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Agricultural Changes in North-Western India as Influenced by Green Revolution and Irrigation Water Availability

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ABSTRACT

North-western India is known as the 'Granary of India' after the introduction of wheat dwarf varieties in the mid-sixties. Dwarf gene varieties of wheat are highly responsive to inputs viz. fertilizer and irrigation water. Earlier in the *Kharif* season maize, pearl millet, minor millets and cotton were the predominant crops in north-western India i.e. Punjab, Haryana and Uttar Pradesh. However, with the increasing infrastructure for irrigation through canals, pump sets and tube wells, farmers started to grow rice even though Punjab soils are not suitable for rice production. Now, most of the farmers are growing rice in *Kharif* season and wheat in *Rabi* season. Hence, the rice-wheat cropping system has become dominant and is being practiced in nearly 10 million ha area. Farmers in north-western India also grow a lot of sugarcane crop, which produce huge tonnage but at the cost of luxury consumption of water. 'Green Revolution', which was a new chapter in the Agriculture history of India, started in this region, but it is using its water too lavishly surpassing its recharge. There is an urgent need to change or at least modify the 'rice–wheat' and sugarcane–wheat cropping systems (CS) of this region by less water-demanding ones viz. maize–wheat, cotton–wheat, soybean–wheat and pigeon pea–wheat etc. cropping systems. Even though, they may be less profitable but will ensure the sustainability of agriculture in this region in long-term.

KEYWORDS: Bhakra-Nangal dam, Ganga canal, Indira Gandhi canal, rice–wheat, sugarcane–wheat

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1. INTRODUCTION

North-western India is agriculturally an important part of India as it contributes huge basket for the food and nutritional security of India. A number of rivers flow from Himalayas, in this region namely, Ganges and Yamuna towards the east and Saraswati (now dried up and non-existent) towards the west. Five other rivers, namely, Sutlej, Ravi, Jhelum, Chenab and Vyas, flow westward and give the area the name Punjab meaning five waters. They join together to make big Sindh River. Only Sutlej remains in India, while the rest are now in the Punjab province of Pakistan. North-western India has special significance not only because of the ancient cities Mohenjo-Daro and Harappa cities (now in Pakistan) but also because all foreign invasions on India were by this region. Even Alexander the Great entered India through this side and won the first battle against the local king Porus, but was so impressed by the demeanor of the king that he gave his kingdom back to him and returned back from there, because his tired soldiers refused to fight against a mighty brave army of king Nand (Raychaudhuri, 1988). The people of this region are known for their bravery and valor.

North-western India is the home of the Green Revolution, which started with the introduction of dwarf gene wheat varieties from Mexico in the mid-1960s (Swaminathan, 2013). Punjab being principally a wheat-growing state, farmers in that state were the first to realize the importance of these new wheat varieties. The impact of grain yield increase was so distinct that William S. Gaud, Chief of the USAID gave the name "Green Revolution" to this change (Prasad, 2019). By 1970, almost the entire Punjab was growing these wheat, and Haryana and Western Uttar Pradesh followed suit. Another discovery less talked about is the agronomy of these new dwarf gene wheat varieties. Agronomists in the All-India Wheat Improvement Project soon found that these new dwarf wheat's demanded a lower temperature for germination, which was available in north-western India by mid-November (AICWIP, 1975) and not in mid-October, the traditional wheat sowing date. This provided one additional month for the *Kharif* (rainy season) crop and permitted the cultivation of high-yielding rice varieties obtained from the International Rice Research Institute, Philippines (Prasad et al., 2017) in place of traditional maize. Rice cultivation caught further momentum when ICAR–Indian Agricultural Research Institute, New Delhi bred high-yielding Pusa Basmati rice varieties (Singh, 2000), which made available rice that could be exported at premium prices in the international markets. The rice area in Punjab increased from a mere 120 thousand ha in 1950–51 to 1.644 million ha (Bhalla et al., 1990) and rice-wheat cropping system almost settled for good in Punjab. Over 10 million ha area now is under this cropping in the country (Prasad, 2005). However, rice being a water-guzzling crop has led to decline in the groundwater table drastically which needs to be arrested by replacing the rice with suitable alternate crops viz. maize, pearl millet, pigeon pea, soybean, and cotton, etc.

2. IRRIGATION WATER AVAILABILITY

Water is an essential component of human body (Prasad, 2016); about 45–75% of human body is water (Yashushi et al., 2018.). It is therefore important for the survival of humans. Most ancient civilizations developed on the banks of rivers, e.g. Egyptian civilization in Africa developed around River Nile (Billard, 1977) and, Harappan civilization in Asia around the River Sindh (Indus), Kaurav civilization around River Yamuna and in South China many civilizations developed along Yangtze River (Loewe, 1999). Even in present-day India, Moghul Emperors and the British had their capitals at Agra or Delhi on the banks of the Yamuna River (Thapar, 1966). Rivers assure water supply for drinking, bathing, navigation and agriculture and thus, assure the survival of life.

India accounts for ~18% of the world's population and has only ~4% of the world's water resources. India receives an average precipitation of 1,170 mm per year annually, but due to a lack of storage management infrastructure is able to retain only 18% of the total rainfall water received (Panda, 2011). Per capita, water availability expected by 2025 in India is only ~1457 m^3/year (Bhatt, 2016), but it was ~5177 m^3/year in 2014. If the water availability in India drops to 1000–1100 m^3 it will be a water-stress country. Water availability has always been a crisis in India, which had many famines in the past (Prasad, 2019) and even now droughts occur almost every year in one or other part of the country.

As regards annual precipitation, four identical rainfall zones are recognized by the Indian Meteorological Department, namely, north-western India (NWI), north-eastern India (NEI), central India (CI), and southern peninsula India (SPIN) (Zheng, 2016). North-eastern region (NEI) comprising the states of Assam, East Bengal, eastern Uttar Pradesh (UP), eastern Madhya Pradesh, Chhattisgarh (MP), Bihar, Jharkhand, receives the most (about 1200–3000 mm) annual rainfall, while the north-western region (NWI) comprising the states of Punjab, Haryana and western Uttar Pradesh (UP), Madhya Pradesh (western) and Rajasthan and the union territory of Delhi receives the least rainfall (about 300–700 mm), the lowest being in western Rajasthan.

With all the advantages, rivers have a major disadvantage of floods they cause, especially during the rainy season, when the water in them is in excess of what they can hold. The way of controlling floods is by making dams or barrages at some point upstream and making canals to divert the flow for irrigated areas in the dry period (Gaur, 1993). In addition to holding water, the release of water from dams also runs turbines that generate hydroelectricity. There are two dams in north-western India: 1) Bhakra-Nangal dam in Himachal Pradesh and 2) Tehri Dam in Uttarakhand and two major canals in this region.

3. BHAKRA-NANGAL DAM

It is a concrete gravity dam on the Sutlej River in Bilaspur, Himachal Pradesh in northern India. The dam forms a reservoir known as Gobind Sagar, named after Sikh Guru Govind Singh ji. The dam has a height of 226 m and the length and the width of the dam are 518.25 m and 9.1 m, respectively. Its reservoir stores 9.34 billion m^3 of water. Pt. Jawaharlal Nehru, the first prime minister of India described it as a New Temple of Resurgent India (The Indian Express, 1955). The Bhakra Canal fed by this dam provides irrigation to ~4 million hectares (40,000) km^2 of fields in Punjab, Haryana, and Rajasthan. It has a hydroelectric power generation capacity of about 1325 Mega Watts (MW).

4. TEHRI DAM

It is a multi-purpose rock and earth-fill embankment dam on the Bhagirathi River near Tehri in Uttarakhand, India. It is one of the highest dams in the world. Its height is 260.5 m and length are 575 m. Its crest width is 20 m and its base width is 1,128 m. The dam creates a reservoir of 4.0 km^3 with a surface area of 52 km^2. The installed hydroelectric power capacity is 1,000 MW along with an additional 1,000 MW of pumped storage hydroelectricity at a lower reservoir, the pump Koteshwar Dam downstream (Nawani, 2006).

Taking a lead from dams, Rajendra Singh leader of a NGO Tarun Bharat Sangh from Alwar, Rajasthan, India started a water harvesting programme by making barriers in drains and gullies to prevent the loss of rain water and use the collected water for irrigation later. They were even able to restart the dried small rivers Arvari, Ruparel, Sarsa, Bhagani and Jahajwali. He is known as "waterman of India", and won the Magsaysay Award in 2001 and Stockholm Water Prize in 2015 (The Tribune, 2006).

5. GANGA CANAL

It was made after the disastrous Agra famine of 1837–38, in which nearly 8 lakh people died, and there was a great loss of revenue to the British. The man behind making this canal was Colonel Proby Cautley of the British East India Company, who convinced the authorities that the revenue gains over years will cover the expenses incurred in its construction. Ganga canal has its own catchment area. It is 560 km long with branches 492 km long and the various tributaries make it over 4,800 km long. It was made to irrigate the *Doabs* (two waters) area between Rivers Ganga and Yamuna in Uttar Pradesh. It has two branches. The Upper Ganges canal is the original *Ganges Canal*, which starts at the Bhimgoda Barrage near Harki Pauri at Haridwar, traverses Meerut and Bulandshahr and continues to Nanau in Aligarh district, where it bifurcates into the Kanpur and Etawah branches After irrigation was commenced in May 1955 (The Indian Express, 1955) over 3,100 km^2 in 5,000 villages were irrigated. The dam was faced with many complications- among them was the problem of the mountainous streams that threatened the canal. Near Roorkee, the land fell sharply and Cautley had to build an aqua-duct to carry the canal for half a km. As a result, at Roorkee the canal is 25 m higher than the original river. When the canal formally opened, its main channel was about 560 km.

6. INDIRA GANDHI CANAL

The Indira Gandhi Canal was proposed by a hydraulic engineer Kanwar Sain in the late 1940s, who pointed out that 2 million ha of desert land in Bikaner and the north-west corner of Jaisalmer could be brought under irrigation from the stored waters of Punjab Rivers. In 1960, Indus Water Treaty was signed between India and Pakistan which gave India the right to use waters of three rivers –the Sutlej, Beas and Ravi. It is the longest canal of India. It starts from the Harike Barrage at Harike, a few km below the confluence of the Sutlej and Beas Rivers, it was formerly known as Rajasthan canal but was renamed as Indira Gandhi Canal on 2 November 1984 following the assassination of Prime Minister Indira Gandhi.

The canal consists of the Rajasthan feeder canal with the first 167 km in Punjab and Haryana states and a further 37 km in Rajasthan followed by the 445 km of the Rajasthan main canal, which is entirely within Rajasthan. The canal enters Haryana from Punjab near Lohgarh village then runs through the western part of the Sirsa district before entering Rajasthan near Kharakhera village in the Tibbi tehsil of the Hanumangarh district. The canal traverses seven districts of Rajasthan: Barmer, Bikaner, Churu, Hanumangarh, Jaisalmer, Jodhpur, and Sriganganagar.

7. GROUNDWATER

In addition to surface water in rivers and canals ground water is an important part of overall water supply. Ground water in India is estimated at 432 m^3 and the annual recharge of aquifers is estimated at 359 m^3 (Panda, 2011). Groundwater meets about 50–60% of domestic needs and 40–50% of irrigation needs of the country and is vital for the survival of the people of the country (Kumar et al., 2005). However, groundwater is being used lavishly in India and according to an estimate of World Bank (Briscoe and Malik, 2006) about 60% of aquifers in India is in a critical condition. This has raised the issue of sustainability of rice–wheat cropping system (Prasad, 2005; Bhatt et al., 2016) in north-western India. Tyagi et al. (2012) observed that underground water use has increased about six times in the last 55 years (1950–2005). Rice–wheat cropping system producing 10–12 tonnes ha^{-1} y^{-1} needs on an average 11,650 L^3 water ha^{-1} (7,650 L^3 for rice and 4,000 L^3 for wheat) (Bhatt et al., 2016). However, because of this cropping, system, the state of Punjab is facing acute water shortage as the groundwater depletion is at a higher rate than its recharge due to rice cultivation. Kaur et al. (2015) reported that withdrawal from ground water has increased considerably in all the 3 regions of Punjab studied by them (Table 1). Unreliable surface water supplies coupled with excessive ground water pumping, due to free electricity to farmers has led to a long-term groundwater decline of 41.6 cm $year^{-1}$ in the state of Punjab (Kaur, 2017; Tur, 2018). Some of the damage to ground water has also been done in western Uttar Pradesh due to excessive tube well pumping for irrigating sugarcane (Mathur, 1970; Shrivastava et al., 2011).

Table 1: Withdrawal from ground water (expressed as % of recharge)

Zone	1984	2011
North	49	103
Central	142	197
South-Western	32	138

Source: Kaur et al. (2015)

8. SUGGESTIONS FOR FUTURE

Green revolution in India was started in north-western India through introduction of dwarf gene wheat varieties, which were fertilizer and irrigation responsive. In general, north-western India has a good spread of canals, but it is using its canal and ground water too lavishly due to rice–wheat rotation and ground water level in the wells is dropping fast. Some serious measures need to be adopted to prevent it. Following suggestions need consideration to avoid declining ground water table in north-western plain zone of India:

1. There is an urgent need to change the cropping system at least once in 2–4 years. Both rice and sugarcane are water guzzling plants (Table 2). The alternative cropping systems to rice–wheat or sugarcane–wheat cropping systems are: maize–wheat, blackgram/cowpea–wheat, groundnut–wheat, soybean–wheat and cotton–wheat, maize–mustard, blackgram/cowpea–mustard. In addition to low water requirement (Table 2), these cropping systems have additional advantages. Blackgram, cowpeas, soybean and groundnut are legumes and are likely to improve the soil fertility. Blackgram and cowpeas will also help in overcoming the protein deficiency in the country. Groundnut will help in overcoming both, the edible oil and protein deficiency in the country. These alternative cropping systems are also quite profitable. Kiran Kumar et al. (2013) reported from Delhi a net profit of Rs. 58,800 from maize–wheat and Rs. 72,100 from groundnut–wheat cropping systems at Delhi. Solvation process of oil extraction leaves groundnut seeds intact, which can be used in making snacks and candies. Groundnut cultivation will encourage the development of oil extraction factories and mini snack/candy industry, providing livelihood to many.

Table 2: Water requirement of some crops

Crop	Water requirement (mm)	Crop	Water requirement (mm)
Sugarcane	2200	Rice	1250
Maize	500	Black gram	280
Groundnut	510	Cotton	600

Source: TNAU Agric. Portal (via internet)

2. Grapes can be successfully grown in Punjab (Chanana and Gill, 2008). Some of the present area under rice-wheat cropping system can be diverted to grape cultivation leading to development of wine industry. Wine can be exported, which will earn foreign exchange. This will also create additional jobs.

9. CONCLUSION

Water scarcity is going to become a serious issue under the climate change scenario and further increasing demand for sustainable intensification agriculture. We need to use water resources judiciously for increased productivity, profitability and environmental safety. Therefore, some of these suggestions also hold true for areas under sugarcane-wheat cropping system in western Uttar Pradesh. Farmers need to consult State Agricultural University Scientists in their area for guidance. The above-suggested changes will lead to prosperity and change the face of north-western India.

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