Chapter 1
INTRODUCTION

Water has gained attention of policy makers and practitioners due to its crucial role and importance in each and every sphere of life from individual to global domain. With the advent of globalization and commercialization in current scenario of advancement and development, water holds its vital position due to its multiple needs (FAO, 2011). As era pacing forth towards the middle of 21st century, focus on the concept of sustainable development superseding the overall economic-social and political issues due to the urgent requirement of conserving resources for future. Water crisis is one of the central issues as far as sustainable development is concerned.

For meeting the demands of consistently increasing population and other sectors of economy water has become an asset because of its essential role in every work. Increasing demand of industrial and agricultural commodities led to the evolution of water crisis lacunae to be checked for securing future of a nation and globally (Wichelns, 2004). Overall water use of agriculture, industrial and domestic sectors are 90%, 7% and 3% respectively (AQUASTAT, 2015). This reflects that agricultural sector is consuming the major part of water resources as compared to other sectors which is very negligible. These figures define the urgent need to focus on agricultural sector for the better management of water resources among different sectors and different user level. The growing demand of food production all over the world led to the depletion of water resources rapidly.

India, being the second populous country of the world, have unraveling pressure on water resources due to the hiking demand of food to feed the explosive population of the country. The uneven distribution of water within the country is also a problem for up surging water crisis. Over time the problems associated with the water scarcity will continue to aggravate the development of a nation. The whole vicious circle of food production, water scarcity associated with agriculture sector is on rampant in contemporary era of globalization.
1.1 Agricultural Productivity & Food Security

The fundamental base of food security is food production. According to the definition propounded by FAO on World Food Security in 1996 in Rome Declaration “Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life”.

Population of India is supposed to cross 1.5 billion by 2030; the main challenge for the country is to grow more and more food from diminishing per capita arable and irrigation water resources and expanding abiotic and biotic stresses as pointed by Swaminathan. To feed the population of 1.15 billion around 230 million tons of cereals are produced in India. On the other hand, food of farm animals are often missed while calculating food requirements. The need of the hour is that production of cereals has to be doubled by 2050 in view of meeting the requirements of population of 1.8 billion including requirements of poultry and livestock. Due to the reduction in land available for agriculture, the requirements would only be met by increasing per unit of arable land and irrigation water. Productivity of factor will have to be doubled, if the cost of production is to be reasonable and the prices of our farm products are to be globally competitive. Around 80% of the families who are involved in farming belong to small and marginal categories of farmers and average farm size is decreasing subsequently. Surprisingly, livestock ownership is more egalitarian (Swaminathan and Bhavani, 2011).

For the reduction in hunger, unemployment in rural sector and poverty and fulfilling targets of food production, increments in income of those farmers who belong to small categories via crop-livestock integrated production systems and multiple livelihood through agro-processing and biomass utilization and enhancement in productivity of small farms should be done. About 60% of the population in India continue to sustain on agriculture sector and allied activities for their survival and livelihood. Thus, an important perquisite for overall economic growth, growth of agriculture sector is very important.

India stands second in terms of having percentage of total arable land in world. Ranks first in terms of largest area under cotton, wheat and rice cultivation, production of milk, pulses and spices. In late 1960s the expansion of HYV seeds, fertilizer,
electricity, subsidies for water and on farm equipment gripped the boom due to the advent of Green Revolution during this period. This led to abrupt increase in agricultural production, securing self-sufficiency of state by the end of 1970s. Now production is plateauing in most of the crops.

Changing patterns of consumption, an exploding population and superseding urbanization are leading to unmanageable growing demand. This requires a reformulation or restructuring of agricultural management, with expansion in investment and a focus on sustainable ecological management. This encompasses a closer assessment of the interaction between outputs of agriculture, use of water (specifically for irrigation) and soil health.

More than 2/3rd of population of a country resides on agricultural sector for their survival, while 67% of land is under the possession of small land holding farmers constituting around four hectares or less. It had been estimated that in India more than 86 million landless laborer households exist (GOI, 2013). Most of these households of rural areas depend on subsidies to access, electricity, water, food, grain and fertilizers, This makes notable challenges for policy makers and practitioners, as the sustainability of food system of India and the economy itself relied on subsidy and resources use reforms in the agriculture sector.

### 1.2 Water Security

India is blessed with plenty of water resources comprising of 13 major and 46 minor basins. The largest basin holding around 34% of India and accounting about 59% of nation’s water wealth. Rainfall and snowmelt through glaciers via river flows from the Himalayan region are the major sources of water in India (CWC report, 2013).

In India, availability of water and rainfall rely on monsoons. Approximately average annual rainfall is 1170mm. As per the estimate of FAO’s AQUASTAT database, 80% area of country has an 750mm annual rainfall or more. Main challenge associated with water security in India is not much related to physical water scarcity, but the problem of mismanagement, proper governance and limited storage facilities. Per capita storage capacity of water is 200m$^3$, whereas world average is 900m$^3$ per capita, signifying India’s per capita storage capacity is below world average. According to estimates, approx. 65% of rainwater flows of a country move to sea uncaptured,
providing a wide opportunity for improving the water scarcity issue by preserving those water flows (FAO, 2014).

According to the forecast of UN when availability of water will be below 1000m$^3$ per year, this will lead to water scarcity. Whereas, according to population forecasts by the end of 2050 average per capita availability will be about 1000m$^3$ per year which is currently is 1600m$^3$. Hence, lack of storage capacity, increasing levels of population in a business-as-usual scenario and overexploitation of groundwater will hike the risk of severe water insecurity in India (World Bank Report, 2013).

During heavy rainfall, programs to revitalize traditional tank systems and rainwater harvesting provide an ample of opportunity to store and capture water. The satisfactory and considerable potential outcomes will be decline in risk of flood occurrence, accessibility to large stores of freshwater and increase in aquifer recharge. Overexploitation of groundwater resources and availability of safe water for human consumption would be met by increase in volumes of traditional tanks and capacity of water storage in India. The positive effect of access to water for agricultural activities has been seen in Andhra Pradesh by formation of traditional water tanks. According to the estimate of World Bank, around 85% of water supply for drinking in India relies upon groundwater. Current use of groundwater ranges between 70% and 100% of the total estimated annual recharge in some basins. About 60% aquifers of India will be in serious plight by 2035 as per some suggested predictions.

1.2.1 Irrigation

Irrigation is prevalent in India for over 5000 years for the production of food. It accounted for 91% out of total 761 km$^3$ of water withdrawn according to FAO, 2010. Use of irrigation basically takes place in northern states of India along the Ganges and Indus rivers. In 2004, as per the estimates of FAO out of 63 million hectares of 97% of land was irrigated by surface irrigation system, 2% of land was irrigated by the method of sprinkler irrigation system and rest 1% used localized irrigation. With the increase in sprinkler and localized methods of irrigation, there has been ample of opportunity for increased efficiency. Recently, around 40% of efficiency gap exists with groundwater irrigation. As demand of water is continuously growing in almost all industrial sector, it is important that the more water productive practices must be adopted by agricultural sector to reduce wastage and limiting potential deficits.
1.2.2 Water Pollution

Water pollution is an additional critical challenges for a country in both water and food security. Water quality of India is amongst the worst in the world. India stands at 120th position out of 122 nations in terms of estimation of water quality that 70% of the supply of water is contaminated. Presently, 21% of communicable diseases are transmitted through contaminated water in a country. Main contributors of pollution are industry effluent and agriculture runoffs, underdeveloped wastewater treatment facilities and it is worst in the lower and middle reaches of rivers (CWC report, 2014).

1.2.3 Climate Change Impacts

Due to climate change, India is supposed to encounter with the problems of longer drought periods and increased rainfall variability. Availability of water and production of agricultural produce are dependent on monsoons; prolonged drought, more intense weather events, increased variability in precipitation will genuinely affect the long run situation. The occurrence of natural disasters is also predicted to increase in a country, hampering agriculture, water security and overall health of the population of a country.

Source: FAO, 2011

Figure 1.1: Water withdrawal by sectors
1.3 Virtual Water Trade

Virtual water present in a commodity or product is the total amount of water used in the process of production of an industrial or agricultural commodity (Allan, 1998). The reason to name this water is ‘virtual’ because the water which is used for the production of a commodity is no more physically present in the product. For instance, 1 kg wheat need 1654 liters of water to produce, 1 kg of maize requires 1937 L of water and so on.

The concept of virtual water has two forms of practical uses. 1) It can be looked as an alternative source of water and therefore can be used as an instrument to attain regional water security. Moreover, Virtual Water Trade can be as an important tool in solving geopolitical problems and even prevent wars over water. 2) Environmental impacts of a commodity due to its consumption can be traced by using virtual water content ideology. This will create awareness among the people by disclosing virtual water content of various consumption routes, stated by the World Water Council. Because the amount of food we consume daily contains much more amount of water as compared to the water we use for other households chores such as drinking, washing, sanitation etc. Nevertheless, some of the countries have water resources in abundance, much more than there need. On the other hand some countries of the world do not have sufficient water to meet their current and projected requirements. While in big countries there are areas of deficient or surplus water availability within the boundaries of a nation.

To reduce the problem of water scarcity, water deficit regions/ countries may control problem of water scarcity through import of water (virtual) by importing agricultural commodities instead of producing domestically or locally (WWC, 2000). Contrarily water rich nations may earn profit by producing water intensive commodities for export. Real water trade between water abundant areas and water deficit is generally impossible because of the huge costs and large distance, but trade in water intensive commodities (virtual water trade) is realistic (Hoekstra and Hung, 2002). Virtual Water Trade between nations and continents could be used as a tool or instrument to enhance global water use efficiency, to acquire security of water in water deficit areas of the world and to reduce the barriers on environment by using best suited production
sites (Turton, 2000). Apparently practically things are not so easy to implicate as the concept is at its initial phase.

1.4 Need and Significance of the Study

Continuous rising population of a country leading to increase in demand for water, energy and food, management of these multiple demands amongst its desired users will be a huge challenge. This signifies that a country must find an avenue to produce more food from less water to evade from an upcoming crisis of resources. Presently, there is surplus food in India, but to maintain accessibility of food for everyone needs an increase in current production. For this purpose, resource planning and water management must be done in an integrated manner keeping view agriculture, industry and domestic users.

For decreasing wastage of water, a proper review of the current market of water is necessary. Prices and management vary widely from one region to other and overall low tariffs offer negligible or less incentive to save water and also articulate unsatisfactory funds to maintain systems. For controlling water loss in a system, changes should be made in wasteful behavior and ensure long term accessibility during increase in demand and water tariffs must be modified. Considering the fact that those groups who are in greater need of reliable water source are also miserable to afford it, this implies that measures to support universal access must be evolved.

To decrease hindrance to upstream development in India needs important changes in the domestic water management system. The problems arising due to water diversions and upstream hydropower projects, emphasis must be given on water use efficiency and rainwater capture and storage which have the scope to absorb the water deficits. Due to the consistent growth of population and demands simultaneously which puts pressure on available water and food is a bigger challenge for a country to overcome these aspects at the same point of time. Lack of resources is not calling the shots but the proper management and distribution of resources among the user is the bigger challenge and its conservation for future generation which is at the core priority of Indian water and food insecurity. Addressing these challenges and issues is much more complex and tougher than the engineering hydro power and water transfer projects. Keeping in view the above elucidation virtual water trade may play a crucial role to overcome the problem of water and food security and related issues.
Water scarcity is becoming a chronic issue globally. Problem of water crisis is directly associated with agriculture sector, because it withdraws around 90% of freshwater from the surface of the earth. With the continuous increase in climate change adversity, its disadvantageous environmental impacts cause serious effects on the water resources in many part of the world. This resulting into up surging problem of water scarcity at a country level or global level, virtual water trade will provide an opportunity to overcome this problem as policy instrument and practical means both to counterbalance the local, national and global water budget which has gained much attention in present time.

On the basis of established phenomenon of virtual water accounting in the literature, this study evaluates the efficiency of water use embedded in the international agricultural trade from the panorama of exporting and importing nations, at the global and country level both. Virtual Water Trade is one of the glaring options to decrease water consumption. Virtual Water Content of commodities varies from one product to another within India. This concept will provide the base for proper planning of appropriate and optimum utilization of water resources for the country so that the gap between the need and availability of water could be decline.

To ensure food security and sustainable agriculture we shall need to formulate an agricultural trade policy which ensures greater emphasis on import of those agricultural commodities which require greater water in its production and export those which use minimum water. Present study is focusing exactly on this. Through the concept of Virtual Water Trade, study tries to analysis the pattern of India’s agricultural trade since 1985-2014 and its impact on sustainable agricultural production.

1.5 Objectives of the Study

Basic aim of this study is to analyse the extent and pattern of virtual water use in food production and global trade in India. The specific objectives of the study are as follows:

- Analyse the extent and pattern of water usage in production of major agricultural commodities across the country
• Examine the volume and direction of agricultural trade in India during last two decades
• Assess the water food-print by analyze the virtual water trade.

1.6 Scheme of the study

The present study has been divided into seven chapters. First chapter is the introductory section. Second chapter is devoted to literature review. Third chapter gives the details of the research methodology and framework used in the study. Chapter 4 to 6 is the core of the study. Fourth chapter undertakes the assessment of water use in agricultural sector in India. Fifth chapter analyses of agricultural trade between India and rest of the world. Sixth chapter is the most important which focuses on analysis of virtual water trade between India and world and tries to explain the major virtual water trade items of India. Seventh chapter summaries the findings in this part study along in the suggestion to policy makers and for future research.

Chapter 1: Introduction

This chapter is designed to provide an overview of whole study. This introduces the topic and the overall perspective associated with the topic with reference to India. Status of water in a country and importance of food production with the entire spectrum of other associated issues with the approach of accomplishing sustainable water management. Also consists of brief description of virtual water trade, significance of the study and need of the study.

Chapter 2: Literature Review

This section of the study is the crux of all the reviewed studies, which were assessed to establish the clarity in the study. Highlights of all the related studies have been explained divide into three subsections: 1) Studies on International Trade and its various aspects, 2) Studies on the Water Use Efficiency, 3) Studies on Virtual Water and Virtual Water Trade

Chapter 3: Research Framework and Methodology

In this part of the study, description about the methods adopted for overtaking the research has been described with all the formula, tools and techniques followed by the limitation at the end of the chapter.
Chapter 4: Agricultural Production and Water use in Agriculture in India

This chapter is the assessment of whole water scenario across country. Present water resource availability within the boundaries of the country from all sources of water. And water use by agriculture sector during the production process of food products.

Chapter 5: Global Agricultural Trade in India

This is the mirror of the second objective of the study. An analysis of total agricultural trade taking place between India and the world during the period 1985-86 to 2013-2014 based on the data of Ministry of Commerce Data Bank in India.

Chapter 6: Virtual Water Trade in Agricultural Commodities in India

This is the essence of the last objectives of the study. The analysis of total water withdrawn from country via virtual water trade during the given period of study i.e. 1985-86 to 2013-2014. Exchange of total amount water through export and import of agricultural commodities have been estimated in this chapter. Major agricultural commodities by which major part of water withdrawal is taking place. And complete assessment of composition and direction of virtual water trade.

Chapter 7: Conclusion

This is the last section of the thesis but the most important part of the research. This section contains all the findings related to the objectives of the study and followed by the recommendations provided by the researcher based on the attained results. Further, future implication of the research has been sighted with futuristic approach for upcoming researcher and R & D institutions.