Asia registering appreciable annual rate of economic growth along with increased food production, making the region almost self-sufficient in food thereby ensuring adequate food availability to meet nutritional requirements along with decline in the incidents of poverty, hunger and malnutrition. Nevertheless, the increase in income inequalities in almost all countries of South Asia has undermined the positive impact of growth on the alleviation of poverty, hunger and malnutrition.

This becomes discernible from the fact in India, Pakistan and Bangladesh, the three largest countries of South Asia, more than two out of every five children are stunted (low height for age), one in three are underweight (low weight for age), and more than 15 per cent are wasted (low weight for height) (WHO, 2015). Apart from about half of the women in these three countries suffering from anaemia, one in three people live below the national poverty line in Pakistan and Bangladesh, and more than 20 per cent in India and Nepal. Undeniably, fast pace of economic growth has assured ample production of food in the region; nonetheless, a sizeable number of women and children are still poor and malnourished. This demonstrates that the region of South Asia is facing problem of unequal access to food because people simply lack resources to purchase food.

In order to fully comprehend the multiple dimensions of food security in terms of access and use of food in the countries of South Asia with equal emphasis on the policies and programmes these countries have adhered to solve the problems of hunger, poverty and malnutrition in South Asia, an endeavour is made here to focus briefly on country-specific issues related to food security.

5.1 Food Security in Afghanistan

In terms of food security, Afghanistan is the most vulnerable country in South Asia. Latest data show that the number of Afghans facing severe food insecurity increased from 4.7 percent of the population in 2014 to 5.9 percent in mid-2015. This means more than 1.5 million people are now considered severely food insecure, an increase of more than 317,000. Another 7.3 million people - more than one in every four Afghans - are classed as moderately food insecure. Another matter of great concern is that the proportion of severely food insecure people who have already exhausted their capacity to cope with these emergencies has increased - meaning many more are now forced to sell land, take children out of school to work, or depend on relatives for support. The data also indicate that the number of people engaged in these last ditch actions has doubled over the past year to more than 20 percent of food insecure people across the country and this is likely to leave even more Afghan people significantly vulnerable to extreme poverty (FAO, 2015).

5.1.1 Food Production

Agriculture forms the backbone of Afghan economy. Wheat, rice, maize, barley, vegetables, fruits, and nuts constitute the major components of agriculture produce. About 70 percent of cultivated crop area is devoted to wheat and about 15 percent is devoted to rice, barley and maize (Chabot and Dorosh, 2007). Wheat is both a major production crop and the main staple of the Afghan diet, with wheat flour contributing 57 percent to the total caloric content of the average bundle of food items of the relatively poor (i.e., the 20th to 50th percentile of the total consumption distribution, which is the basis for the official Government of Afghanistan poverty line). Grains make up the largest share of calories in Afghan diet, as shown in Fig. 5.1

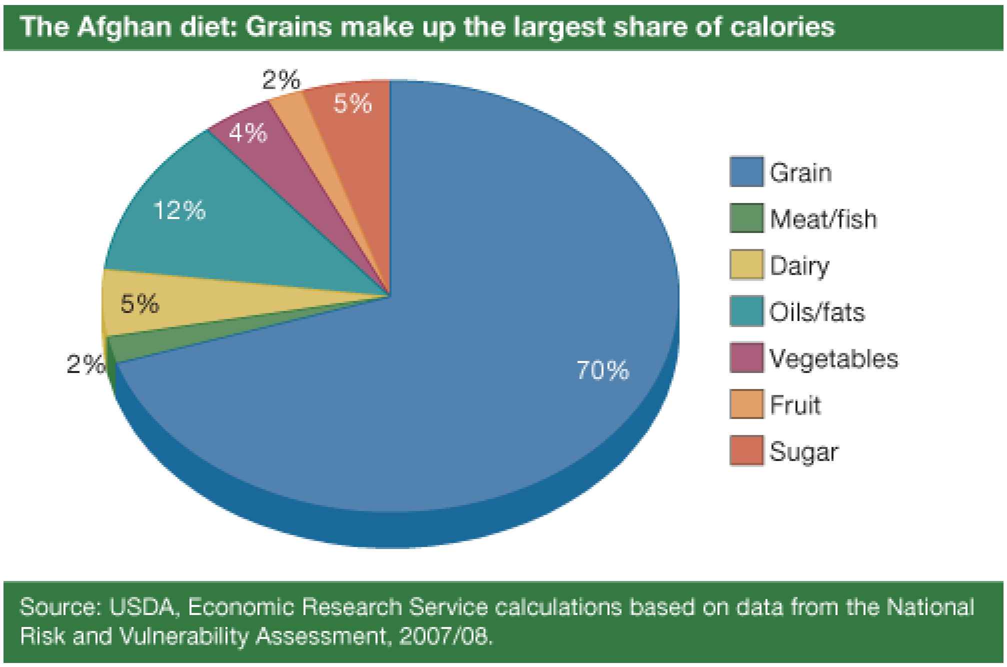


Figure 5.1: Composition of Afghan Diet

The availability of cereals in Afghanistan, especially wheat which accounts for 77 percent of total cereal production, depends on both local production and imports. Cereal production in Afghanistan during 2004-2008, as shown in Table 5.1, reveals that local production of cereals met nearly three-fourths of the total national demand during 2004-2008. Self-sufficiency rate in cereal production was the highest in 2005 and 2007 while it was the lowest in 2004. The wheat constituted the major component of the cereal production during the period under review. But due to large fluctuations in weather and insecurity, wheat and other grain crop production remained highly volatile and Afghanistan is dependent on its trading partners and food aid to meet any shortfalls. Pakistan is the major supplier of wheat, mostly in the form of flour, and estimates of Pakistan's share of the Afghan wheat and flour import market range from 59 percent (Chabot and Dorosh, 2007) to 79 percent (Maletta, 2004).

Table 5.1: Cereal Production in Afghanistan, 2004–08 (thousands of tons)

Category	2004	2005	2006	2007	2008	2004-08 (Average)
Total Cereal Production	3,057	5,243	4,447	5,443	3,860	4.410
Total Demand	5.717	5,866	6,018	6,175	6,500	6,055
Demand-Supply Gap	2,660	623	1,571	732	2,640	1,645
Self-Sufficiency Rate (%)	53	89	74	88	59	73
Wheat Production	2,293	4,266	3,363	4,343	2,767	3,406
Wheat as percent of Total Cereal Production	75	81	76	80	72	77

Source: World Bank (2010)

Food aid, although small in relation to other sources of food, still constitutes a vital part of the on-going national efforts to overcome food insecurity in Afghanistan. During 2005-2009, more than 1.12 million metric tons of food aid was delivered to Afghanistan to provide emergency food relief and nutritional support to vulnerable and acutely food insecure households, including those whose livelihoods were disrupted by conflict and protracted drought conditions.

5.1.2 Malnutrition

Afghanistan is faced with a severe problem of poor nutrition. Chronic malnutrition among Afghan children is one of the highest in the world. More than half (54%) of Afghan children under age five are stunted (chronically malnourished) and over a third (34%) are underweight. Around 72 percent of children (under age 5) suffer from the deficiency of key micro-nutrients (such as iron and iodine). These poor nutritional outcomes are closely linked to the state of food security in Afghanistan. More than a quarter (29 percent) of Afghan population cannot meet its calorie requirement, that is, it consumes less than 2100 calories per day. Twenty percent of the population consumes a diet that lacks adequate dietary diversity, thus affecting their micro-nutrient intake. Moreover, the problem of food insecurity compounds in lean seasons (for example during the spring season) when 33 percent of the population suffers from calorie deficiency and 24 percent from poor diet (World Bank, 2012).

Afghanistan has one of the highest stunting rates in the world. More than half (54%) of Afghan children under age five are stunted (chronically malnourished) and over a third (34%) are underweight (World Bank, 2011). More than two-thirds (72%) of children also suffer from iodine and iron deficiency. These poor nutritional outcomes are closely linked to poor access and utilization of food in Afghanistan. According to the NRVA 2007/2008, nearly a third of Afghan population (29 percent) suffers from calorie deficiency—population whose calorie consumption is less than 2,100 calories per capita. Twenty percent of the population consumes a diet that lacks adequate dietary diversity, thus affecting the balance and diversity of micronutrient intake (World Bank, 2012).

5.1.3 Food Availability and Access

Undoubtedly, agricultural production conditions in 2014-2015 were good, auguring for a good harvest for the third year in a row; nevertheless, due to high inequality in access to land, food availability does not automatically translate into improved food security, especially with deteriorating terms of trade of wages to wheat. As stocks only last for five months on average, market supply is a major component of food availability, however bad road conditions, or blockades, often cut-off entire communities from markets provoking supply shortages and price shocks. Reduced purchasing power caused by deteriorating terms of trade and price shocks forced the average Afghan households to downgrade their average diet towards less nutritive but cheaper food, at the expense of meat. Beyond food intake, with half of the population deprived from access to safe water or health facilities, concern arises about the quality of food absorption and nutritional outcomes (FAO, 2015a).

Severe food insecurity is on the rise in Afghanistan, as a result of lower wages and asset depletion. Taking into account coping capacity, 1.57 million people were in need of emergency relief when stocks were exhausted (5 months after the harvest on average), particularly in Ghor (299,000 people). Another 7.3 million moderately insecure need livelihoods support, particularly where assets are already depleted. Punctual food aid could help to cope with shocks and avoid depleting their assets. Labour migration and conflict induced displacement are swelling the ranks of the urban poor, and further worsening their livelihoods as the labour market is already saturated. In order to prevent a further increase in the severity and breadth of food insecurity, rural livelihoods need to be urgently supported in order to slow the rural exodus, and avoid further asset depletion. In urban areas, alternative livelihoods – independent of access to land – should be promoted equally urgently (FAO, 2015a).

5.1.4 Poverty and Inequality

The poor account for about 36% of the total Afghan population, as per data of 2012. Though the percentage of the poor was down in 2012 by only 0.5% from 2007, the poverty gap has actually increased from 7.9% in 2007 to 8.4% in 2012. This means that the poor are less able to cater to their basic needs than they were in 2007. Income inequality translates directly into uneven food security: In 2012, the richest quintile of the population (20%) accounted for 39% of cereals consumed in the country, whereas the poorest quintile shared only 9% of the total cereal consumption (FAO, 2012). World Bank's economic forecast for Afghanistan for 2015 had estimated a growth rate of only 2% for 2015, down from an average growth rate of 9% between 2003 and 2012 (World Bank, 2015) and this slow down has been attributed to the withdrawal of aid and a reduction in investment due to political instability. It is worth noting that impressive economic growth between 2003 and 2012 in Afghanistan did not benefited the poor.

Undeniably, there was rapid increase in unemployment and underemployment along with economic slowdown and rapid population growth; nonetheless, food security in the midst of the economic slowdown was cushioned by lowering food price inflation, which declined from close to 10% in December 2013 to just 2.9% in December 2014, driven by a good domestic and regional harvest and global falling oil prices (World Bank, 2015). The increase in the poverty gap is also the outcome of asset depletion through recourse to negative coping strategies, such as the sale of assets or the withdrawal of children from school, which are often irreversible. In 2014, it was estimated that the child labour rate was as high as 38% for children aged between 12 and 14 years old, and 20% for children from 5 to 11 years (FAO, 2015a). Bolstering the Afghan economy to be able to absorb its growing labour force is crucial to food security, and ultimately political stability.

5.1.5 Remedial Measures

Afghanistan has been reeling under turmoil for the past four decades and even presently it is in deep throes of civil strife which prevents the Afghan government to take long-term policy measures to tackle the problem of food insecurity in the country. Afghanistan's food production is unable to meet the growing food demand and humanitarian food assistance and food imports from neighbouring countries fill up the gap between demand and supply. Establishment of peace and political stability is a pre-requisite for tackling Afghan food problem. However, international donor agencies and UN agencies like World Bank, FAO, WHO should supplement assistance to Afghanistan to improve nutrition conditions in the country and simultaneously Afghan government should also take necessary steps to build up food stocks for lean season and checkmate increase in food prices.

5.2 Food Security in Bangladesh

Geographical location of Bangladesh makes it as one of the most vulnerable countries of the world, which is visited by frequent natural disasters. Besides, underdeveloped infrastructure and a low natural resource base further adds to its difficulties to march onward path of development. Despite obstacles like high incidence of poverty, inequality, hunger, and population density etc., Bangladesh has managed to perform impressively in recent decades not only in terms of increasing and sustaining economic growth, but also ensuring that growth is inclusive and pro-poor. Resultantly, the incidence of poverty, hunger and malnutrition has decreased. In terms of food security, the focus has been towards food availability, access and proper utilisation. Despite these positive developments, the country is still facing challenges in the form of high prevalence of malnutrition among children and women, and a high proportion of poverty.

5.2.1 Food Production, Availability and Access

Recent decades have witnessed Bangladesh successfully expanding its availability of food network and it has attained self-sufficiency in the production of rice, its staple food. Undoubtedly, government of Bangladesh has managed to reduce incidence of poverty, hunger and malnutrition in the country; nonetheless, food insecurity— attributed to insufficient food access— is still widespread.

A significant reduction in the number of food insecure people - from 73 per cent in 1981 to 40 per cent in 2005 – has been reported in Bangladesh, and interestingly this reduction took place in both rural and urban areas; however, progress was better in the former. Consequently, in 2005, the proportion of food insecure people in urban areas exceeded those in rural areas and in absolute terms, the number of hungry people in Bangladesh declined by 11.3 million between 1981 and 2005. The corresponding decline in rural areas stood at 19.7 million persons, while in urban areas it rose by 8.4 million people. Thus, the share of the urban population in the total number of hungry people increased from 9.5 per cent to 26.4 per cent during this period (GOB, 2011).

5.2.2 Malnutrition

Commendable progress has been achieved by Bangladesh in recent decades in child nutrition, as shown in Table 5.2, especially between 1997 and 2011 in terms of the number of stunted, underweight and wasted children. Child malnutrition as measured by stunting and underweight decreased per annum by 1.1 and 1.4 percentage points respectively, while wasting increased marginally (GOB, 2013a).

Table 5.2 Malnutrition trends among children (0-59 months) under-five in Bangladesh, 1986-2011 *(%)*

Year	Stunting	Wasting	Underweight
1997	54.6	17.7	56.3
2004	50.6	14.5	42.5
2007	43.2	17.4	41.0
2011	41.3	15.6	36.4

Sources: GOB 2013a and Das *et al*. 2009.

Over the past two decades, a mixed progress is discernible and deficiencies of micronutrient like vitamin A, iron, iodine and zinc are also common among children of Bangladesh. Undoubtedly, Bangladesh has recorded significant progress in reducing vitamin A deficiency among children (aged 6-59 months) and increasing the consumption of vitamin A rich foods at 60 per cent; nonetheless, half of the children are anemic and few programmes have been initiated to address this. Besides, more than one-third of children and women are suffering from sub-clinical iodine deficiency (Tahmeed et al., 2012).

Arguably, improvement has taken place in the nutritional status of women in Bangladesh in recent decades; however, disparities have continued to exist by income and social status. In 2011, 24.2 per cent of women (aged 15-49 years) suffered from chronic energy deficiency (with a BMI of less than 18.5) compared to 52 per cent in 1997 (GOB, 2013a). Micronutrient deficiencies in iron, iodine and vitamin A are also widespread in the country. Even though anaemia among pregnant women decreased from 53.5 per cent to 50.0 per cent between 1990 and 2011, it is still very high (FAO, 2014; GOB, 2013a).

5.2.3 Availability and Access to Food

Bangladesh's major food items comprise rice and wheat; and rice constitutes 74 per cent and wheat accounts for 57 per cent of total per capita calorie and protein intake respectively. Rice production has tripled from 11 million tonnes in 1971 to 33 million in 2012. The per capita rice production has increased substantially over the level at independence. The growth of production was achieved by fast adoption by farmers of higher yielding crop varieties developed by scientists, supported by rapid expansion of irrigation infrastructure through private investment in tube wells (Hossain, 2013). Wheat production in Bangladesh has almost remained at the levels of the early 1990s for want of a favourable climate for the production of wheat. The production of fish has also increased at an annual rate of two per cent over the last four decades. In the 2000s, its production more than doubled.

Per capita income, which is the main determinant of access to food, has more than doubled in Bangladesh over the past three decades, as a result of which income poverty registered a significant decline in both rural and urban areas during this period. However, the distribution of income became more inequitable in the country.

5.2.4 Poverty and Inequality

Bangladesh has managed to reduce the proportion of people living below the national poverty line almost by half, with a higher decrease in urban areas during the past two decades, as shown in Table 5.3. Measures like population control, a rise in the working age population and labour force participation rate, and growth in wages etc are regarded as responsible for such a substantial decline in poverty in Bangladesh between 1992 and 2010. Other factors included improved infrastructure, transfer of labour from the farm to non-farm sector, and comprehensive social safety net programmes. However, the proportion of poor people remains high, as about one out of every three people is still poor.

Table 5.3 Proportion of population below national upper poverty line (2,122 kcal/person/day), 1984-2010 *(%)*

Year	Rural	Urban	National
1992	58.8	42.8	56.7
1996	54.5	27.8	50.1
2000	52.3	35.2	48.9
2005	43.8	28.4	40.0
2010	35.2	21.3	31.5

Sources: MHHDC 2012 and GOB, *Household Income and Expenditure Survey of Bangladesh*

In 2009, there were around 50 million poor people in Bangladesh, of which 28.8 million were in the clutches of extreme poverty. By the closing part of 2013, the number of poor and extreme poor came down to around 38.05 million and 15.07 million respectively, as shown in Fig. 5.2. Many of the extreme poor have crossed poverty line over the last 22 years. It is also worth mentioning that 45 percent of those extreme poor were pulled out of poverty within the last 5 years (CRI, 2014).

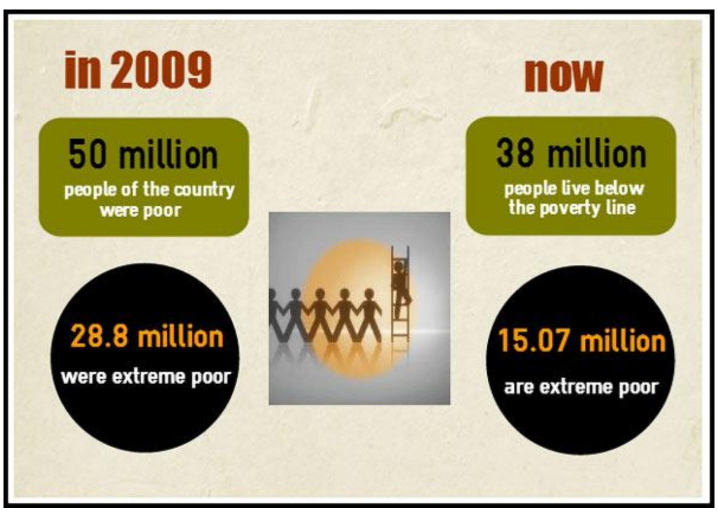


Figure 5.2: Decline of Poverty in Bangladesh between 2009 and 2013.

Disparities in income in both rural and urban areas of Bangladesh over the past three decades have widened thereby indicating a low impact of growth for the poorest households. Inequality in incomes increased from 0.350 in 1984 to 0.458 in 2010, with a similar trend in both rural and urban areas. Growing inequity in the distribution of economic output is also evident from an increase in the income of the rich at the expense of the poor. Between 1984 and 2010, the share of the poorest 20 per cent of population in national income decreased from 2.9 per cent to 2.0 per cent, while for the richest 20 per cent of population, it grew significantly from 28.3 per cent to 37.6 per cent (GOB, 2011; GOB 2013b). An increase in food prices is prone to aggravate poverty and food insecurity among the poor. Increase in rice's price inflation in Bangladesh, between January 2005 and March 2008 led to the number of poor people increase by 12.1 million (Roksana et al., 2014). Between 2005 and 2010, food prices rose at an alarmingly high annual rate of 14 per cent.

5.2.5 Remedial Measures

Bangladesh's economic progress over the last three decades has helped it reduce poverty rates substantially, and deal with the critical issues of hunger and malnutrition. Successful policies and Five Year Plans aimed at poverty reduction and food security were central to its success. The recent macroeconomic plans—the Vision 2021, the Perspective Plan 2010-21, and the sixth Five Year Plan (2011-2015)—also emphasise the need for creating economic growth while lessening poverty, malnutrition and food insecurity. Meanwhile access to food has been enhanced by introducing an effective social safety net that includes a food distribution system. Government prioritisation of pro-poor growth, human development and poverty reduction is evident from the composition of public expenditure. The National Food Policy 2006 governs food security in Bangladesh.

The Government of Bangladesh has taken various steps to ensure food security, which include widening the ambit of safety net programmes and ensuring a Public food distribution system (PFDS). Since the 1970s, Bangladesh has formed a comprehensive social protection system to empower the poor and marginalised. In the 1990s, the government developed social safety net schemes in the form of school stipend programmes, and allowances for the old, disabled and widows. Food security programmes are the largest component in the social sector budget (GOB, 2014f). There are a number of safety net programmes to ensure food security in Bangladesh including Open Market Sales, Vulnerable Group Development, Vulnerable Group Feeding, Test Relief Food, Gratuitous Relief Food, Food Assistance in Chittagong Hill Tracts Area, and Food for Work.

The Bangladesh Government has set the target to bring down poverty to 13.5 percent by 2021. In the time of proposing budget for the current fiscal year (FY 2014-2015), scrutinizing the progress rate, they have drawn an assumption that poverty will be reduced to 10.2 percent by 2021. They further believe that, extreme poverty will be totally eliminated from this country by 2018. To attain the target the budget proposal contains various programmes to eradicate extreme poverty (CRI, 2014).

5.3 Food Security in Bhutan

Bhutan's geographic location in that part of Himalayan region, which is a region of powerful tectonic activity, makes it vulnerable to natural disasters and consequently Bhutan has suffered from earthquakes throughout its history, with a quake registering 6.3 on the Richter scale as recently as 2009. Glacial floods have damaged development structures in the recent past. Bhutan is also vulnerable in the area of food security. Almost all food is imported, mostly from India, and the price of every food item is closely linked to international food prices.

5.3.1 Food Production in Bhutan

Inadequate agricultural land, unproductive soil, fallowing of agriculture land, crop damage by wildlife, lack of irrigation are considered major reasons for inadequate domestic productions. During food deficit periods, seasonal borrowing from food surplus households, bartering of food with other local products, work for food and income from wages or remittances from salaried family members are some of the coping strategies adopted by households (RGOB, 2013).

Availability of food in general is ensured through domestic production and distribution of imported food through markets. A National Food Security Reserve (NFSR) is currently being maintained through the Food Corporation of Bhutan (FCB) comprising of rice, oil and sugar. The NFSR has a total of 1,658 MT of food distributed and marketed through 20 regional and local depots of FCB. In addition to NFSR two separate reserves are also maintained by FCB, i.e. the SAARC Food Security Reserve and the SAARC Food Bank both of which comprise of 180 MT of rice. In some areas, community grain silos are maintained to store food grains. At household level, storage of food is mostly based on traditional practices. The diversity of food items of the Bhutanese is also enhanced by a wide variety of wild vegetables, medicinal plants and NWFPs collected from the nature. Besides acting as a source of supplementary income, these wild foods also supplement availability of cultivated food products in times of food shortages (RGOB, 2012).

In 2006 Bhutan produced an estimated 74 thousand tons of paddy, equivalent to 49 thousand tonnes of milled rice. The same year, Bhutan imported 52.1 thousand tonnes, which implies a self-sufficiency ratio of 49%, as shown in Table 5.3. Overall cereal production in 2006 was 143 thousand tonnes, while cereal imports were 62 thousand tonnes, yielding a cereal self-sufficiency ratio of 70%.

However, cereal production and imports vary substantially from year to year, so the self-sufficiency ratio does as well.

Table 5.3: Cereal production, imports, and self-sufficiency in Bhutan

Category	2000	2003	2006	2007	2008
Production (thousand MT)					
Rice	45.3	30.2	49.1	49.8	51.8
Maize	77.3	49.7	71.1	61.8	66.8
Wheat	4.4	4.7	9.6	8.87	5.6
Other Cereals	8.4	6.1	13.4	21.7	12.2
Total cereals	135.4	90.7	143.1	142.2	136
Imports (thousand MT)					
Rice	33.7	54.9	52.1	46.5	52.2
Wheat	8.9	31.4	10.4	8.7	1.7
Self-sufficiency ratio (%)					
Rice	57%	35%	49%	52%	50%
Cereals	76%	51%	70%	72%	72%

Source: IFPRI (2010)

The domestic production of total cereals is able to meet about 60% of the total cereal demand. It ranged from 61% in 2008 to 59% in 2009, in 2010 it reached 66% and in 2011 it was about 69% within the cereals buckwheat and maize demands are all met through domestic production. In 2011, the self sufficiency ratio of paddy was about 53% (RGOB, 2014).

5.3.2 Malnutrition

Malnutrition is the most serious consequence of food insecurity. Adult malnutrition results in lower productivity on farms and in the labor market. In women, it also results in fetal malnutrition and low birth weights. Fetal and infant under-nutrition leads to lower cognitive development and schooling performance. For school-age children, nutritional deficiencies are responsible in part for poor school enrollment, early dropout, and poor classroom performance with consequent losses in productivity during adulthood (RGOB, 2012). The National Nutritional Survey of Bhutan conducted in 2009 confirmed improvement in nutritional indicators with the numbers of stunted and underweight children decreasing steadily since 1988: 37.5 percent of children under 5 were stunted, while only 12 percent were underweight in 2008, a pattern that is consistent with other mountainous countries. The survey reported that the proportion of the population below the minimum level of dietary energy consumption increased from 3.8 percent in 2003 to 5.9 percent in 2007 (RGOB, 2013).

Although the national average energy consumption exceeds 2500 Kcal/person/day, in the worst-off areas this figure does not reach 1900, or only 85-90% of the 2124 set as the minimum required. Average consumption of protein, vitamins, and minerals is even further below that is needed for good health. Nutritional status of the under fives have improved a lot with stunting rate of 56% in 1988 to 37% in 2008, as revealed in the National Nutrition and IYCF survey of 2008, with higher concentration in the east. Apart from insufficient dietary intake for a long period of time, inappropriate infant and young child feeding practices is one of the major contributing factors to stunting status of the children. Anemia is still a major public health problem with over 80% of 6-36 months children anemic, over 50% in women and adolescent girls, and over 28% in men, as apparent from the National Anemia Survey conducted in 2002 (RGOB, 2012).

Iodine Deficiency Disorder (IDD) has been a major public health problem in the early 60s with the prevalence of Total Goiter Rate (TGR) over 64%. Several Nationwide studies have been carried out and based on the studies lot of interventions has been taken up through multi-sectoral collaborations/approaches. These periodic studies, evaluation and interventions indicated that Bhutan has made a dramatic progress in the control of iodine deficiency disorders. It also demonstrates that the IDD control program has made a considerable impact, which led to the declaration of elimination of IDD as no more a public health problem (2003) with TGR at 5% and iodized salt coverage at 95%. The biggest challenge is the sustenance of the elimination status which calls for even more collaboration between stakeholders like MoAF, MoH, BAFRA, Customs, FCB, Bhutan Salt Enterprise (BSE). Therefore, awareness on the need to buy and consume iodized salt by general population is an all time requirement (RGOB, 2014).

Vitamin A is another important micronutrient that needs to be addressed, however in Bhutan Vitamin A deficiency (VAD) is not a public health problem with only sub-clinical prevalence rate at 2.6% as per National VAD study of 2000. Therefore, regular supplementation of vitamin A to the school children and under-fives are appropriate enough to meet the requirement. Infant and Young child feeding practices are not optimal among the mothers and caregivers which leads to malnutrition, and contributes to the growing Non Communicable Diseases in the later part of their life. There are a lot of cultural and traditional barriers which need to be addressed so as to promote optimal breastfeeding (RGOB, 2014).

5.3.3 Poverty

Food insecurity and poverty are predominantly a rural phenomenon with higher concentrations in the Eastern and Southern parts of Bhutan. The Poverty Assessment and Analysis Report, 2004 estimated 31.7%of the Bhutanese population to be under the national poverty line of Nu. 740.36 per person per month. In 2012, the population under poverty was reduced to 12% with a national poverty line of Nu. 1704.84 per person per month. However, about 3% of the population lives below the food poverty line of Nu. 1154.74 per person per month (RGOB, 2012). The Vulnerability Analysis and Mapping (VAM), 2005 attributes food insecurity as one of the causes for poverty in Bhutan and identifies lack of productive assets as causal agent of food insecurity. Therefore, it recommends creating access to agricultural land or productive assets as interventions for poverty reduction and addressing food insecurity (RGOB, 2014).

5.3.4 Remedial Measures

The Royal Government of Bhutan (RGOB) is affirmed its commitment to addressing food security, which is indicated by its adoption of the Food and Nutrition Security Policy, 2012 which provides broad policy measures to address the food and nutrition security situation in the country. Realizing that there is no single measure of food insecurity, the Government of Bhutan adopted a Food Security Strategy Paper with the objective of increasing food security and set the following targets to be achieved by 2015 (FAO, 2011):

- Reduce stunting among children under five years old to 28 percent
- Reduce the poverty rate to 20 percent, or less
- Reduce by half the proportion of people who consume less than 2 124 kilocal/day
- Reduce the prevalence of anaemia among children and women.

In 2014, the Bhutanese government adopted the *Food and Nutrition Security Policy of the Kingdom of Bhutan, 2014*, which will be guided by the following principles;

- Secure access to sufficient food, adequate nutrition and attaining an active and healthy life is a basic human right;
- Food and nutrition security programs must be sensitive to culture and traditional practices;
- Sustainable use of natural resources and entitlements is crucial for food and nutrition security;

- Ability to access safe and adequate food as well as its proper utilization by all members of a society is the basis for a healthy population and for Gross National Happiness;
- Food and nutrition security programs must be gender sensitive and socially inclusive of the interest of poor and vulnerable communities and individuals;
- Food and nutrition security has multi-sectoral and inter-generational ramifications; and
- Food and nutrition security initiatives have to be based on continuous research programs enabling strengthened linkage between food production and nutrition, efficient resources management and increased productivity.

5.4 Food Security in India

Food security has been a foremost developmental objective since India's achievement of self-sufficiency in food grain production in the 1970s. Notwithstanding the increased food grain production along with the high economic growth rates achieved by India in recent decades, food security situation in the country has deteriorated in almost all aspects—absorption, access and production—making India one of the world's most undernourished countries. A sizeable number of people in both rural and urban areas lack sufficient food, while women and children face micronutrient deficiencies.

Irrespective of some progress made by India in addressing the calorific deficiency, still much is to be achieved. In 2009-10 about one-seventh of the rural and one-sixth of the urban population had a caloric intake below 1,890, which is only 70 per cent of the global adult norm of 2,700 calories per day, he said. According to him though some progress has been made the caloric intake, the country is way down when it comes to protein and micro-nutrient intake and that is why malnutrition among children and women is still rampant (Bhattacharjee, 2015). Declining trends in agriculture production along with high rates of poverty and unemployment have proved instrumental in limiting food access. Undoubtedly, the Government of India has implemented a wide range of nutrition-based intervention programmes; India has been unable to provide sufficient food for all its population.

5.4.1 Food Production

Recent decades demonstrate mixed trends discernible with regard to food production in India. The country managed to attain self-sufficiency in food grain production by the 1970s and has not imported since the 1980s. Food grain production increased from 176 million tonne in 1991 to 245 million tonne in 2011, as shown in Table 5.4. Even though there has been a general increase in cultivated area and yield, per capita production was unstable. Between 1991 and

2001, per capita production of food grains decreased from 198 kilogrammes (kg) to 192 kg, but by 2011 it had risen to 205 kg. The 1990s saw food availability decline in India, as in addition to the fall in per capita production, the growth rate of production and yield also dropped substantially from the preceding decade.

Table 5.4 Area, production and yield of food grains, 1991-2011

Year	Area (million hectares)	Production (million tonnes)	Yield (kg/hectares)	Per capita production (kg)
1991	128	176	1,380	198
2001	121	197	1,626	192
2011	127	245	1,930	205

Source: GOI 2014b.

Over the past two decades, food availability per capita for essential food items like pulses and cereals, including rice and wheat, has been worsening, as shown in Table 5.5. However, slight improvement in items like sugar, milk and eggs does not compensate for the decline in essential food items. Poor performance of agriculture over the years has culminated in decreasing share of agriculture in GDP from 35.7 per cent in 1981 to 14.6 per cent in 2011 (GOI 2014b). Besides, decline in agricultural growth by more than population has been instrumental in lowering food availability. Since the mid-1990s, India has, on average, been exporting 5.3 million tonne of cereals annually and this has also led to exacerbation of the problem (ibid).

Table 5.5 Trends in average annual food availability per capita in India, 1990-2010

Item	1990-2000	2000-2010
Cereals (kgs)	439.7	409.4
Pulses (kgs)	35.8	34.4
Sugar (kgs)	15.1	16.2
Milk (litres)	72.7	92.0
Eggs (dozens)	2.5	3.7

Source: GOI 2014b.

5.4.2 Malnutrition

There is growing serious concern about malnourishment amongst children and women in India. National Family Health Survey conducted by the Government of India from time to time reveals that on an average about 48 per cent of the children are stunted, 43 per cent are underweight and 20 per cent are wasted. Besides, India's ranking has been worst amongst 41 countries participating in a *Demographic and Health Survey* during 2003 and 2007 in terms of underweight children. India's performance has been bad in comparison to countries in Sub-Saharan Africa, which are generally poorer and have slower economic growth rates—the number of children who are underweight is almost twice the Sub-Saharan average of 25 per cent (Arnold et al., 2009).

Some progress, though gradual, has been noticed in India with regard to tackling the problem of malnourishment amongst children. The proportion of underweight children in India, which stood at 77 per cent in 1975-79, declined to 43 per cent in 2006; however, the subsequent years saw slowing down in this rate of decline. Specifically, there was a 24 percentage point decrease between 1975-79 and 1993, but over the next decade it hardly declined by 10 percentage points. Similar is the trend in child stunting. Wasting among children likewise increased from 18 per cent in 1975-79 to 20 per cent in 2006 and malnutrition explains 54 per cent of under-five child mortality in India (*ibid*).

According to Deaton and Dreze (2008), one-third of women aged 15-49 years are undernourished, having a Body Mass Index (BMI) less than the acceptable standard of 18.5, the highest number amongst countries in South Asia and Sub-Saharan Africa. This number was, however, much higher during 1975-79, at 52 per cent. Maternal malnutrition is more prevalent in central and eastern states of India, with two undernourished women for every five in the states of Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh and Odisha. In contrast, this number falls to less than one in five women for Delhi, Kerala and Punjab (Arnold *et al.* 2009). Undernourishment is more prevalent among women belonging to disadvantaged social and economic groups, especially in women belonging to the Scheduled Tribes and Scheduled Castes.

5.4.3 Poverty and Inequality

Access to food is undermined by poverty and inequality, which are in turn impacted by employment, income and inflation. Augmentation in the rates of unemployment and inflation in recent decades in India has made access to food somewhat difficult. Unquestionably, there has been decline in poverty rates; nonetheless, poverty levels are still very high and the situation is exacerbated by increasing inequality. In India, more than one-fifth of its total population live below the poverty line, which makes the incidence of poverty high, despite the fact that poverty rates have been declining since the 1970s (GOI 2014i). The incidence of poverty, which stood at 45.3 per cent in 1994 declined to 37.2 per cent in 2005 and further to 21.9 per cent in 2012. In absolute terms, the total number of poor decreased from 404 million in 1994 to 270 million in 2012 (GOI 2014b).

There exist significant variations in poverty rates between rural and urban areas, amongst states and across various social groups. Poverty rates are higher in rural areas, with around one in four people living in poverty in villages as compared to 13.7 per cent in cities. But poverty has declined over time in both rural and urban areas (GOI 2014i). However, the gains accruing from some progress in reducing poverty have been undermined by increasing income inequality in India, especially in rural areas. In rural areas, the Gini coefficient increased (inequality rose) from 0.325 in 1983 to 0.380 in 2005. In urban areas, inequality increased less, with the Gini coefficient rising from 0.330 to 0.373 between 1983 and 2005 (GOI 2007b). This has made access to food difficult for the poor, as reflected by the insignificant share of the poorest 20 per cent in monthly per capita food consumption (GOI 2013d). Inflation in food prices in India also adversely impacts access to food and entails the potential of increasing overall food insecurity.

5.4.4 Remedial Measures

India's pursuit of a poverty reduction strategy is designed to ensure food security by uplifting the majority of the population from the levels of deprivation, hunger and malnutrition. Realizing that focusing on economic growth alone was insufficient to be able to achieve the objectives of poverty alleviation and food security, Government of India incorporated poverty reduction strategies aiming at addressing food insecurity in the Five Year plans from the fifth Five Year Plan onwards. Simultaneous efforts were also undertaken to reform the food security policies, which underwent in three phases. In the first phase, focus was on increasing area under cultivation to produce more food and in the second phase, spanning the mid-1960s to the 1990s, India attained self-sufficiency in food by increasing agricultural productivity. Irrespective of the fact that India had surplus food during the second phase, starvation existed, suggesting failures in ensuring adequate access to food. Hence, at the outset of the 1990s, the third phase promoted subsidies and incentives to increase food access.

With the shift of emphasis of the focus of food security programmes in India from food production to food access and nutrition, new and more holistic initiatives like the Integrated Child Development Scheme (ICDS), the Mid-day Meals Scheme and the Public Distribution System (PDS) have been introduced to not only improve nutrition, but also education and health outcomes. These programmes are in addition to employment, livelihood and social security programmes that also indirectly improve food security outcomes. The National

Food Security Bill 2013, which is still to be passed by the Indian Parliament, promises food and nutritional security through the provision of adequate and affordable quality food. It aims at consolidating various food-related programmes and entitlements in India, including the TPDS, Mid-day Meals Scheme and ICDS. However it is still in the early phase of implementation. The passage and then the implementation of the proposed Bill is expected to “address many areas including strengthening the public distribution system (PDS), which is an important component for food security” (Bhattacharjee, 2015).

5.5 Food Security in Maldives

The Maldives is extremely dependent on food imports. It is self-sufficient in fish production but rice, wheat flour, fruits, vegetables and other food items are imported. It is estimated that the Maldives produces less than a tenth of its food requirements (MEE, 2012). Most of the food products including all staples (rice, flour and sugar) are imported. Food production in the country is limited to horticultural crops and fishing. Both sectors are highly dependent on specific climatic factors, which are rapidly changing.

5.5.1 Food Production

The food insecurity problem in Maldives entails unique features. The key distinguishing feature is that Maldives is dependent on imports of most of its food requirements, including the staple food rice and that income generated by two main activities, fisheries and tourism are being utilized for meeting food import requirements. Maldives’ agriculture is generally characterized by its subsistence nature. The total area suitable for cultivation is estimated at less than 30 sq. km. Given the limited capacity for agriculture production, 90 per cent of country’s food demand is fulfilled by imports making the country vulnerable towards food security (MPND, 2006).

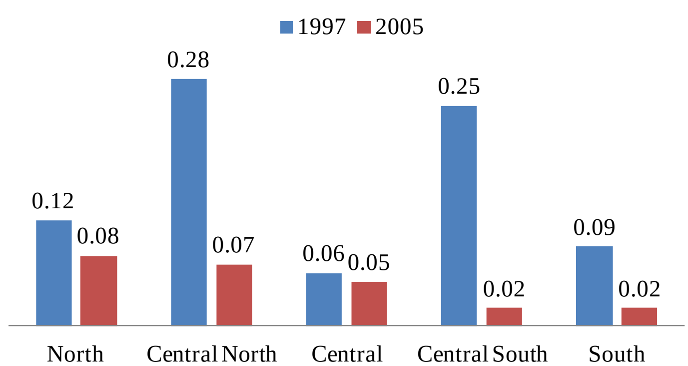
To cater for the demands of the growing population and the expatriate communities, coupled with the large number of tourists visiting the country, the Maldives needs to import large quantities of food every year. In 2012, food items accounted for about 21 percent of the total imports and the food bill reached US$ 318.9 million, demonstrating huge implications for both food security as well as inflation (MED, 2013). Food price spikes and volatility are a growing concern. There has been a consistent rise in food prices over the years. It has a direct impact on food security, economic growth and poverty reduction. Price volatility has a strong influence on food security since it affects household incomes and purchasing power. It limits the ability of people to eat well and enough, and increases the risk of vulnerable people becoming poor and food insecure (UNDP, 2014).

5.5.2 Malnutrition

Malnutrition and is prevalent more in the islands than in the capital, Malé. There is an emerging trend of more boys being stunted than girls ((MOH, 2012). According to a World Bank (2012) report, 32% of children under the age of five are stunted, 26% of children under the age of five are underweight, and 13% are wasted. Besides, 44% of those aged 15 and above are overweight or obese and 22% of infants are born with a low birth weight. Roughly 10% of preschool aged children and 20% of pregnant women are deficient in vitamin A. It is further reported that rates of anemia among preschool aged children and pregnant women are 82% and 55%, respectively. Iron-folic acid supplementation of pregnant women, de-worming, provision of multiple micronutrient supplements to infants and young children, and fortification of staple foods are effective strategies to improve the iron status of these vulnerable subgroups (World Bank, 2012). It is therefore critical that policies be oriented to close the gaps in nutrition among girls and boys, as well as between the capital, Malé and the islands.

5.5.3 Poverty and Inequality

Poverty in the Maldives is primarily related to physical vulnerabilities. The Vulnerability and Poverty Assessments (VPA) of 2004 showed that poverty has declined rapidly since 1997 and indicated that absolute poverty had effectively been eliminated, using a poverty line of US$ 1 per day at Purchasing Power Parity (PPP), or MVR 4.34. However, if the poverty line is set at MVR 15 per day (approximately US$3 per day in PPP terms), which was broadly considered as the national poverty line, 19 percent of population lived in poverty.5 Within the Maldives, substantial poverty reduction took place between 1997 and 2004, and the incidence of poverty at MVR 7.5 per day dropped from 26 percent to 7 percent in the Central North Region and from 25 percent to 2 percent, in the Central South region, as shown in Fig. 5.3.



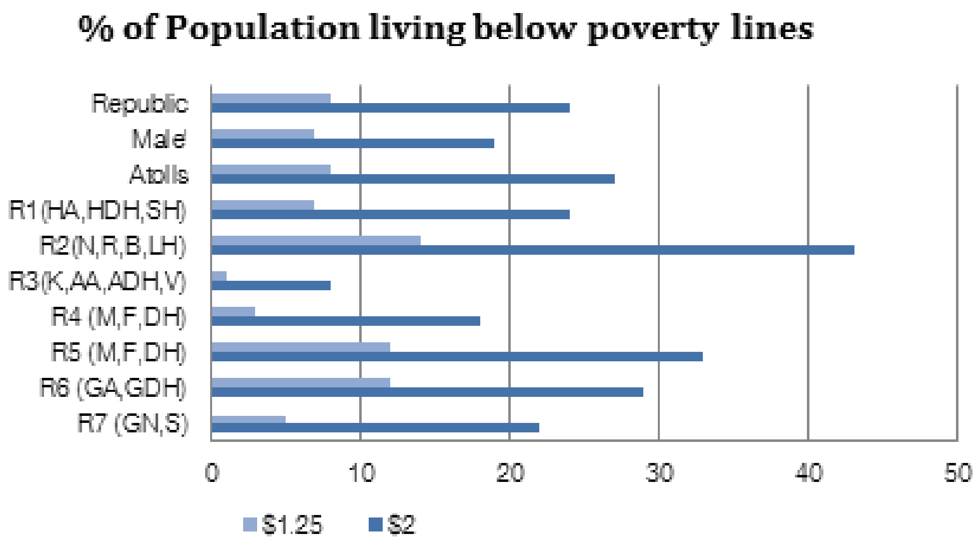
Source: MPND, 2004

Figure 5.3: Significant Decline in Poverty, 1997 to 2004

It becomes evident from the Household Income and Expenditure Survey (HIES) 2009/2010 that using the MDG poverty line of US$ 1.25, the incidence of poverty dropped from 9 percent to 8 percent between 2003 and 2010. For the atolls (excluding Malé), poverty incidence dropped from 12 percent to 8 percent. This is mainly due to the increase in access to social services and spread of economic activity across the country such as tourism. Interestingly, poverty incidence increased in the capital Malé, from 2 percent in 2003 to 7 percent in 2010. Poverty in the Maldives has been characterized by transient poverty, people moving in and out of poverty. Panel data from VPA I (1998) and VPA II (2004) show that during the six-year period, three out of five of the poor households in 1997 managed to escape from income poverty. At the same time, one in five of the non-poor households fell into poverty. Taking two poverty lines at MVR 15 per day and MVR 10 per day, the majority of those who were income poor in 1997 had escaped from poverty for both poverty lines. For instance, for poverty line MVR 15 out of the 49 percent poor in 1997, 33 percent escaped poverty in 2004. Similarly, for the poverty line MVR 10 out of the 26 percent poor in 1997, 22 percent had escaped poverty in 2004. Large movements between income groups indicate that the income poverty situation is quite dynamic (UNDP, 2014).

There are continuing income disparities in Maldives. The VPAs of 1998 and 2004 show a significant degree of spatial variation in poverty. Head count ratios calculated on a continuum of MVR 7.5 to MVR 15 per person per day poverty lines, indicate that among all the regions, poverty is highest in Central North (Noonu atoll, Raa atoll, Baa atoll and Lhaviyani atoll), followed by Central South (Meemu atoll, Faafu atoll, Dhaalu atoll, Thaa atoll and Laamu atoll). These are atolls with limited infrastructure, accessibility and service delivery.

Regional disparities in income have been confirmed by more recent surveys, for instance HIES 2009/2010 data. Income poverty at the International Poverty Line of US$2 per person per day and the Millennium Development Goal poverty line of US$1.25 per person per day shows that poverty continues to be highest in the Central North Region of Maldives. (Noonu, Raa, Baa and Lhaviyani atolls) as defined in the VPA, Region 5 (Thaa and Laamu atolls) which is part of the Central South region as defined in VPA and Region 6 (Gaafu Alifu and Gaafu Dhaalu atoll) which is defined as South region in VPA [Figure 22]. These regions were most severely affected by the December 2004 tsunami. Central North Region and Region 5 (Thaa and Laamu atolls) lack access to quality social services and transport infrastructure. Tourism in Region 5 has only recently developed. The emergence of poverty in Region 6 (Gaafu Alifu atoll and Gaafu Dhaalu atoll) may be explained by the decline in fishing, the main source of livelihood, especially in GaafuAlifu atoll. Similar to the VPA data, HIES data shows that poverty remains lowest in the Central region, Region 3, where the Capital Malé is located and tourism continues to be dominant. There appears to be more spatial variation of poverty in 2010 compared to the VPA 2004 data (Fig. 5.4).



Source: DNP, 2012.

Figure 5.4: Percentage of Poor Across Regions

5.5.4 Remedial Measures

Food security is one of the country's biggest concerns for Maldives when addressing hunger because of availability, affordability and accessibility to food. There is very low production of food, and therefore, the country must import most of its food, which increases price, making it harder to get sufficient amounts of food. Since accessibility and affordability are major factors in the availability of food, the government is trying to find strategies to combat these things and some of the strategies include stimulating the local food production and markets, tackling micronutrient deficiencies, and also starting to develop capacities of trained personnel. By stimulating local food production and markets, the Maldives can have its local and national markets see improvement. Micronutrient deficiencies are tackled by promoting nutrition awareness through nationwide nutrition campaigns, specifically targeting vulnerable groups.

5.6 Food Security in Nepal

Nepal is a food insecure country where, according to UNOCHA estimates, around 6.9 million people are suffering from insufficient access to food (UNOCHA 2008) and as per the World Food Programme (WFP) estimates there are approximately 3.5 million people in Nepal (especially in rural areas) who suffer from severe food insecurity, out of which 410,000 live in the mid- and far-western hill and mountain regions of the country (WFP 2013). The country often faces issues with all aspects of food security—production, access and utilisation. Nepal's food insecurity has earned it lower ranking globally. According to the Global Food Insecurity Index 2012 Nepal is 79th out of 105 countries. Among South Asian countries, Nepal is second last in terms of food security. This situation is compounded by global price hikes in terms of food accessibility and food distribution around the globe (AfDB 2012).

During the first half of 2013, Nepal imported agricultural products worth Rs 59.07 billion, up from Rs 49 billion in 2012, while the exporting only Rs 13.26 billion (MoCS 2014). Some people argue that due rising population and dwindling production, exports will continue to drop, making Nepal even more reliant on imports, especially cereal grains, from abroad (Parajuli 2006). This type of uneven exchange makes Nepal vulnerable to food insecurity. Limited food production, low agricultural productivity, inflation, unemployment, poverty and deep-rooted social divisions are the main factors behind food insecurity in Nepal (GON *et al.* 2009).

5.6.1 Food Production

Wide variations in food production and food security pervade across Nepal depending on terrain and proximity to urban areas. About one-third of the nation's crop production comes from central region, by the eastern and western regions in Nepal. Not surprisingly, then, the western region suffers the most intense forms of food insecurity (CBS, WFP and WB, 2006; Regmi, 2007). Of the total land coverage in Nepal, only 16 per cent is agricultural (NPC 2010). Eight per cent of population lives in the mountainous region where they can produce only 3/4ths of what is required for daily consumption (ICIMOD 2011). It is estimated that households pursuing farming activities in the mountains would require 0.64 hectare of land to feed a family of 6 members, while the figure for this in the hills and Terai is 0.52 hectares and 0.42 hectares respectively (NPC 2010). As the average landholding in these rural areas is below 0.5 hectares, the people in these areas are faced with multiple problems in regard to food. Additionally, the lack of infrastructure in the rural areas—roads, marketplaces—makes obtaining supplementary food and agricultural products difficult (Seddon and Adhikari 2003).

Recent decades have witnessed improvement in food availability in Nepal. Besides, an increase in per capita food availability at an annual rate of 1.2 per cent has also been recorded; per capita food availability that was 1,761 kcal/day in 1980 increased to 2,542 kcal/day in 2010. Similarly, there has been an increase in per capita protein supply from 47.3 grams/day to 64.3 grams/day. Notwithstanding these positive trends in per capita food availability, there is a growing concern in Nepal about food availability because the country has often experienced a food deficit. Cereal production, with a demand of 69 per cent in Nepal's food basket, has persistently been in deficit (FAO 2010b). The annual growth rate of cereal production between 1991 and 2006 was 1.9 per cent per year, below the cereal requirement growth rate of 2.3 per cent.

There is also a regional dimension to food availability in Nepal as the Mountain and Hill regions are often food deficient compared to food abundant Terai. The average annual per capita food deficit in the Mountain and Hill regions is 37 kg and 23 kg respectively, while the Terai region has a surplus of 24 kg (FAO 2010a). Overall, Nepal has been unable to attain self-sufficiency, and is often reliant on food imports. Declining trends in agricultural production and productivity coupled with other factors like poor land management, natural calamities and high food losses etc have been identified as major determinants of poor food availability in Nepal. The share of agriculture in GDP declined from 60 per cent in 1980 to 39 per cent in 2004-2005 (MoAC, WFP and FAO 2009; Sanjel 2005) and to 35 per cent by 2010, indicating a shift from agriculture to other sectors. Such shifts have occurred largely due to migration and livelihood diversification, which has resulted in a decrease in productivity and barren lands.

Nonetheless, the agricultural sector employs around three-fourths of the total labour force, indicating the low productivity of labour in the agricultural sector. Other factors contributing to low productivity and limited food availability include small land holdings, reliance on traditional and subsistence farming and limited use of improved crop varieties. Food availability is further exacerbated by climate change and rising susceptibility to seasonal flooding, flash floods, erosion and droughts. Poor road infrastructure and high cost of transportation also hamper food availability in many districts of Nepal. Besides, youth migration from rural households has also led to intensification of the severity of food insecurity in Nepal culminating in womenfolk shouldering additional responsibilities of farming along with other household responsibilities; as a result, agricultural productivity suffers. According to one report, women can occasionally take up additional income-generating work either through agriculture, or by working as laborers or porters (OXFAM 2009). Thapa (2011) has argued that agricultural productivity lingers below 1 US$ per labourer per day, which does not provide sufficient food for families nor sufficient food to markets for sale.

5.6.2 Malnutrition

Nepal's performance in terms of nutritional status amongst children has been poor. The CBS (2010) provides evidence that the average dietary intake in kilocalories (kcals) in Nepal is 2,536 per capita per day, which is higher than the minimum average requirement; however, there is significant variation within the country, and people in the rural areas have lower calorie intake than those in the urban areas. Under-five stunting is at 41 per cent of children, 29 per cent are underweight and 11 per cent are wasted (table 4.20). These indicators, with the exception of wasting, have however improved over time. The rate of stunting declined from 57 per cent in 2001 to 41 per cent in 2011, and the proportion of children underweight also declined from 43 per cent to 29 per cent. NPC (2013) reveals that nearly half of the children in Nepal under-five years suffer from under nutrition. Also 25 per cent of households do not have sufficient food to cover their dietary needs. People in rural areas have less access to food or have lower food consumption than people in urban areas and stunting is higher in the mountains and the hills (NPC 2013).

Malnutrition amongst women and micronutrient deficiency among children is still a matter of concern in Nepal. Female malnutrition has often resulted in high rates of maternal and infant mortality. Around two-fifths of the women in the reproductive age group are undernourished (GON *et al*. 2012). However there has been some improvement in maternal malnutrition, declining from 28 per cent in 1996 to 18 per cent by 2011 (Macro International Inc. 2007). Micronutrient deficiency amongst women—especially pregnant and lactating mothers—is a serious health concern. According to the *Demographic and Health Survey 2011*, around 35 per cent of women aged 15-49 years were anaemic (*ibid*). Undoubtedly, Nepal has made some progress in addressing micronutrient deficiency amongst children; nonetheless, iron and vitamin A deficiency are still major causes of child malnutrition. Anaemia fell to 46 per cent as compared to 48 per cent in 2006 and similarly 53 per cent of children consume food deficient in Vitamin A (ibid). Iodine deficiency, however, has reduced significantly owing to increased consumption of iodized salt.

5.6.3 Malnutrition

Poverty, inequality, and inflation are regarded amongst the major factors contributing to food insecurity in Nepal. Irrespective of the fact that there has been increase in per capita income in Nepal and some progress has also been made towards poverty reduction, expanding access to food still remains a major challenge. Poverty rate which stood at 41.8 per cent in 1996 had declined to 25.4 per cent in 2009 (table 5.6). However, there has been corresponding increase in inequality along with increase in per capita income thereby indicating rise in inequality. The income of the richest 10 per cent of population outpaced the growth in income of the poorest 10 per cent. Inequality, as measured by the Gini coefficient, worsened in Nepal, from 0.34 in 1996 to 0.46 in 2009 (table 5.6). Increasing inequality has direct repercussions on food security, as food poverty is higher amongst the poorest segment of society (GON 2010).

Table 5.6 Trends in poverty and inequality in Nepal, 1996-2009

Category	1996	2004	2009
Poverty rate, national poverty line (%)	41.8	30.9	25.4
Poverty headcount ratio at US$1.25 a day (PPP*) (% of population)	68.0	53.1	23.7
Poverty headcount ratio at US$2 a day (PPP) (% of population)	89.0	77.3	56.0
Gini coefficient	0.34	0.41	046

Note: *: PPP means purchasing power parity.

Sources: GON 2010, UN 2010 and World Bank 2015.

Notwithstanding the decline in Nepal's poverty rate over the past two decades, every fourth person in Nepal is still categorized as poor, and poverty rates are high for rural areas and amongst marginalised groups. This large concentration of population living around the poverty line entails serious consequences for food security, as a decline in income or a rise in food prices will result in a large proportion of people consuming less than their caloric requirement. The surge in food prices entails serious implications for food security and poverty reduction in Nepal. Inflation which was at low levels prior to the 1980s, started steadily increasing over the subsequent period and in the aftermath of the global financial and food crises in 2008, inflation rates have recorded substantial increase. Prices of essential food commodities like rice and wheat increased by around 50 per cent, while that of lentils and fish doubled between 2004 and 2010 (GON 2013). According to the *National Living Standard Survey 2010-11*, around 82 per cent of households are vulnerable to inflation-related food insecurity as their food consumption is just adequate to meet their dietary requirements (GON 2011).

5.6.4 Remedial Measures

Undoubtedly, the Interim Constitution of Nepal recognizes food security as a fundamental human right and the state is legally responsible for food security of all its citizens along with different state policy documents addressing various aspects of food security; nonetheless, there is no comprehensive food security policy in Nepal. Different aspects of food security have been articulated in Nepal's Five-year plans and other documents, with specific emphasis on accelerating the pace of agricultural sector growth and productivity through improved agricultural research and extension support, to reduce poverty by increasing employment and income-generating opportunities in agriculture, to minimize the adverse effects of climate change and to develop human resources for the management of the agricultural development process.

The Government of Nepal has also undertaken policy measures to address nutritional aspects of food security. Overall, while there has been an increased commitment to address the multi-dimensional nature of food insecurity by addressing issues of access and availability in addition to enhancing food production, there is no coherent single policy document to deal with the various aspects of food insecurity. The Nepalese Government taken various steps to enhance social protection in order to improve food security and these programmes, *inter alia*, include: Food for work, Public Food Distribution (PFD), Food for Education; and Mother and Child Healthcare.

5.7 Food Security in Pakistan

Food security in Pakistan has been under constant threat during the last few years, a period coinciding with a global food crisis that peaked in 2008. That year, when world food prices reached their highest levels since the 1970s, Pakistan's food inflation registered as high as 34 percent (WFP, 2009). The WFP data from 2008 concluded that 77 million Pakistanis—nearly half the country's total population—were going hungry, a 28 percent increase from the 60 million in March 2007. About ninety-five of Pakistan's 121 districts were faced with hunger and malnutrition-related diseases. Undoubtedly, Pakistan managed to register growth in its GDP and agriculture production between 1980 and 2010; with country producing enough food to meet the minimum nutritional requirements of every citizen; nevertheless, the prevalence of hunger and malnutrition has widespread, especially among children. Growth policies along with subsidies didn't benefit the poor and marginalized owing to leakages, corruption and inefficiency. However, in the wake of adoption of the National Nutrition and Food Security Policy 2013 and Vision 2025, the Government of Pakistan has also started to focus on poverty, hunger and malnutrition in a more holistic way.

5.7.1 Food Production

For the past three decades spanning from 1980 to 2010, the agricultural sector of Pakistan grew at 5.1 per cent per annum, while the population increased by 2.6 per cent. Food availability remained satisfactory during this period and there was positive growth in all food items, including cereals, milk, meat and eggs (Table 5.7). A higher growth rate in dairy product showed an increased share in the available food basket. Overall, the average daily caloric availability increased from 2,301 kcal/person to 2,415 kcal/person between 1980 and 2010. This is higher than the average daily per capita requirement of 2,350 kcal, indicating sufficient availability of food.

Table 5.7 Food availability per capita in Pakistan, 1980-2010

Category	1980	2010	Annual growth rate (%)
Cereals (kg)	147.1	158.8	0.3
Pulses (kg)	6.3	6.8	0.3
Milk (litre)	94.8	117.2	0.7
Meat (kg)	13.7	20.5	1.4
Eggs (dozen)	1.2	5.8	5.4
Edible oil (litre)	6.3	12.6	2.3
Calories (kcal/person/day)	2,301	2,415	0.2
Protein (grams/person/day)	61.5	71.5	0.5

Source: MHHDC, 2015.

Pakistan enjoyed another good wheat harvest in 2014, putting the country in a fairly comfortable situation in terms of national availability of its main staple. The *Rabi* crop for 2013-2014 was completed in May 2014, and the production of wheat in 2013-14 stood at 25.3 million metric tons (MT) (Table 5.8). This shows an increase of about 5 percent compared to 24 million MT produced in 2013. The increase could be mainly attributed to an increase in the area harvested and timely rainfall at regular intervals suitable for health grain. Undoubtedly, over all these years, food production has increased at a reasonable rate in Pakistan. The country has enough food to ensure food security of all of its citizens. However, despite sufficient availability of food, purchasing power is low and food access is far from universal.

Table 5.8: Estimated wheat production per capita (2014) by provinces

	Crop Estimates (MT)		Population (Million)		Per Capita Production (KGs)	
Provinces	**2012-13**	**2013-14**	**2013**	**2014**	**2013**	**2014**
Punjab	18.13	18.90	100.17	103.6	181	182.44
Sindh	3.81	4.00	44.08	45.47	86	87.98
Khyber Pakhtunkhwa	1.63	1.25	24.79	25.27	66	49.52
Balochistan	0.729	0.87	9.5	9.69	77	90.71
Pakistan (Total)	24.3	25.02	178.54	184.03	131	136

Source: World Food Programme, 2014

5.7.2 Malnutrition

Malnutrition is a serious problem in Pakistan. Broadly speaking, the number of malnourished people in Pakistan soared from 24 million in the early 1990s to 45 million in 2008. According to the results of a 2009 survey conducted among smallholders and the landless across Pakistan to ascertain whether internationally recommended nutritional needs were being met, it was revealed that while protein intake was found to exceed international standards, considerable shortages were found in micronutrient consumption. In desert areas, calcium consumption was determined to be 48 percent below international standards, while Vitamin A consumption across Pakistan's rural areas was a whopping 85 percent short of global norms—a reality attributable to the high cost of Vitamin A-rich foods (Kugelman, 2010). Other experts in Pakistan report high levels of Vitamin D deficiency as well, owing to the relatively small number of food items (fish, egg yolk, and cod liver) rich in this mineral (Zubairi, 2009).

UNICEF has estimated that poor nutrition contributes to about half of the child deaths in Pakistan. Child nutrition insecurity is in fact a major concern throughout South Asia; Hazarika points out that 41 percent of the region's children (ages zero to five) are malnourished—the highest rate in the world. In sub-Saharan Africa—a region no more economically developed than South Asia—this figure is only 27 percent (Kugelman, 2010).

Recent decades have made a mixed trend discernible with regard to protein energy malnutrition among children in Pakistan. The stunting rate among children under-five increased from 36 per cent in 1990-94 to 44 per cent in 2011, and wasting also increased from 11 per cent to 15 per cent during the same period as shown in table 5.9. In 1977, every second child was underweight as compared to every third child by 2002. This is still alarmingly high and has remained stagnant since then. Rural areas have a higher Prevalence of child malnutrition is higher in rural areas as compared to urban areas. Micronutrient deficiency of vitamin A, iron and zinc is also very high in the country. The prevalence of anaemia among children under-five decreased from 65 per cent in 1987 to 51 per cent in 2001 but increased to 62 per cent in 2011 (GOP 1988 and 2012d). In 2011, 18 per cent of women (aged 15-49 years) suffered from chronic energy deficiency (with a BMI less than 18.5) compared to 34 per cent in 1987—a sizeable improvement (*ibid*). The ratio was higher in rural areas (20 per cent) compared to urban areas (14 per cent). Micronutrient deficiencies are also widespread: one in two women (aged 15-49 years) in Pakistan continues to suffer from anaemia during pregnancy, and there has been no improvement between 1990 and 2011 (FAO 2015b).

Table 5.9 Malnutrition trends among children under-five in Pakistan, 1977-2011 *(%)*

Year	Stunting	Wasting	Underweight
1987	42	11	48
1990-94	36	2	40
2002	42	14	32
2011	44	15	32

Source: GOP 2012d.

5.7.3 Poverty and Inequality

Recent years have witnessed rising trends in the percentage of people afflicted with food insecurity in Pakistan and it can be discerned from the fact that in 2003 the number of food insecure people accounted for 38 per cent and this percentage increased to 49 per cent in 2009 and by 2011 it stood at 58 per cent (GOP, 2012d). Poor access to food is regarded as the main cause of food insecurity and this poor access to food is attributable to job insecurity, insufficient employment creation, increasing inflation, poverty and inequality. Persistent hike in food prices over the years is said to have led to the erosion of people's purchasing power. The growth in real per capita income didn't commensurate with food inflation thereby widening the inequality gap.

The declining trends in the incidence of poverty which were discernible in the 1980s got reversed in the 1990s, indicating the absence of pro-poor growth. In the first half of the 2000s, poverty first declined, then increasing in the second half on account of high food and non-food inflation, low economic growth and floods in 2010. This led to a rise in the number of poor in all parts of Pakistan. However, there are some disputes regarding recent poverty figures for Pakistan, as lower poverty figures appear in various published documents. Inability of economic growth to improve the distribution of income was followed by decrease in income inequality, as measured by the Gini coefficient, in the 1980s, both in rural and urban areas. Anwar (2005) has pointed out a fall in income inequality from 0.39 to 0.35 between 1977 and 1988, driven largely by more rural equality (that fell from 0.35 to 0.30), and a slight improvement in cities—from 0.41 to 0.40. However, this trend got reversed subsequently, as pointed out by Jamal (2009), because income inequality increased from 0.35 to 0.41 between 1988 and 2005. The situation worsened in the 2000s, by which time the ratio of consumption of the richest 20 per cent to the poorest 20 per cent of the population increased from 3.76 per cent (in 2002) to 4.25 (in 2011) (GOP 2011d and 2012c).

5.7.4 Remedial Measures

Pakistan has adopted policies and programmes from time to time that usually focus on the reduction of poverty, hunger and malnutrition. The emphasis of the Five-Year plans has been on agricultural and rural development, education and health sector with a view to give the poor access to land, create jobs and develop infrastructure such as farm-to-market roads, water supply and sanitation schemes, as well as schools. Pakistan chalked out its poverty reduction strategies in light of the interim-PRSP in 2001, PRSP-I for 2004-06, and PRSP-II for the period of 2008-10 and beyond, with the avowed objective of achieving economic growth and macroeconomic stability, improve governance, invest in pro-poor sectors, and transfer growth benefits to the vulnerable.

Pakistan formulated the Vision 2025 in 2014, with the objective of achieving sustained and inclusive growth based on seven pillars: human and social capital; inclusive and sustainable growth; institutional reforms and democratic governance; energy, water and food security; private sector-led growth and entrepreneurship; knowledge economy; along with modernization of infrastructure and regional connectivity. It also addresses the issues of availability, access and utilization of food and intends to reduce malnutrition from 60 to 30 per cent. Thus far, however, the government's financial allocations do not signal its commitment to social sector and human development (MHHDC, 2015).

Pakistan finalized its draft policy on National Food and Nutrition Security in 2014. The Government of Pakistan is providing social protection to the poor through indirect and direct measures. Indirect assistance is through subsidies on wheat flour, electricity, gas and oil, and other food items, where as direct support includes programmes such as zakat, Pakistan Baitul-Mal and the BISP. Undoubtedly, these programmes nurse ambitious goals; nonetheless, these are afflicted with maladies like lack of inclusiveness, efficiency, fairness and occasional paucity of funds.

5.8 Food Security in Sri Lanka

Recent years have witnessed considerable improvement in the food security situation in Sri Lanka. International Food Policy Research Institute (IFPRI) report on Global Hunger Index (GHI) 2014 ranks Sri Lanka at the 39th position among 76 countries, ranking above all the other South Asian countries. Comparing the 1990 GHI and the 2014 GHI, shows a noteworthy absolute progress in Sri Lanka's GHI with 42 percent decrease in its index score. Most importantly, Sri Lanka has been recovering from a three decade long conflict, which ended in 2009. While no longer in the "alarming" category, according to the GHI, Sri Lanka's hunger status is still classified as "serious" (Thibbotuwawa, 2015). The country is self-sufficient in rice production, its staple food. The prevalence of malnutrition, hunger and poverty has reduced significantly over the last three decades. However, malnutrition, particularly protein energy malnutrition and anaemia, is common and significant disparities exist between the rural, urban and estate regions.

5.8.1 Food Production

The ongoing improvement in the food situation in the last few years demonstrates that Sri Lanka is food secure at the national level. Domestic agriculture still provides about 75 percent of Sri Lanka's food requirement in value terms while only one fourth was imported in 2013. Even at individual commodity level, local production of all major food items -- except for wheat flour, sugar, pulses, and milk which are imported in bulk quantities -- exceeds 75 percent of the total availability (*ibid*.).

Undeniably, food imports have been increasing in absolute terms; nonetheless, their share in total imports and total exports has been slightly declining or constant in recent years. As a whole, national level food availability has been on the rise due to increased domestic food production and importation without putting much pressure on the balance of payments. While the share of agricultural exports in total exports was 25 percent, the food imports as a percentage of total exports remained at 14.7 percent in 2014, which means the total value of food imports is sufficiently covered by the value of agricultural exports. The availability of adequate food at national level doesn't necessarily ensure food security at the household level. Hence, it is important to look at, if the national food availability has sufficiently ensured access to food at the household level. The level of income and income distribution mainly determine the access to food at the household level (*ibid*.).

In recent years, Sri Lanka has managed to achieve self-sufficiency in the production of paddy and this evident from the fact that in 2010, domestic rice availability (in terms of rice equivalent of paddy) was 2.7 million metric tonne against the requirement of 2.4 million metric tonne, which implied a self-sufficiency ratio of 114 (Jayasuriya 2012). The production of paddy doubled between 1980 and 2010, increasing at an annual rate of 2.4 per cent (GOS and CIC Agri Businesses Lmd. 2012 and GOS 2014c). This was attributed to a one-fourth increase in land area for paddy cultivation. This period also witnessed an increase in average yield per hectare by half due to a significant investment in research and development. Although rice is the staple food, wheat flour is also used as a substitute in the country. However, it is not produced locally and completely imported.

During 2009 the paddy production was higher than the previous average annual production as shown in Fig. 5.5 and forecast for higher paddy production was made for 2010. Second season paddy rice (Yala) harvest was forecasted at a bumper level of 1.6 million tonnes, 27% over the previous year. The first season (Maha) paddy was estimated at a record level of 2.65 million tonnes, 12% above last year's reduced harvest. With this level of production very little if any, import of rice was expected. Wheat requirements were estimated at some 1 million tonnes (FAO, 2010).

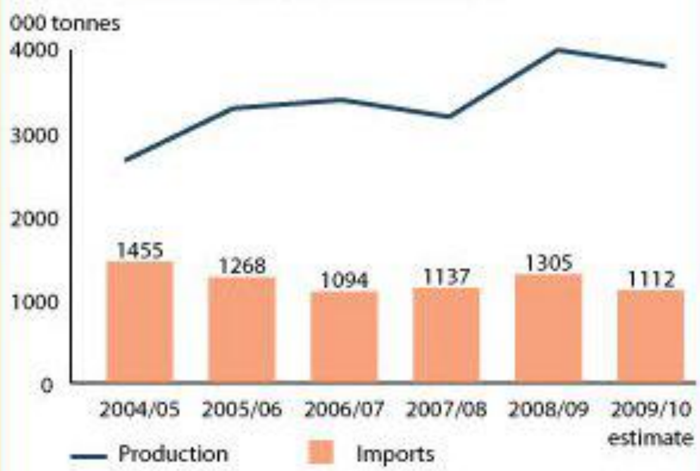
Sri Lanka

Cereal production

	2005-2009 average	2009	2010 forecast	change 2010/2009
	000 tonnes			percent
Rice (paddy)	3449	3652	4250	16
Maize	80	144	144	0
Millet	6	6	6	0
Others	0	0	0	0
Total	3536	3802	4400	16

Note:percentage change calculated from unrounded data.

Total cereal production and imports



Notes: Total cereal includes rice in milled terms. Split year refers to individual crop marketing years.
Source: FAO/GIEWS Country Cereal Balance Sheets

Source: FAO, 2010

Figure 5.5: Sri Lanka Cereal Production, 2009-2010.

The period between 2001 and 2010 saw an increase in food availability in terms of average per capita daily caloric availability from 2,392 kcal to 2,688 kcal. Protein availability also increased from 57.5 grams/person/day to 67.1 grams/person/day between 2004 and 2010 (GOS and CIC Agri Businesses Lmd. 2012 and Samaratunga 2011). However, there is a big difference in the availability and the consumption of food on account of poor access arising from lower purchasing power.

5.8.2 Malnutrition

Child malnutrition rate in Sri Lanka is the lowest in South Asia. The number of stunted and underweight children in the country has almost been halved in the past three decades. However, the incidence of wasting has remained stagnant at 12 per cent. Despite having the lowest regional malnutrition rates, in 2009, about 21.6 per cent of children under-five years were underweight, 19.2 per cent were stunted, and 11.7 per cent were wasted (see Table 5.10). The main factors responsible for child malnutrition are maternal education and household income. In the estate sector, about half of all women of reproductive age do not have primary education, and 30 per cent of women are malnourished.

In the same manner, relatively low female educational outcomes were reported in most districts with high levels of child malnutrition in 2009 (UNDP and IPS, Sri Lanka 2012). Along with decrease in micronutrient deficiency of iodine, vitamin A and iron in the country in 2009, 25.2 per cent of children below the age of five years were also reported to be afflicted with anaemia and within districts, its incidence varied from a moderate 19.3 per cent in the district of Kurunegala, to a high 34.0 per cent in the district of Jaffna (GOS 2009b). Likewise, the prevalence of goitre (iodine deficiency) among children (aged 5-12 years) declined from 18.8 per cent in 1987 to 4.4 per cent in 2011 (Jayatissa and Fernando 2011).

Table 5.10 Malnutrition trends among children under-five in Sri Lanka, 1987-2009 (*%)*

Year	Stunted	Wasted	Underweight
1987	27.5	12.9	38.1
1993	23.8	15.5	37.7
2000	13.5	14.0	29.4
2007	18.0	15.0	22.0
2009	19.2	11.7	21.6

Sources: GOS 2009a and 2009b.

Prevalence of undernourishment, with a BMI of less than 18.5, was reported in 2009 among 18.2 per cent of non-pregnant women (aged 15-49 years) in Sri Lanka. However, the situation varied by age across regions and income groups. Micronutrient deficiencies are also common among women. In 2009, the prevalence of anaemia was 16.7 per cent among pregnant women, 20.5 per cent among lactating women, and 22.2 per cent among non-pregnant and non-lactating women (GOS 2009a). The percentage of people living below the minimum level of dietary energy consumption decreased from 30.6 per cent to 25.9 per cent between 1991 and 2010. However, the total number of undernourished people remained unchanged due to population growth. They increased from 5.4 million in 1991 to 5.9 million in 2006, and decreased to 5.4 million again in 2010 (UN 2014). A survey on nutrition and food security conducted by the Government of Sri Lanka in 2009 revealed that only 12.4 per cent of households were found to be food insecure. Prevalence of significant disparity among urban, rural and estate sectors, income groups and districts was also reported. Food insecurity among the poorest 20 per cent of the population is 26.9 per cent as compared to only 2.3 per cent among the richest 20 per cent of population (GOS, 2009b).

5.8.3 Poverty and Inequality

Despite the fact Sri Lanka has sufficient availability of food, about one-fourth of its population is still malnourished and this is generally ascribed to the prevalence of insufficient access to food as indicated by high levels of inequality and poverty. In 1991, the percentage of population living below the national poverty line accounted for 26 per cent which declined to 9 per cent in 2010 (GOS 2014e) indicating an almost three times decrease as well as the inclusiveness of growth policies in Sri Lanka. However, a large number of people are at risk of slipping into poverty due to their vulnerability to economic shocks. For instance, in 2010, a 10 per cent increase in the national poverty line could increase the ratio of the poor to 12.8 per cent—an additional 0.8 million people would become poor (Galappattige 2013).

Sri Lanka has seen a steady decline in its poverty levels over the past two years. Accordingly, the number of people below poverty in 1995-'96 amounted to 28.8% of the total population. This ratio fell to 22.7% in 2002, 15.2% in 2006-7, 8.9% in 2009-10 and further to 6.5% in 2012. This Head Count Index of poverty was established by Sri Lanka's Department of Census and Statistics (DCS) in 2002 taking into account a composite basic need of foods accounting for 68% and non-foods accounting for the balance 32%. According to DCS, the total basket containing both these items cost Rs. 1,423 per person per month in terms of the prices that had prevailed in that year. Thus, a poor man in Sri Lanka could meet his basic needs by spending Rs. 47 or 50 US cents a day. According to DCS's split of income between foods and non-foods, a poor person could satisfy his food requirements with an income of Rs. 32 or 34 US cents. This was pretty much lower than the threshold fixed by the UN for poverty in the Millennium Development Goals or MDGs that amounted to $ 1.25 a day. Hence, Sri Lanka's poverty reduction was not compatible with those specified in MDGs. This was the threshold poverty level in Sri Lanka and for subsequent years, it was updated by inflating the threshold value by using the Colombo Consumers' Price Index. Since Sri Lanka rupee had not depreciated on par with local price increases, the dollar value of the poverty threshold has increased gradually over the years. Accordingly, in 2010, it was 89 US cents and in 2012, it could be estimated to be at $ 1.32 a day made up of 90 US cents for foods and 42 US cents for non-foods (Wijewardena, 2014).

Despite the reduction in poverty in recent years, Sri Lanka has seen an increase in income inequality over these years. In Sri Lanka, income inequality, as measured by the Gini coefficient, increased from 0.43 in 1981 to 0.49 in 2010 and slightly declined to 0.48 in 2012-13 which still denotes a high income inequality (Wijewardena, 2014). The unequal distribution of benefits from growth is also evident from the fact that the ratio of the income of the richest 20 per cent to the poorest 20 per cent of population increased from 9.9 per cent to 12.0 per cent between 1991 and 2010 (GOS 2011a). In Sri Lanka, 42 per cent of income is spent on food, rising to as high as half of all income in the estate region, and almost two-thirds in the district of Jaffna— the poor spend a high proportion of their income on food (UNDP and IPS, Sri Lanka 2012). Besides, the food price index increased from 10.0 to 219.1, by a significant 10.8 per cent per annum between 1980 and 2010 (GOS 2014a).

5.8.4 Remedial Measures

Sri Lanka has pursued policies and programs which have often emphasized on inclusive and pro-poor economic growth to reduce poverty and enhance food security. All governments have focused on social sector development, including the provision of universal and free education and health, food subsidies, cheap credit and safety net programmes. The country has also adopted a number of other initiatives to empower the poor, including price controls to protect the poor from inflation. However, Sri Lanka's adoption of Structural Adjustment Programme in 1977 to improve macroeconomic stability affected the allocation of expenditures for the social sector, rural development and food subsidies in subsequent years.

The main growth framework during 2005 to 2009 was the Mahinda Chintana: Towards a New Sri Lanka. The Plan aimed to share the benefits of economic growth, especially with the poor and marginalised. In order to make the growth process more inclusive and equitable, the Mahinda Chintana: Vision for the Future 2010 concentrated on food security and poverty reduction. By 2016, the Plan aims to eradicate hunger and extreme poverty, reduce the malnutrition rate of children from a third to 12-15 per cent; improve access to clean water in urban areas from 65 per cent to 90 per cent; universalize secondary education for all; and raise forest coverage from 28 per cent to 43 per cent (GOS 2010b).

Besides this, the country has also formulated a number of policies with the specific objective of improving nutrition and food security. This includes the National Agriculture Policy 2007, the National Livestock Development Policy 2007, the National Fisheries and Aquatic Resources Development Policy 2006, and the Food and Nutrition Policy 2004-10. These policies provide the necessary directives to ensure food and nutrition security in the country. The three main social safety net programmes in Sri Lanka are *Smurdhi*, School Meal and *Thriposha*. Their objective is to reduce poverty, hunger and malnutrition.

5.9: Conclusion

The entire SAARC region is afflicted with food insecurity and ranking of each country in the Human Development Index (HDI) and Hunger Index is not satisfactory thereby denoting prevalence of malnutrition, poverty and income inequality, which all contribute to food insecurity. Each country of the region needs to focus on pro-poor and inclusive growth policies with the avowed objective of addressing the issues of poverty, hunger and malnutrition and improving human development.

There is a need to have clear political commitment at the highest national level for hunger eradication, with specific emphasis on ending hunger, poverty and undernourishment on priority basis. Since prevalence of poverty, malnutrition and hunger is more prominent in rural areas where bulk of population resides, each SAARC is called upon to encourage small-scale farming by endowing the poor with land, credit, crop and farm technology, and providing access to output markets. Apart from these, there is also a need to promote a rural non-farm sector to absorb surplus workers from the rural areas. Other measures which need to addressed, *inter alia*, include: inclusion of all stakeholders in decision-making process with regard to food and agriculture policies, introducing better coordination and governance mechanism at local level, especially in rural areas, increased emphasis of the social safety nets on the poor with increased transparency and empowerment of women.

Chapter 6

The Way Forward

In South Asia, where food production has become increasingly water and energy intensive, WEF nexus assumes added significance. Tremendous increase in the demand for food, water, and energy in South Asia is taking place at such a time when land, water, and other natural and environmental resources are in either shrinking or depleting at a faster pace. Under this scenario, the increased food production in South Asia can only be had from the same or even less land. Water, energy and food related challenges facing South Asia can be aptly tackled via WEF nexus because, "The nexus approach provides a framework for better understanding of the interdependencies of the food, water, and energy sectors and linkages between upstream and downstream countries as well as better insights into how to address such challenges by maximizing synergies and managing trade-offs" (Rasul, 2014).

The interconnectedness and interdependence between food, water, and energy security, especially in the South Asian context, emphasizes the urgency for ascertaining inter-sectoral integrated solutions. Lack of appropriate incentives, paucity of capacity building and other policy and institutional mechanisms has already culminated thereby jeopardizing the food, water, and energy security in South Asia. Emphasis is stressed on identifying synergies across boundaries at the basin level by Crow and Singh (2009) to address the challenges of food, water, and energy security and Lindstro¨m and Granit (2012) have cited the example of the Aswan Dam on the Nile River, which not only contributes to mitigating drought and flood damage but also supplies electricity to half of the rural communities in Egypt, supports the fishing industry, and has created new livelihood opportunities.

Christopher Scott of the University of Arizona outlines that in order to get a handle over solutions for South Asia's problems it is essential to devise good strategies by exploring both the risks and rewards of using the water-energy-food nexus for policy discussions and decisions to get a handle on. Asserting that each component of the nexus is fundamental to human life and wellbeing, he further opined that understanding of the connections among these components can help promote efficiency in their use, greater equity in their distribution, and greater national security for the resource-stressed countries of South Asia. Irrigation is fundamental to food security and hydropower is fundamental to energy security in South Asia. Sustainable farms and cities require water security. Using the nexus can help define some of these interrelationships (Scott, 2015).

Climate change and governance; being forces outside of the nexus, are prone to influence all three components of the nexus. Climate and climate change can increasingly influence resources and decisions about managing them. While environmental quality essential, clean water is required for drinking and to grow food. Governance is the mechanism through which pursuit of development goals is facilitated. Thus, both these should factor in formulating policy and managing resources. Scott (2015) has cautioned that there are risks and trade-offs in WEF couplings. Gaining efficiency in one could lead to waste or inequity in another; e.g., when electricity becomes cheaper it is typically used more, which may have unintended consequences.

While lamenting at the neglect of agriculture in depictions of the nexus/hydrological cycle, which has to be seen as central to such discussions, Scott (2015) opines that mere refining of understanding of nexus complex, in tandem with social and ecological systems is in itself insufficient because there emerge many urgent problems that entail the potential of threatening the wellbeing of those systems. This scenario has led to a critical point where one is faced with a choice: either to follow previous path of unsustainable resource extraction and exploitation or to continue to rely on economic models that promote accumulation and extraction at the expense of depletion, leading to ecosystem degradation throughout the world, and to people trapped in systems where their only survival option is to contribute to depletion and degradation or to chart a new course that supports sustainability, ecosystem health, and equity.

In the wake of emerging shift in global thinking towards sustainable futures and resilient ecosystems, a change in direction has seemingly begun based on holistic systems thinking, which has engendered a new understanding of the complex interconnected links in human and environmental interactions, leading to the development of the idea of Sustainable Development Goals, in which, as Scott (2015) opines, the WEF nexus can be a useful tool in pursuit of this new way of framing development goals.

Scott (2015) has suggested looking at each of the three resources – water, energy and food – through the lens of the other two to begin to ward off the prevailing silo mentality. He cites the example: the view of food from a water perspective reveals that the over pumping of groundwater depletes aquifers and that climate change will require even more water; the view of energy from a water perspective might reveal that energy generation degrades water quality. Thus, energy portfolio decisions have consequences for water resources and require a debate about the trade-offs. Likewise, looking at water from an energy perspective highlights an ever increasing demand for hydropower, while looking at food from an energy perspective reveals that climate change will require more refrigeration of food, which makes local food sources preferable to long distance ones. Scott (2015) refers to what he calls ‘vicious cycles’ and ‘virtuous cycles’. In vicious cycles, one use of a resource detracts from another use: hydropower generation degrades water quality and river health; cheap electricity combined with no incentives to conserve leads to over-extraction of groundwater. Using the WEF nexus might promote more virtuous cycles, mitigating the harm use of one resource has on another.

By citing the example of the Ganges basin, Dr Bill Young (2015), the World Bank’s lead water resources specialist, sees river basin planning as a significant way to get a handle on the complexities of managing the WEF nexus in the South Asian context. He cautions that even looking at the region’s issues through a river basin lens does not simplify the challenges. While asserting that each area has distinctive qualities of river flow variability, agricultural productivity, and climactic variability; he further adds that all countries in the region experience challenges created by the monsoon, extreme variability in river flows, as well as sewage mismanagement and river pollution.

Undoubtedly, agriculture engages bulk of the population of the basin; nevertheless, it does not provide proportional economic benefit. Overexploitation of groundwater and undeveloped hydropower are the highlights of SAR. All the SAR countries are almost food deficit. Young (2015) opines that food production is not really constrained by water availability in the region; the problem is that water is used inefficiently. Contending that the same amount of water could feed twice as many people, he argues that inefficient use of available water is compounded by other problems, including poor soil quality, pointing to a need for better water management throughout South Asia. Suggesting that decoupling food security from increased water use can help promote the sustainable use of water, he further adds that similarly economic growth should be decoupled from increased use of water because demand for water will continue to grow, but the resource is finite. Young laments at lack of reliable data, especially related to water resources, which plagues planning and decision making in South Asia. Data is often contradictory and hard to access. Cooperation among countries will be hampered until there is more reliable data and countries are more willing to share it.

Adoption of 2030 Development Agenda by the United Nations (UN) in September 2015 encompasses 17 Sustainable Development Goal (SDGs) is based on an integrated approach like the WEF nexus and the latter has a potential role to play in the realization of the SDGs, especially the SDG-1 about ending poverty, SDG-2 about food security, SDG-6 about water & sanitation, SDG-7 about energy and SDG-13 about combating climate change along with the objectives envisaged in the Paris Agreement on Climate Change adopted in December 2015. Undoubtedly, projections for Target 2.1 of SDG-2 about ending hunger report that the number of people suffering from hunger is set to fall from around 12% to 8% of the developing world's population from 2015 to 2030; nevertheless, progress would need to be over three times faster to reach the goal of zero hunger. The fastest progress is projected in East Asia and the Pacific where the number of hungry people is set to reduce from 143 million to 94 million. In Latin American and the Caribbean, some progress will be made from a low starting position; hunger is projected to reduce from 38 million to 28 million. In sub-Saharan Africa, the number of people suffering from hunger is set to fall only slightly, from 195 million to 180 million from 2015 to 2030. In South Asia the number of hungry people is projected to remain stable at over 200 million, which is the largest amount for any region (Nicolai *et al*., 2015).

Similarly, projections for Target 7.1 about access to energy in terms of electricity reveal that around 12% of the world's population is set to continue to lack access to electricity in 2030, falling from 16% in 2015. Progress would have to be between three to four times faster than projected in order to meet the universal energy coverage target by 2030. Population growth has an important role to play in slowing the expected pace of improvement. It is further revealed that an additional 1.7 billion people are expected to gain access to electricity by 2030, but 1 billion people will still be left without access. The regional story is most positive in the case of East and South Asia, where the number of people lacking access to electricity is expected nearly to halve between 2011 and 2030, driven mainly by substantial decreases in India (Nicolai et al., 2015).

This reinforces the fact that WEF nexus is imperative for South Asia to ensure all-round growth and speedy realization of the SDGs. Following suggestions can be instrumental in effective and efficient implementation of the WEF nexus:

- Synchronization of policy measures in water, energy and food sectors, keeping in view inter-relatedness and interdependencies of resources across both sectors and scales, upstream and downstream, as well as the role of regional ecosystems in long-term security of water, energy, and food in the region.
- Stress on facilitating reduction of inter-sectoral externalities by adopting integrated planning and management of water and energy sources and according equal emphasis on managing land, forest, ecosystems, and agriculture to ensure food security.
- Introduction of regulatory mechanism for managing demand for water and energy and launch incentives for judicious use of water and energy for food production.
- Political will required to tackle issues related to trans-border water-sharing to pave way for better cooperation in implementing WEF nexus approach.

- Capacity building of the people inhabiting trans-border areas in the realms of conservation and judicious use of natural resources and improve their livelihoods.
- Cooperation in the management of trans-boundary river basins and share the fruits of WEF nexus for mutual benefit and region's development.
- Policies should be informed by scientific modelling results, as well as the principle of equity.
- Trans-boundary river basin management needs to be addressed in a cooperative manner.
- There is need for synthesizing information and specialist knowledge into an unbiased base of evidence, which could then serve as the basis for policy and action to be supported by the use of new technology and innovations in communication.
- Efficient and effective institutional mechanism needs to be in place for the implementation of the WEF nexus. At the domestic or household level, managing the nexus is easy, but beyond that level things can fall apart because different institutions and agencies manage food, water, and energy.
- There is absence of coordination between various departments and ministries and they lack any incentive to cooperate. Even when there is political will, it can be cumbersome in getting people to change their mindset and behaviour. There is need for inter-departmental convergence, coordination and cooperation among departments and they could foster mutual interdependence between departments and tie that to performance evaluations and reward systems.
- The three nexus sectors – water, energy and food – are not integrated regionally in South Asia, even though there are interdependencies among all regions, and as such there is need for maximizing synergies, create more opportunities, facilitate upstream downstream cooperation, and share data for mutual benefit. There is also need to overcome mistrust between countries to facilitate cooperation.
- Innovations have to come not just in technology, but also in management and behaviours. Conventional approaches don't work anymore. Policies and treaties need to acknowledge realities.
- There is a need to embed a WEF perspective in development projects, as WEF is a necessary component of sustainable development.
- Good planning requires reliable and accessible data. Agencies generate a lot of data, but the challenge is linking it together and data democratization can

help optimize resource management. Sharing data is crucial, on the regional scale, to accomplish a WEF analysis.

- There is need for finding bridges that can lead to productive work with politicians and politicians at the local level have to be brought into planning along with those at state and federal levels.

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