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Agroecology-based Biodiversity Management

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The Green Revolution helped India to avoid famine and destruction and ensured food security in most developing countries. Currently, India is not only self-sufficient in food production but also has foodgrain buffer stocks. This agricultural growth revolved around harnessing genetic potential of major food crops developing via high input responsive improved varieties. In the long run, these agricultural technologies, that contributed to food security of an ever-growing population, led to soil degradation, water and air pollution and loss of biodiversity. In order to tackle these negative consequences, agroecology-based agriculture is catching up globally for sustainable development. The agroecology principles are relevant to organic farming, regenerative agriculture, conservation agriculture, nature-based agriculture and several other traditional agri-food systems. Common principle among these traditional agri-food systems is protecting the natural resources including vulnerable bioresources. Using rich crop and landrace/farmer varietal diversity that are nutrient dense, pest resistant and resilient to climate aberrations is a sustainable approach. It is in this context, the need for identification and enhanced use of genetic resources that demand minimal or no chemical inputs yet possess the potential to meet the growing food demand.

Introduction

The extreme and indiscriminate adoption of the modern agricultural technologies for higher crop yields has shown its baneful effect over the years. Consequences are deterioration of soil fertility (75% of the earth's land is degraded losing 36 billion tons of soil annually). The Food and Agricultural Organisation indicated that due to soil degradation, only 60 harvesting years are left and this is a major concern for the growing population (FAO, 2016). Fertiliser consumption has increased from 12.4 kg/ha in 1969 to 133.4 kg/ha in 2020. The imbalanced use resulted in a declining fertiliser crop response ratio from 123.47 kg grain/kg in 1970 to 3.70 kg grain/kg in 2005. During 2020-21, the Government of India spent Rs 127,921 crore on fertiliser consumption and the nation consumes pesticides worth Rs 6,000 crores. The extreme consumption of agrochemicals has led to contamination of water, soil and air, thereby reducing crop productivity (Smith *et al.*, 2013). Conventional chemical farming increased the cost of cultivation and led Indian farmers to debt trap. Climate change has further aggravated the situation and yield losses have led to 1.5% loss in GDP on annual basis. Do we have alternatives to arrest plant biodiversity loss? Can we revive natural systems through enhanced use of crops and landraces diversity?

Challenges

Modern agricultural practices have promoted monocropping in only five major crops compared to fifty crops commonly cultivated in traditional agricultural systems about eight decades ago. Traditional cultivars and landraces have largely replaced with improved varieties and hybrids. Thus, several wild relatives of crops, neglected and underutilized crop species are now conserved only in ex-situ genebanks and have almost disappeared from the cultivation. India is one of the eight important *Vavilovian* centers of origin and crop diversity. India has 8% of the total global biodiversity with an estimated 49,000 species of plants of which 4900 are endemic (Anil *et al.*, 2014). In addition to several sacred groups maintained by indigenous communities, institutional efforts have led to establishment of 514 wildlife sanctuaries and 102 national parks including 18 biosphere results covering about 5% of the total geographical area. India has institutionalized agrobiodiversity management with five Bureaus under ICAR with the mandate of collection, conservation, evaluation and documentation. In spite of conscious institutionalized efforts to conserve, there has been severe biodiversity loss at ecosystem level and at farm level.

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Components of Agroecology and the importance of Biodiversity

Agroecology is the holistic integration of concepts and principles of ecology, science and technology, practices, economics, political, and social processes for the sustainable management of agriculture and food from production to consumption (FAO, 2022). It provides a strategy to increase the diversified agro-ecosystem, i.e., by promoting the effectiveness of plant, animal biodiversity, and nutrient recycling through the use of natural resources systems, like, legumes, trees, livestock, etc. and thus making the food and societal system sustainable (Tripathi et al., 2015). This system can support the huge production in quantity and quality of diverse food, fabric, and medical crops both for family consumption and market, as this reduces the risk of nutrition as a whole. Agro-ecosystem on which our food and agriculture production system depends is provided by biodiversity or in general it is biodiversity-based agriculture, addressing the current crisis. These two are central for food security and climate resilience and guide us in managing and mitigating health and climate shocks and crises.

An experiment conducted in all districts of Andhra Pradesh to see whether the birds returned to the natural farming adopted landscapes revealed a substantial difference in bird visits between farms that use agroecological techniques and those that use chemical farming methods. Natural farming practices increased the micro-climate for birds with lower temperatures compared to outside temperatures and a variety of bird species lay eggs and stay for longer periods in natural farming fields (Hussain et all, 2022). Shift from intensive farming to adopting agroecology or natural farming can increase the soil organic carbon pool, enhance soil quality, and increase soil resilience to adjust to the extreme climate effects. Similarly, recycling of nutrients, forage yield, pollination, resistance to weed infestation, etc. are some of the ecosystem services and ecological functions in agroecosystems (Dumont et al., 2013).

Traditional agricultural systems and promoting landraces

Several localized traditional agricultural systems have evolved over millennia of years suited to the soils, weather and local food and fodder needs. These systems were eco-friendly and sustainable. An innovative collaborative effort is being made by Watershed Support Services and Activities Network (WASSAN), an NGO, to document and experiment to understand the principles behind these systems (Table 1). Traditional agricultural systems that have the potential to be recognized as Heritage systems in India are documented with details of locations of practice and their unique features (Singh and Rana, 2019).

Table 1. Localized traditional agricultural systems documented and experimented by WASSAN (https://www.wassan.org)

Hangadi Kheti, Barediyo, or Hath-hangdo	Tribal junction of the state of Gujarat, Rajasthan, and Madhya-Pradesh
Akkadi Saalu/Saalu Bele/ Mishra Bele	Karnataka
Olya, Sat-Gajra	Madhya Pradesh
Nau Anja	Himachal Pradesh
Pata	Maharashtra
Kurwa	Jarkhand
Rammol	Gujarat
Panamkuthu	Kerala
Misa Chassa	Odisha

Lakhs of indigenous varieties have been permanently lost (John and Babu 2021). Diversification of agriculture refers to the shift from the regional dominance of one crop/varieties to regional production of a number of crops/ varieties. It aims to improve soil health and a dynamic equilibrium of the agroecosystem. Crop diversification takes into account the economic returns from different value-added crops. Diversified farms are usually more economically and ecologically resilient.

These technologies have continued to exist only in rainfed areas. Nutrient dense landraces evolved over thousands of years in the rainfed ecosystem with local relevance to cultural and organoleptic needs of the communities. They have distinct advantage of resilience to climate change effects. Neglected and underutilized species and minor crops remained out of the formal seed system. Hence there is a need to develop an alternative seed system to meet the requirements of rainfed areas. Such an alternative seed system should aim to enhance crop and varietal diversity; promote landraces that are adopted to local soil types and multiple cropping systems; access to seed in times of contingencies; reasonable price margin between seed and grain; intrinsic conservation of crop diversity in the ecosystem and timely access to quality indigenous seed by encouraging local Farmer Procedure Organizations (FPOs). Operationalization of such an alternative seed system will bring the following benefits to rainfed farmers.

1. Resilient diversified cropping systems; availability of quality seeds
2. Enhanced farmer income [e.g. Navdanya crop system in Anantapur, the most drought prone district, increased the farmer income by about rupees 15000 per acre]
3. Increased productivity [e.g. Ragi local (*Pedda Chodi*) productivity improved from 4 quintals to 8 quintals per acre in Andhra Pradesh and Odisha; paddy landrace Kalachampa promoted by Department of Agriculture Odisha yielded more than local checks].
4. Enhanced market share with premium price [landraces viz. black rice, brown rice, short grain scented rice, etc.]

Enhanced household food and nutritional security [due to enhanced access to pulses, oilseeds and millets owing to multiple and mixed cropping systems]

New Paradigm for Indian Agriculture

The Government of India has come up with an approach for Indian agriculture to shift from agroindustry to agroecology farming. Five main areas through which agroecology can point a new way for agriculture are 1. Reduced reliance on pesticides, 2. Enriching biodiversity, 3. Revitalising small farms, 4. Creating alternative animal production systems and 5. Enhancing urban agriculture (Neelam Patel *et al*., 2022). It is also important modify and revise varietal release criteria with:

- Focus on evaluation in eco-geographic regions/ districts from where the landrace cultivated/ collected/originated
- Farmers' yields based on crop cutting experiment documented by the State Department of Agriculture considered
- Nutrition, local preference, cropping system and resilience to climate and biotic stresses value considered
- A comprehensive on ground pilot study encompassing all components of alternate seed system is needed.

Conclusion and Action Points

There is an urgent need to shift from the current chemical based agri-food system to a system that aims to provide a *one-health ecosystem to plants, animals and humans*. In a large chunk of landrace diversity is still with rural and tribal communities. These communities are holding this diversity and conserving them on-farm through use for reasons of taste, religious use, food preference and other organoleptic properties.

1. Participation of communities and general public in conservation through use and exchange of material/ knowledge with the genebanks/seed banks needs to be facilitated through appropriate policies in place.
2. Granting rights to group or individual claims on farmer varieties by the Plant Variety Authority is illogical and all the farmer varieties shall remain as nation's property. There is a need to revise policy and define process of establishing sovereign rights of India linking contributing communities.
3. Changing genebank's approach on accession-oriented collecting, evaluation and conservation to respecting communities' wisdom precipitated through several generations.
4. Benefit sharing implementation needs to be strengthened; the logic of pre-CBD collections not attracting benefit sharing is illogical.
5. Substantial increase in investments by governments on community seed banks facilitating access to quality seeds of farmers' varieties that are locally produced and locally consumed.
6. National Agricultural Research System to invest more time and resources on mainstreaming farmer varieties particularly in rain-fed areas.
7. Science based examination of traditional systems that encourage use of local biodiversity for sustainability, ecological stability and one-health.

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