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IS THE PROPENSITY OF INCREASING THE RICE PRODUCTION A SUSTAINABLE APPROACH? AN ANALYSIS

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ABSTRACT

Rice production signifies the single largest land use for food production on the earth where Asia accounts for 90% of the world's rice production and consumption. Demand pressure for food will, however, remain significant in low-income countries that comprise the bulk of Asian populations, because of high population growth rates. India, Bangladesh, and Pakistan are the three foremost rice producing countries in South Asia. With the implantation of high yielding crop varieties, farm mechanization, application of numerous types of chemical fertilizers and pesticides, food production has raised remarkably. During, 1961-2014, 314.20%, 262.65%, and 193.89% of rice production were increased by Pakistan, Bangladesh, and India respectively. Maintaining self-sufficiency in production to fulfil the increasing food demand is the prime objective of these countries. However, water consumption rate to produce per kg of rice is much higher compared with other crops. Besides, climate change has an adverse impact on the productivity of rice production. High water demand for rice production and inadequate availability of surface water in the non-monsoon period, continually increase the pressure on groundwater. The research reveals the overall scenario of the rice field in India, Bangladesh, and Pakistan by considering the water consumption, agricultural land use, and production patterns of rice during 1961-2014. AQUASTAT and FAOSTAT databases of Food and Agriculture Organization are used as the data sources for the study.

Keywords: *Land use, water consumption, production patterns, rice*

1. INTRODUCTION

Hunger is one of the most challenging issues in the 21st century. Even though Africa is represented as the heart of hunger, a large volume of hungry people lives in Asia (HN, 2017). As the developing nation, South Asia faces this challenge comparatively high. 281 million people who are not getting adequate food and nutrition live in South Asia (SDGs, 2017). Besides projection revealed that the global population would be increased by 50% compared to the present and demand for food will be doubled within 2050 (Tilman et al., 2002). Moreover, the pressure of the food demand will significant for developing nations due to the high growth of population. Increasing food production to fulfil the food demand will be one of the major challenges for sustainable development.

Considering the land area and population size, India, Pakistan, and Bangladesh are three dominating countries in South Asia (FAO, 2017). The annual rate of population increase in India, Pakistan, and Bangladesh are 1.1%, 2.0%, and 1.1% respectively (WDI, 2017). Agriculture is the most dominant sector of economics where a significant part of the population in the South Asian region lives in rural area and depends on agriculture for livelihoods. In 2016, Agriculture contributes around 17.35%, 14.77%, and 25.23% of GDP in India, Pakistan, and Bangladesh (WDI, 2017). It is abundantly clear that future growth of agricultural sector holds the key to livelihoods and food security, elimination of poverty, increasing the growth and sustainable progress of economy in each of the nations.

Target 2.1 of the United Nations Sustainable Development Goals aims to end hunger and assure access by all people, in particular, the poor and people in vulnerable circumstances, including children, to safe, nutritious and sufficient food all year round by 2030 (SDGs, 2017). Large and growing population in SAARC countries creates more demand for food and places greater stress on limited resources. More productive crops need to be produced to fulfill this growing food demand. Besides, the SAARC countries currently depend heavily on the production of India, Pakistan, Bangladesh, and Nepal for the supply of balanced food (Sahu, 2010). People of this region largely depend on high water consuming crops such as rice because of their food habit.

Rice is the second most demanding crop in the world (Nguyen & Ferrero, 2006; Kuenzer & Knauer, 2013) and it is the staple food for more than half of world's population (Roy et al., 2014) especially for the South Asian people (Singh, 2009). Besides, South Asia is the second largest rice producing region in the world. In 2003, South Asia used almost 37.5% global area for rice production and contributed 32% of global rice production (IRRI, 2016). India, Bangladesh, Nepal, and Pakistan contribute to 38.35% of world rice harvested area (Sahu, 2010). Moreover, rice production has gone through historical changes during 1980 to 2011 as it is increased three-fold (Roy et al., 2014). However, India has the largest rice cultivated area and is the leading rice producing country in the world next to China (Zhang et al., 2016). In addition, India produces 20% of global rice production as well (IRRI, 2017).

Furthermore, rice is a major crop in India and the staple food of most Indians. Rice covers 24% of the total cultivated area in India and contributes 40% of total grain production (Bishwajit et al., 2013). Eventually, 65% of the total population in India depends on rice (Rahaman et al., 2016). After the 'Green Revolution', planting high yield varieties and high uses of agrochemicals result to increase rice production in India during the recent years (Janaiah et al., 2006). 41.50% of rice production has increased in India during 1990-2012 (FAOSTAT, 2017; Rahaman & Shehab, 2017).

As an agricultural country, agriculture is a primary source of economy in Bangladesh, and rice plays a significant role (Roy et al. 2014). Bangladesh is the third largest rice producer in South Asia and sixth largest rice producer in the world. 75.4% of total population in Bangladesh entirely depend on rice production for their livelihoods (Majumder et al., 2016). Besides, rice covers 70% of the total cultivated area in Bangladesh (Karim et al., 2012; Majumder et al., 2016; Hossain et al., 2006). Rice cultivation produced enormous employment opportunities which employ around 65% of total labor force (Roy et al., 2013). Additionally, rice contributes 10% of the total GDP in Bangladesh (Roy et al., 2013). In fact, 95% of cereal production in Bangladesh is covered by rice (Karim et al., 2012). Moreover, Bangladesh is in the fourth position in the world considering the per capita rice consumption (Majumder et al., 2016). Bangladesh has increased rice production about three-fold during 1970 to 2009 (Ahmad et al., 2014). Expansion of using high yield crop, fertilizer, and pesticide, rice production has increased remarkably (Hossain et al., 2006; Roy et al., 2014). Besides, the groundwater-based irrigation system is the key to boost the rice production in recent years (Ahmad et al., 2014).

One-third of the country's population is currently living in poverty and malnutrition is challenging issue in Pakistan (Hussain et al., 2009). Besides, the economy of Pakistan mainly depends on agriculture. It accounted 20% of the national GDP in 2012 and employed 45% of total labor force in 2008 (Akhter et al., 2017; Zhu et al., 2013). Pakistan is the eleventh largest rice producing country in the world and rice is the second largest demanding crop in Pakistan. In addition, Pakistan is well-recognized worldwide for exporting rice (Akhter et al., 2017). Moreover, it covers 10% of the total cultivated area in Pakistan (Bashir et al., 2007).

International Water Management Institute (IWMI) indicates that there will be a need for 17% more irrigation water to feed the world population by 2025, at the same time near about 2 billion people of the world will have to face absolute water scarcity during this period (Sahu, 2010). Mitigating the shortage of water can be solved by making efficient use of water in agriculture globally (Prasad et al., 2006). Approximately 70% of total global freshwater withdrawal fulfills the agricultural water demand and more than 90% of its consumptive use (Watto & Mugera, 2016; Rahman et al., 2010). The irrigated area represents less than 20% of the global cropland, but it contributes more than 40% of the global food production (Watto & Mugera, 2016). One of the significant factors affecting agricultural production around the world is irrigation water (Arfanuzzaman & Ahmad, 2016). Groundwater is considered as a hidden resource which has been recognized as an essential element of the water resources system. Due to increasing use of groundwater for irrigation and consequently higher extraction rates, groundwater resources are rapidly dwindling in many parts of the world. Currently, groundwater is used for about 38% of all global irrigation supply and about 50% in South Asia (Shrestha et al., 2014). To fulfil the growing demand, irrigation by using groundwater is a key to increase the crop production in recent decades (Ahmad et al., 2014).

Projection stated that rice demand in the world would be increased 571.9 million tonnes in 2001 to 777.1 million tonnes in 2030 due to the continuous growth of population (Nguyen & Ferrero, 2006). Acquiring self-sufficiency to secure the food supply locally is the prime goal of those developing countries in South Asia (Ahmad et al., 2014). Besides, the significance of self-sufficiency and effective policies for food security have raised after the world food crisis in 2007-2008 (Mainuddin & Kirby, 2015; Hussain et al., 2009). However, rice is a high water consuming crop compared to the other common producing crop in South Asia (WFN, 2017). Besides. India, Pakistan, and Bangladesh mostly depend on groundwater for irrigation. Due to the lack of implementation of advanced technology for irrigation, most of the developing countries have low irrigation efficiency. So the propensity of increasing rice production to achieve self-sufficiency with sustainable agricultural practices is now a challenging issue for all rice producing country.

With this in mind, this study aims to reveal the overall scenario of available water resources and production pattern of rice in India, Pakistan, and Bangladesh during 1961-2014 so that proper steps could be taken to shorten the challenges to cope with water and land deficiency and to secure long-term regional food security.

2. METHODOLOGY

The data has been analysed based on specific parameters stated by AQUASTAT and FAOSTAT database of Food and Agricultural Organization, (i.e., land use, water resources, water use, harvested area of rice and rice production) to explain the changes in the rice production and the availability of water resources in India, Pakistan, and Bangladesh that have occurred during 1961-2014. Secondary data has been collected from various international, governmental and local organizations as well as published articles, books, documents, and reports.

3. ANALYSIS AND RESULTS

3.1 Agricultural land use

Among all the county in South Asia, India is in the leading position considering the land use for agriculture. India uses 169.36 million hectares of land for agriculture in 2014 followed by Pakistan and Bangladesh (FAO, 2017; Figure 1). Besides, India uses 51.52% of total land for agriculture in 2014 (FAO, 2017; Figure 1). The agricultural land use remains almost constant in India in recent past (1961-2014). Pakistan is the second largest country in South

Asia who uses over 31.25 million hectares of land for agriculture in 2014 (FAO, 2017; Figure 2). Besides, 39.26% of total land is used for cultivation in Pakistan which is comparatively low in amount (FAO, 2017; Figure 2). Moreover, Figure 2 reveals that the agricultural land was fluctuating over the recent past.

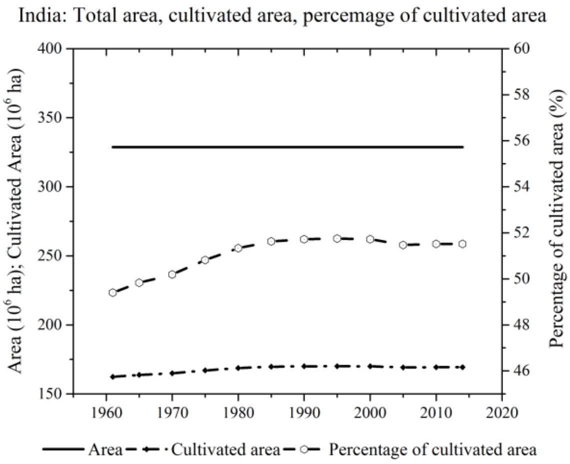

Figure 1: Total area, cultivated area, and percentage of cultivated area in India.

Source: FAO, 2017

Bangladesh is in the fourth position in South Asia considering the total land size (FAO, 2017). 8.50 million hectares of land is for agricultural practice in Bangladesh in 2014 (FAO, 2017; Figure 3). Being a small country compared to India and Pakistan, Bangladesh uses the highest percentage of land for agricultural practices. 57.57% of total land is used for cultivation in Bangladesh in 2014 (FAO, 2017; Figure 3). However, in recent years, the cultivated area in Bangladesh is gradually decreasing which is an alarming issue for Bangladesh. Moreover, In Bangladesh, almost 6.52% of agricultural land is decreased during 1985-2014.

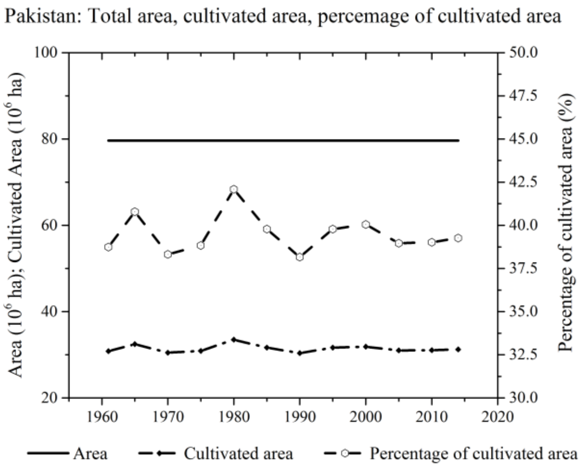

Figure 2: Total area, cultivated area, and percentage of cultivated area in Pakistan.
Source: FAO, 2017

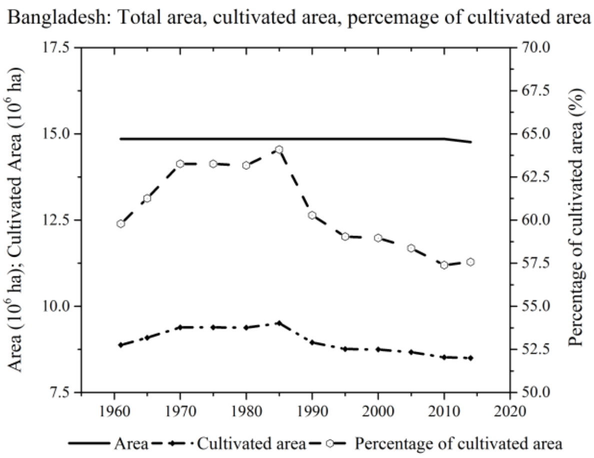

Figure 3: Total area, cultivated area, and percentage of cultivated area in Bangladesh.
Source: FAO, 2017

Irrigation potential means that the area of land which is potentially irrigable. In 2013, irrigation potential area in India, Bangladesh, and Pakistan were 139.5 million hectares, 6.93 million hectares, and 21.3 million hectares respectively (FAO, 2017).

3.2 Available water resources and water uses

India has a typical monsoon climate where the annual average rainfall over the country is around 1083 mm (FAO, 2017), but it varies significantly from place to place. The intensity of rainfall is relatively low in northwest part of India. The annual average rainfall in Pakistan is 494 mm (FAO, 2017). Bangladesh has the monsoon climate with significant fluctuations in rainfall throughout the country. The annual average precipitation is 2666 mm per year (FAO, 2017) which is the highest value among the South Asian countries. 80% of the total rainfall occurs during the monsoon season, and the intensity of the rainfall is relatively high in northeast compared to the northwest part of Bangladesh.

Table 1: Water resources in India, Pakistan, and Bangladesh.

Parameters	Unit	India	Pakistan	Bangladesh
Total renewable surface water	10^9 m^3/year	1869	239.2	1206
Total renewable groundwater		432	55	21.12
Total renewable water resources		1911	246.80	1227

Source: FAO, 2017

Total renewable surface water is the sum of the internal renewable surface water resources and the total external renewable surface water resources (Climpag, 2017). Similarly, total renewable groundwater is the sum of the internal renewable groundwater resources and the total external renewable groundwater resources (Climpag, 2017). India has the highest amount of total renewable surface water in South Asia which is 1869 billion m^3 per year (FAO, 2017; Table 1). Besides, the total renewable surface water in Bangladesh and Pakistan are 1206 billion m^3 and 239.2 billion m^3 respectively (FAO, 2017; Table 1). Moreover, considering the total renewable groundwater, India is in the top position among the South Asian countries. India has 432 billion m^3 the total renewable groundwater followed by Pakistan and Bangladesh (FAO, 2017; Table 1).

Table 2: Water withdrawal in India, Pakistan, and Bangladesh (2008-2012)

Parameters	Unit	India	Pakistan	Bangladesh
Agricultural water withdrawal	10^9 m^3/year	688	172.4	31.5
Industrial water withdrawal		17	1.4	0.77
municipal water withdrawal		56	9.65	3.6
Total water withdrawal		761	183.5	35.87
Surface water withdrawal		396.50	121.90	7.39
Groundwater withdrawal		251	61.60	28.48

Source: FAO, 2017

Total water withdrawal is the quantity of water withdrawn for agricultural, industrial and municipal purposes annually. Agricultural water withdrawal is the annual quantity of self-supplied water withdrawn for irrigation, livestock and aquaculture purposes. India uses the highest amount of water compared to Pakistan and Bangladesh (Table 2). During 2008-2012, the total water withdrawal in India was 761 billion m^3 per year (FAO, 2017; Table 2) among which 90.41% of total water withdrawal was used for agricultural uses. Besides, 94.68% of agricultural water use is increased in India in between 1973-2012. Moreover, in 2008-2012, the total surface water withdrawal in India was 396.50 billion m^3 per year (FAO, 2017; Table 2) which represents 52.10% of total water withdrawal.

The total water withdrawal in Pakistan was 183.5 billion m^3 during 2008-2012 (FAO, 2017; Table 2) where 93.95% of water was used for agriculture. 14.70% of agricultural water use was increased in Pakistan in between 1973-2012. Furthermore, the total surface water withdrawal in Pakistan in 2008-2012 was 121.90 billion m^3 per year which was 66.43% of total water withdrawal. Although the dependency on surface water is significant, the volume of groundwater uses has already crossed the recharge limit. In 2008-2012, the total groundwater withdrawal in Pakistan was 61.60 billion m^3 per year where the total renewable groundwater was 55 billion m^3 per year (FAO, 2017; Tables 1, 2). The consequence of overuse of groundwater is alarming where the groundwater table is lowering in Pakistan which is now a significant concern for sustainable development.

During 2008-2012, the volume of total water withdrawal in Bangladesh was 35.87 billion m^3 per year. 31.5 billion m^3 of water was used for agricultural practices in Bangladesh during 2008-2012 which is 87.82% of total water withdrawal. Bangladesh used 7.39 billion m^3 of surface water in 2008-2012 (FAO, 2017; Table 2) where it used only 0.61% of renewable surface water potential. Moreover, the dependency on groundwater is huge in Bangladesh compared to India and Pakistan. Groundwater contributes 79.40% of total water withdrawal in Bangladesh. Same as Pakistan, the quantity of using groundwater which was 28.48 billion m^3 per year in Bangladesh has exceeded the recharge rate of 21.12 billion m^3 per year (FAO, 2017; Tables 1, 2). Excessive use of groundwater results to fall of groundwater table and increases salt contamination which are serious concern for both Pakistan and Bangladesh (Rahaman et al., 2016).

3.3 Production pattern of rice

Considering the rice harvested area and production, India is in the second position all over the world (Zhang et al., 2016). Besides, India is the top rice producer in South Asia and used

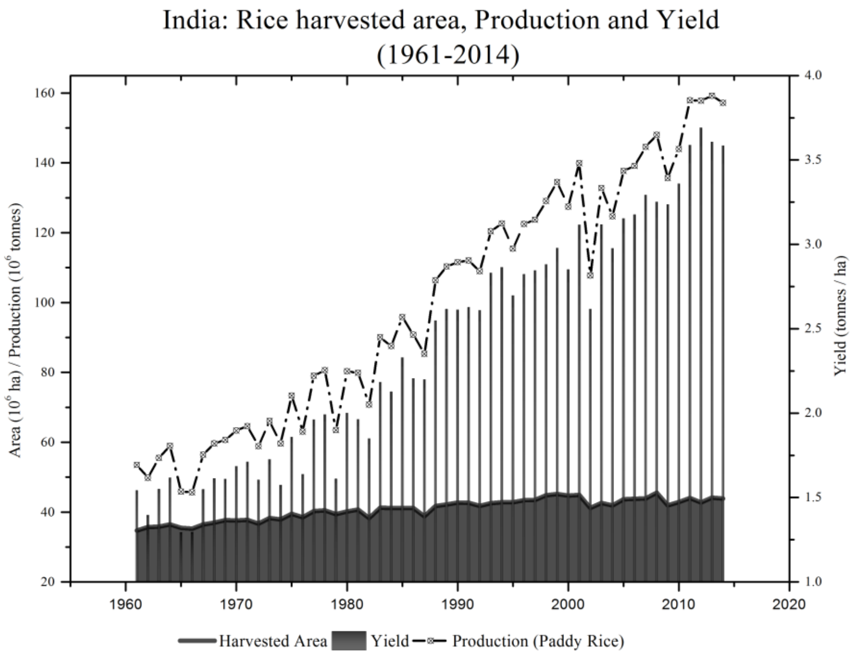

Figure 4: India: Rice harvested area, production and yield during 1961-2014.

Source: FAOSTAT, 2017

over 43.85 million hectares of land for rice production and produced 157.20 million tonnes of rice (paddy rice) in 2014 (FAOSTAT, 2017; Figure 4). During 1961-2014, 26.40% of rice harvested area was increased by India (FAOSTAT, 2017). After the 'Green Revolution', expansion of cultivating high yield varieties crop results to increase the rice production in India in past decades (Auffhammer et al., 2012). During 1961-2014, 193.89% of rice production has increased in India. The government of India emphasis on cultivating hybrid rice for increasing rice production to fulfill growing food demand. Besides, a study revealed that rice planting area is increasing at a rate of 0.27 million hectares per year in India (Zhang et al., 2016). Moreover, the yield of rice production in India was 3.58 tonnes per hectares. Figure 4 represents the production pattern of rice in India during 1961-2014.

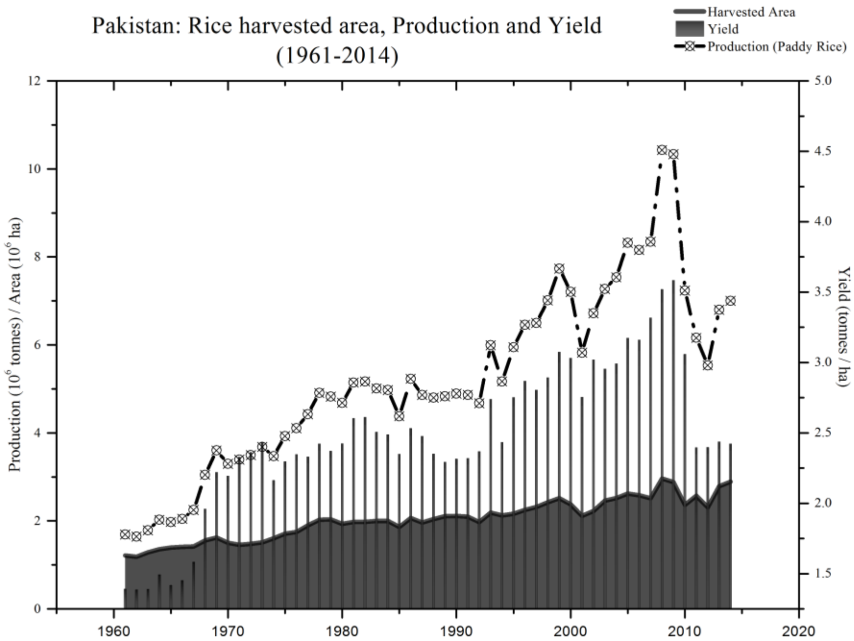

Figure 5: Pakistan: Rice harvested area, production and yield during 1961-2014.

Source: FAOSTAT, 2017

Pakistan is another dominating rice producing country where rice is the second largest demanding food. In 2014, 2.89 million hectares of land was used for rice cultivation, and the production amount was 7 million tonnes (FAOSTAT, 2017). 138.84% of rice harvested area and 314.20% of rice production were increased in Pakistan during 1961-2014. Pakistan is well known for exporting 'Basmati' rice all over the world (Bashir et al., 2007). In 2013, Pakistan extorts 3.8 million tonnes of rice (FAOSTAT, 2017). Additionally, the rate of exporting rice in Pakistan is gradually increasing. The yield of rice production in Pakistan was 2.42 tonnes per hectares in 2014 (FAOSTAT, 2017). The productivity of rice production is relatively low compared to India and Bangladesh. Figure 5 shows the production pattern of rice in Pakistan during 1961-2014.

Bangladesh is the fourth leading rice producing country in the world and second largest rice producer among the South Asian countries. In 2014, 11.32 million hectares of land was used for rice cultivation in Bangladesh (FAOSTAT, 2017). Besides, Bangladesh produced 52.32 million tonnes of rice in 2014 (FAOSTAT, 2017). As rice is the staple food in Bangladesh, achieving self-sufficiency is the prime goal of Bangladesh. Promoting the cultivation of high yield varieties and fertilizers by the governmental and nongovernmental organization helped to increase rice production in recent years. During 1961-2014, 33.49% of rice harvested area and 262.65% of rice production were increased in Bangladesh. In fact, the yield of rice production in Bangladesh was 4.62 tonnes per ha in 2014 which is the highest value among the South Asian countries (FAOSTAT, 2017). Figure 6 shows the productivity of rice and the production amount is gradually increasing over the years. Besides, the groundwater based irrigation system is the key to boost the rice production in Bangladesh.

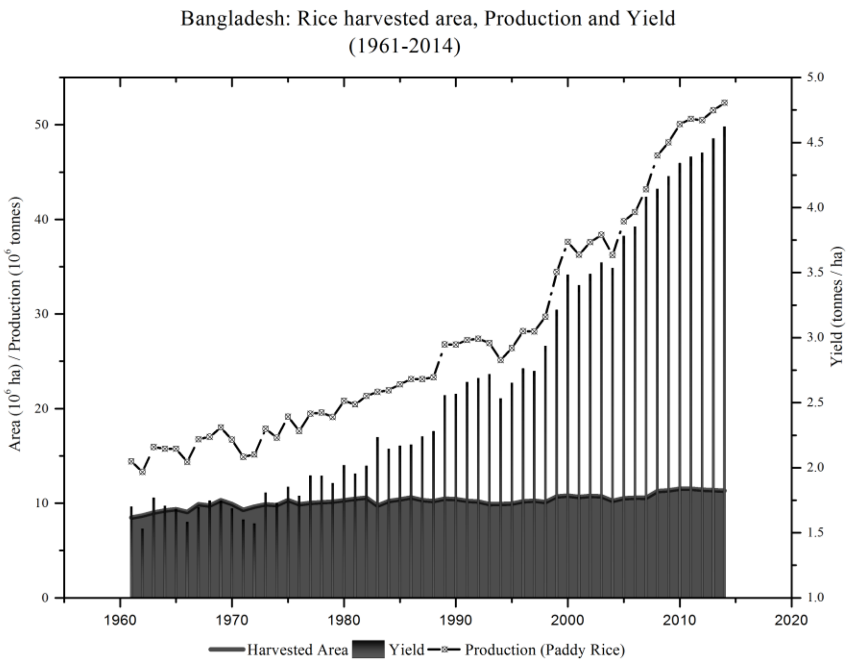

Figure 6: Bangladesh: Rice harvested area, production and yield during 1961-2014.

Source: FAOSTAT, 2017

4. CONCLUSIONS

Being the highly populated countries, India, Pakistan, and Bangladesh are the leading water consuming countries in South Asia. By using limited land and water resources, it is now a great challenge to fulfil the growing food demand. However, the agricultural practice remains almost constant in India. Meanwhile, high population growth and increasing urbanization caused to decrease the land use for agriculture in Bangladesh in recent past. Almost 6.52% of agricultural land is decreased during 1985-2014. The water demand for irrigation put stress on limited water resources. Although Pakistan and India depend on the source of surface water to fulfil more than 50% of their consumptive and non-consumptive demands, the dependency on groundwater is increasing at an alarming rate. On the other hand, Bangladesh significantly depends on groundwater to fulfil the growing water demand.

Moreover, amount of groundwater abstraction has already exceeded the rechargeable amount in Pakistan and Bangladesh that contributed to fall of groundwater table and increase in salt contamination that are serious concerns for both countries. Promoting long-term loans with low interest by the government and expansion of using local made diesel engines caused to increase the number of tube wells as well as uses of groundwater in Pakistan. In consequence, the irrigated area under surface water is decreasing in Pakistan in recent years. Similarly, in Bangladesh, the dependency on groundwater is increasing due to eliminating import duties on diesel pumps and allow importing agricultural equipment without a permit since 1983 (Rahaman et al., 2016). In addition, more than 94% of surface water in Bangladesh originates from upstream countries and inadequate surface water in the non-monsoon season results to increase groundwater uses in Bangladesh (Rahaman, 2009).

Rice is the most demanding crop and high water consuming crop. The historical changes in rice production in India, Bangladesh, Pakistan are occurred by the expansion of cultivating high yield varieties where groundwater was the primary key. As malnutrition is a notable challenge for India, Pakistan, and Bangladesh, increasing rice production by sustainably using limited water resources could minimize the hunger issue.

India, Pakistan and Bangladesh should enhance their tendency of trading products among themselves, which will allow each of them to achieve food sufficiency. Each country should give priority to produce the least water consuming crops such as potato and vegetables especially during non-monsoon months which will help to reduce the pressure on limited water and land resources. Besides, conjunctive use of surface and groundwater for irrigation and rainwater harvesting could be a way to minimize the stress on groundwater. Reducing use of groundwater and increasing irrigation efficiencies should be encouraged. The increase of surface water for irrigation during non-monsoon months should be ensured through transboundary water cooperation among the countries sharing international river basins.

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