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Strategies for Efficient Use of Natural Resources to Sustain Agricultural Production in Indo-Gangetic plains

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ABSTRACT

The natural resources are at stack and creating very alarming situation for the future under irrigated and rain fed conditions. The adoption of rice-wheat system in Indo-Gangetic plains greatly contributed to India's food self-sufficiency and livelihood of millions of people. However, deterioration of soil health and its quality, ground water depletion and climate change are jeopardising the sustainability of rice-wheat cropping system. Traditional agronomic practices had various negative implications on the agricultural sustainability. The naturally available resources are now under threat because of their irrational use. A perspective strategic plan is delineated to efficiently utilize these resources so that the agricultural production can be made sustainable for long time. Some technologies for efficient management of water, soil and air resources have been suggested which can be helpful in saving irrigation water, maintain soil productivity and decrease climate change.

Key Words: Depletion of underground water, Natural Resources, Soil degradation, Soil productivity, Sustainability.

INTRODUCTION

The rice–wheat crop rotation has led to a manifold increase in irrigation water demand. Unreliable surface water supplies coupled with excessive groundwater extraction due to free electricity (in Punjab) and agricultural practices, has led to a long-term groundwater decline of 41.6 cm/yr in the state (Baweja *et al,* 2017). The recent report published in 2022 by Central Ground Water Board and IIT, Hyderabad have shown that 73.4, 3.5, 9.1 and 14 percent area of Punjab is overexploited, critical, semi critical and safe with respect to underground water use. Now in Punjab 13.83 million Acre feet (MAF) total water is available through surface and underground recharge from all sources. The water pumped out to meet irrigation requirement of crops (21.62 MAF) and domestic and industrial use (1.08 MAF) is 22.7 MAF. Thus, there is a deficit of 8.87 MAF which is met through overexploitation of groundwater. Groundwater management is the key to combat the emerging problem of water scarcity. Rice and wheat are also the exhaustive cereal crops that lead to a heavy depletion of soil nutrients, and the problem is further aggravated when farmers burn the rice crop residues left in their fields after mechanized harvesting. Air pollution from crop residue burning also causes human health problems.

The major challenges related to water, soil and air that affect the sustainability of rice-wheat system can be managed as:

A. Management of ground water resources

The following approaches should be adopted for the best use of water resource:

- Timely sowing and transplanting of paddy: The Punjab Preservation of Subsoil Water Act, 2009, prohibits farmers from sowing nursery of paddy before 10th May and transplanting paddy

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before 10th June in a year. The main purpose of the Act was to save groundwater by prohibiting sowing and transplanting paddy before specified dates in hot and dry periods. With the successful implementation of this Act, it is estimated that 276 million units of electricity can be saved and the fall in water table can be checked by about 30 cm (Singh, 2009).

- Direct seeded rice also helps to save substantial quantity of water because no puddling is required and irrigations are applied at 3-5 days interval led to save water substantially. Moreover, the crop does not suffer from transplanting shock and crop take about 10 days less for maturity. Adoption of short duration rice varieties are recommended for cultivation for example PR115 and IR36.
- Alternate wetting and drying: It has been observed that farmers in Punjab keep on water ponded in transplanted rice fields continuously, which is not required. Researchers have made it clear that there is need to keep standing water in rice field just for first 15 days after transplanting in order to establish the crop more vigorously and to enhance the use efficiency of applied herbicides thus keep weeds under check. After that irrigation should be applied as and when ponded water is percolated in the soil. This practice can save irrigation water consumption up to 25 per cent.
- Crop diversification: The promotion of basmati rice over the common paddy is often suggested as an option to reduce the groundwater demand in the light of less water requirement by the former and on account of the growing season of basmati rice coincidence with the rainy season (Hindustan Times, 2014). A shift in the cropping pattern away from Rice-Wheat to a Maize-Wheat has been one of the suggestions to curb the groundwater depletion since the submission of Johl committee report in 1986 (Sarkar and Das, 2014). However, under the prevailing conditions of free electricity supply and minimum support price, paddy will remain the most remunerative crop (Sarkar and Das, 2014) and farmers may not move towards diversification until incentivised by economically attractive alternatives. However, keeping in view the prevailing water and soil health conditions of Punjab, there is dire need to reduce some area from paddy crop. Another problem has been created by some private companies who have started cultivation of spring maize for silage production. The water requirement of spring maize is at par with that of paddy. On the other hand, the area under cotton is not increasing rather it has been drastically reduced in south-west Punjab during the year 2023-24. Therefore, there is an urgent need to acquaint the farmers for efficient use of natural resources particularly irrigation water.
- Artificial recharge: The Central Ground Water Board (2013) has proposed new schemes on artificial recharge and aquifer mapping and management under the Twelfth Five-Year Plan period (Planning Commission, 2013). In this, about 79,924 structures in rural and 375,000 in urban areas are proposed for the Punjab State. It is estimated that influence of recharge scheme will be observed about 26,650 km^2 area and it will help to check decline in water level.
- Laser land levelling: A remarkable innovation in the water conserving technique which saves 25–30 per cent water and increases water and nutrient use efficiency through uniform depth of water. Likewise, it improves germination, crop stand, productivity, resource use efficiency and farm profitability.
- Using appropriate method of irrigation: Apply irrigation to the crops based on criteria for applying irrigation to the crops *viz.,* soil indices, climatic parameter or plant indices. It helps the sizeable saving of water. Moreover, the right method of irrigation are considered highly useful to enhance the use efficiency of irrigation *viz.,* Ridge and furrow method of irrigation,

drip and sprinkle method of irrigation save substantial amount of irrigation water.

- Watershed management under rainfed conditions: The adoption of watershed management approach is a boon. It has catchment area and command area. The catchment area sheds water to a given point *viz.,* dam, reservoir, tank, pond. The command area where water is used for applying irrigation using gravity method. This approach not only enhances the productivity of crop but also sustained the productivity along with the conservation/ improvement in the ecological balance. In the catchment area, the economic value plants viz. timber plants and Bhabar grass as inter crop during rainy season are planted after digging trenches across the slope. These dug out tunnels act as water barrier and help to retain water. More the covered space in the catchment area ensures the regular flow of clean water without carrying soil in the reservoir. The other benefits of watershed can also be availed *viz.,* multiple use of water, adoption of integrated farming approach, recharging of ground water, making condition favourable to ecology and also create the employment along with ensuring the regular income flow.
- Use of poor quality water: In areas where the underground water is of poor quality should also be used by following precaution measures such as conjunctive use of water:
    - The poor quality is applied after mixing with good quality water. On account of dilution of salt, the crop growth is not affected.
    - The poor quality water should be avoided at germination (early stage).
    - The conjunctive use of water can be given in alternate row, to save water.
    - The salt amendments should also be used in the field on the basis of soil test.
- Domestic use of water: Every household use water and water should be saved by following measures:
    - Not keeping water taps running.
    - Check water leak and repair.
    - Adopt minimum water use pattern.
    - Installing water saving toilet that use optimum water for flush.
    - Collect waste water in your home and use it for watering kitchen garden.
    - Watering lawn and kitchen garden plants in the evening to minimize evaporation losses and not watering then in the midday.

B. Management of soil resources

The following measures should be adapted to take care of soil resources.

- Recycling of crop residues: For the last so many years, different innovative rice residue management strategies have been developed including in situ residue incorporation and zero-till sowing of wheat with surface-retained rice residue. These technologies have many benefits over rice residue burning, such as improving soil health, creating a positive nutrient balance in the soil, decreasing environmental pollution, and ultimately lowering the cost of cultivation.
- Inclusion of legumes in crop rotation: It is one of the agricultural practices in which different crops are grown in the same area following a rotation system which helps in replenishment of the soil. A short window of about 65–70 days *i.e.,*after harvesting of wheat and before transplanting of rice, can be utilized as an opportunity to include short-duration legume crop such as mungbean. Inclusion of short-duration mungbean after wheat harvest has the potential to increase productivity of rice–wheat system, besides improving the physical and chemical properties of soil. The incorporation of mungbean or Sesbania green manuring into soil also resulted in recycling of 77–113 kgN/ha and

improved plant nitrogen uptake by 12–35 kg/ha/year, besides increasing the productivity of rice–wheat system by 0.5–1.3 t/ha/year (Khedwal*et al,* 2022) over rice–wheat system without summer crop. Inclusion of legumes in the cropping system enhanced the nitrogen economy and also contributed to cropping systems' sustainability (Arora *et al,* 2020).

- Ridge and Furrow formation: Soil erosion is one of the factors responsible for land degradation. It can be prevented by formation of ridge and furrow during irrigation which decreases the run-off.
- Construction of Bunds: This usually checks or reduces the velocity of run-off so that soil support vegetation.
- Plantation of Wind brake: It is the common method to reduce the velocity of wind which cause soil erosion and harm the crop by lodging and dropping of fruits.
- Plantation of vegetative barrier across the slope: This practice has also proved very effective where in SaccharumMunja(*Cynodondactylon*), *Arundodonax* and *Sorghum halepense*planted at 50 m interval across the slope help to retain water and siltation takes place. Only decant filtered water moves to the next strip and ultimately soil and water both are conserved.
- Formation of terraces: The small fields are levelled at different elevations and for disposal of excess water, the brick structures are installed in each field. The exit point of structure has high level than the field, which restrict water up to certain depth allowing to settle down the soil particles and only excess water free from silt comes out to the nearly field. The same processes are adapted in the lower field. The excess water of the farm is stored in dam/ tank/reservoir and can be used for life saving irrigation or supplemental irrigation. The only precaution kept in mind the brick structure installed in the bunds in different field from high elevation to lower elevation should be in a zigzag manner to reduce the flow water disposal rate from the field.
- Riparian farming: The trees are planted along the river embankments. The inter space is planted with perennial grass such as Napier bajra which acts as a barrier and help to filter the water through vegetative barrier and siltation is drastically reduced in the river, canal or water disposal stream.

C. Management of air pollution/climate change

The following measures should be adopted

- Reduce, Reuse and Recycle: Buying products with minimal packaging will help to reduce waste. By recycling of your household waste, one can save 2400 pounds of carbon-dioxide annually.
- Use less heat and air conditioning: Adding insulation to your waste and installing weather stripping or caulking around doors and windows can lower your heating cost by 25 percent.
- Replace light bulbs with compact florescent light(CFL) bulbs.
- Drive less and drive smart: Less driving means few emissions. Besides saving gasoline, walking and biking are great forms of exercise.
- Plant a tree: Tress absorbs Carbon-dioxide and give off Oxygen. A single tree absorbs approximately one ton of CO2 during its life.
- Carbon sequestration concept: It helps of strong carbon in a carbon pool. Carbon-dioxide is naturally captured from the atmosphere through biological, chemical and physical processes. It is the one method to reduce the CO2 in the atmosphere with the goal reducing global climate change.
- Stop burning of crop residue: The emission from burning crop residues consist of methane (CH4) and nitrous oxide (N2O), carbon mono oxide, carbon dioxide gasses produced by the

combustion of a percentage of crop residue burn on site. Moreover, it increased level of particulate matter and smog that cause health hazard, loss of bio-diversity of agricultural land and deterioration of soil fertility.

- Adoption of conservation agriculture: The technology evolved for using second generation machinery such as happy or smart seeder, which can sow crop in the standing stubble and crop residue without cultivating the soil complete provides the solution of crop residue burning. This practice helps to benefit the ecosystem in following ways:
  - No cultivation saves fossil fuel thus avoiding pollution.
  - It improve the soil fertility when decomposes with the passage of time.
  - It conserves water in the soil.
  - The water is saved while applying first irrigation on account of hard soil surface.
  - It reduces the heat terminal effect by keeping the soil moist when abruptly temperature increases.
  - Time is saved and ensured timely sewing of crops thus increasing productivity.
  - It reduces the cost of cultivation and checks the pollution problem.

CONCLUSION

On the basis of these strategies, it is imperative to conserve the natural resources by strictly following these conservative measures. The groundwater demand can be reduced by adopting efficient irrigation practices/technologies *i.e.,* micro irrigation, bed planting, laser levelling, zero tillage, crop diversification, and others. The soil resources must be avoided from the various degradation processes. The efficient management of water resources under rain fed conditions will enhance water productivity. The adoption of conjunctive use of water where underground of water is of poor quality can save good quality water. The recharging of groundwater can take care of underground water. The climate change has taken places and proved true. The ways and means discussed here will help to check the menace to some extent in the coming future. Therefore, it is the duty of every person on earth to think twice about the natural resource if we want to protect the planet from natural calamities. The policy makers have already made some efforts to prevent further depletion of this resource, like delayed paddy transplanting; implementation of various artificial groundwater recharge schemes; promoting crop diversification of low water consuming crops and providing training and subsidies for promoting drip, sprinkler, and poly house technology. All these activities need to be adopted in the right spirit and in a holistic manner for tangible results. Also, there is a need to strengthen more people participatory projects to create public awareness regarding the natural resource degradation and its management

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