

Synergy among knowledge systems

for sustainable agriculture: Lessons for G20 nations from India

Ranjay K Singh*, Dheeraj Singh and Sanjit Maiti

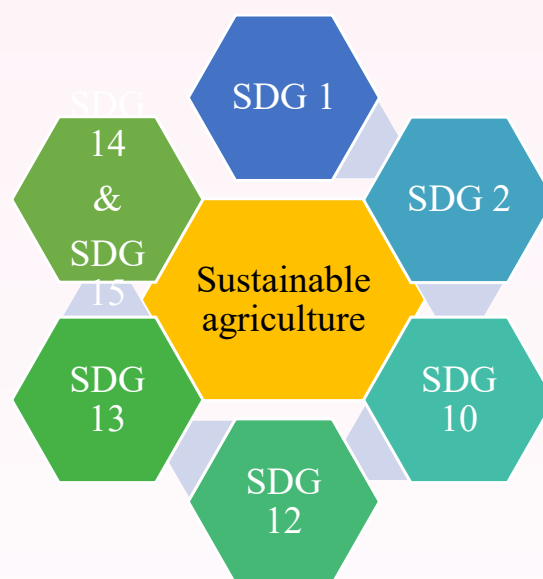
Division of Agricultural Extension, Indian Council of Agricultural Research, New Delhi 110 012

Agricultural sustainability is essential for addressing climate change, arresting biodiversity loss and ensuring food security. However, a balanced relationship between cultural ideals, environmental conditions and economy is crucial for using, and creating new information through a synergy among the knowledge systems. Agricultural communities world over have evolved local knowledge systems that help in conserving natural resources, while scientific knowledge, developed by agricultural research institutions, play vital role in either eliminating agricultural issues directly or through strengthening local knowledge systems. Additionally, agricultural extension services gather and integrate such knowledge systems by constantly interacting with farmers and other stakeholders. These diverse knowledge system and related practices may aid context-specific management of agricultural resources and strengthening resilience strategies. Such resources are valuable in developing agricultural technologies, capacity building and coherent policies for G20 nations. With sharing and collaboration on knowledge systems, policy coordination, financial support to developing nations and partnerships, G20 nations can facilitate debates on knowledge management system and ensuring the sustainable agriculture.

Keywords: Agricultural sustainability, Collaborations, G20 countries, Knowledge systems, Reciprocal learning

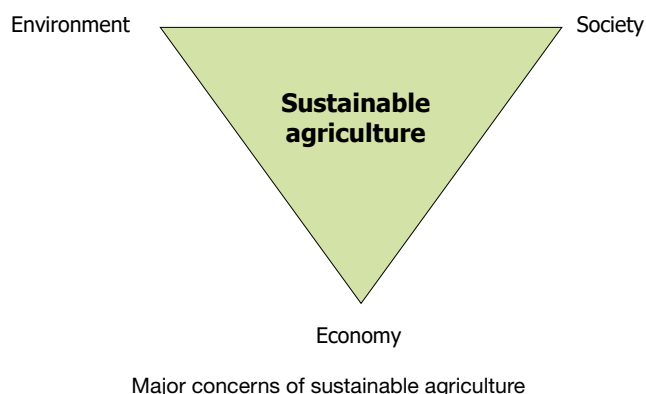
FOOD and Agriculture Organization (FAO) has defined sustainable agriculture as the efficient production of safe, high-quality agricultural products, in a way that protects and improves the natural environment, the social and economic conditions of farmers, their employees and local communities, and safeguards the health and welfare of all farmed species. It can help achieve several UN Sustainable Development Goals (SDGs), including those on poverty (SDG 1), hunger (SDG 2), inequality (SDG 10), responsible consumption and production (SDG 12), climate change (SDG 13), and ecosystem health (SDG 14 and 15), as well as local and national development and environmental goals. It is a farming approach that balances the long-term needs of the environment, society and economy while supplying enough food, fibre and other agricultural products for a growing population and helps in maintaining agricultural production within economic, environmental and social boundaries.

Sustainable agriculture integrates the environment, society and economics into a holistic framework. Environmental management and resource conservation



Sustainable agriculture and supported SDGs

enhance ecological balance and ecosystem health. These strategies ensure farmers have productive



resources, making agricultural systems economically viable. Social equity and fairness principles, however, promote inclusive participation, gender equality, and human rights in agriculture, ensuring a more equitable distribution of resources and opportunities. This social dimension helps farming communities from across the groups to adjust to the environmental and economic challenges. In this process, integrating traditional and modern knowledge, collaborating, and sharing knowledge boosts innovation, capacity building, and sustainable farming with environment security. Five key principles for guiding the strategic development of new approaches and the transition to sustainability, according to Food and Agriculture Organization of the United Nations are: (i) Sustainable agriculture requires resource efficiency improvements; (ii) It involves direct action to conserve, protect, and enhance natural resources; (iii) Agriculture that doesn't safeguard and develop rural livelihoods and social well-

being is unsustainable; (iv) It must strengthen people, communities, and ecosystems, notably against climate change and market instability; and (iv) Good governance sustains natural and human systems.

In this context, knowledge systems and innovations drive the adoption of sustainable agriculture methods, allowing farmers to maximize productivity while reducing environmental damage. Knowledge systems help farmers, researchers, and other stakeholders improve sustainable agriculture by providing crucial insights, guidance, and tools. Knowledge systems from indigenous methods to modern scientific research help us understand and implement sustainable agriculture. This knowledge synthesis helps in learning the intricate relationships between natural systems, human activities, and agricultural production. It also helps farmers find new solutions to soil degradation, water scarcity, and pest management. Sustainable agricultural innovations, from technology to social and policy, have the ability to change agricultural output and consumption. These advances boost farmers' productivity and support environmental protection, social equality, and rural development. Precision agriculture technologies, biotechnology, genetic engineering, and novel financing and policy frameworks that encourage sustainability methods are examples of such developments.

Types of knowledge systems in sustainable agriculture

Traditional knowledge system: Indigenous and local communities world over have evolved and passed down local wisdom, practices, and belief system, termed as 'traditional knowledge' that help to manage

Success story

Intervention: Establishing resilience with soil moisture conservation and coping multiple stresses

Availability of good quality irrigation water in many arid regions has been a major stress for the farming communities. Farmers of such regions, for instance, Rajasthan India, have evolved a number of local soil and water conservation practices which are blended with scientific knowledge and institutional resources to manage agricultural risks. For example, farmers (Hemawas village) of Pali district, Rajasthan harvest water in open-well and conserve residual soil moisture to grow wheat, mustard and muskmelon crops in order



Cultivation of muskmelon in conserved soil moisture (rainwater harvesting); and adopting improved mulch technique in rainfed agroecosystem

to diversify crop produce, reduce crop failure risks and maintain soil health. While cultivation of cover crops, such as muskmelon, scientific knowledge of crop variety, improved varieties of wheat (e.g. salt tolerant KRL-210) and agricultural inputs are adapted. Farmers also practice the mulching technique using organic matter to conserve soil moisture and take vegetable crops to diversify the farming system. The required resources including water, labour, cost and sometime other inputs are managed through exchange, sharing and pooling mechanism. Farmers navigate in accessing institutional resources (knowledge and inputs) and markets to fetch good produce price. Such institutional arrangements offset the drudgery, and also provide opportunity to learn, organize and plan the local soil and water management practices thus enhances social-ecological resilience. These strategic adaptations help farmers to spread the livelihood risks caused by not only the climate, but also the ecological and socioeconomic factors and thus contribute in multiple ways to sustain agroecosystem services (ecological, provisional and regulatory).

Success story

Intervention: Agrobiodiversity conservation for multiple outcomes

Farmers of Rajasthan (Pali district) are exposed to multiple stresses which include climate change, land degradation (soil and water salinity), lower socioeconomic status and poor access to institutional resources. As a result, the agriculture and associated livelihood are always at higher risks. Although, farmers try to explore and adopt scientific knowledge and external inputs to adapt such challenges, they also prefer to use local knowledge of conserving and using indigenous biodiversity, including crop varieties and agroforestry system. In this context, for instance it has been learned with the farmers of villages (Kharchia and other) under Pali district that they conserve landrace of wheat called Kharchia, which is highly adaptive to soil and water salinity stress. Farmers perceive that, despite relatively high risks of soil and water salinity and harsh climate, this variety provides on average 2.0 to 3.5 tonnes yield/ha. Moreover, Kharchia wheat has been integral part of traditional food systems and socio-cultural institutions of these farmers. Similarly, for adapting high climatic risks, poor irrigation facility, and high soil and salinity stress farmers have evolved indigenous agroforestry system led by khejri (*Prosopis cineraria*) with which bajra, sesame and other crops are taken. With this, a network of micro-environment is evolved by the farmers which not only contribute to crop production and ensuring food security, but also enable farmers to enhance soil health, conserving local biodiversity to adapt climate change in arid environment. These two examples of agrobiodiversity conservation indicate that community based efforts and local knowledge are crucial in sustaining agricultural systems.



A farmer with Kharchia landrace (agro-biodiversity) adapted in dryland salinity stress; khejari (*Prosopis cineraria*) with sesame (*Sesamum orientale*) based agroforestry system (blend of local and scientific knowledge).

the agricultural challenges. Over centuries, societies changed their farming practices to their particular environmental conditions. Traditional knowledge systems help farmers to manage natural resources, conserve biodiversity, and adjust to changing climates. Traditional agricultural practices may include crop rotation, intercropping, agroforestry, and organic inputs to increase the productivity, soil fertility, and insect control. These practices, align with sustainable agriculture, help in prioritizing land and biodiversity management, and people health also. Such practices have been multiplied and used in conserving numerous crop and animal landraces that are well-adapted to the local communities' biophysical and socio-economic milieus. These bio-resources are vital for food security in a changing climate of not only India, but also for South Asia, Africa and other similar regions in the world. It has been recognized that agricultural systems being conserved by these approaches are found to be more resilient.

In risk prone agroecosystems, conservation of natural resources is pursued at two levels, i.e. individual and community scales. At individual level, farmers may apply either their own creativity alone or sometime use only scientific knowledge; while third condition may also arise when farmers can blend both the knowledge systems to get rid of livelihood risks. Such practices are in vogue among farmers of many Asian and African countries. Examples may span from cropping system to animal husbandry (pastoral system management) and agroforestry systems. Lessons learned on cropping and agroforestry system management, attributed with

local landraces and perennial trees suggest that these have been adapted to sustainably manage land and water resources with least external use of resources. Simultaneously, such management system has enhanced conservation of local biodiversity and ensured food security of local communities. Such grassroots insights suggest that using diversity, integration, and sustainability, local crop and agroforestry practice help in achieving the environmental conservation, climate resilience, and livelihood resilience of the agrarian community. Thus, multiple outcomes of agricultural sustainability are ensured in view of the United Nations SDGs.

Scientific knowledge system: Scientific and technological advances provide evidence-based solutions, improve resource efficiency, and meet new issues to promote sustainable agriculture. In recent past, a significant amount of work and progress has been achieved in the area of sustainable agriculture. These efforts have led to develop a number of replicable sustainable agricultural practices (Table 1) which have potential to be used in many developing countries where the environmental challenges and agricultural sustainability are major concern.

Now the question arise how best such sustainable agricultural practices are articulated with the scientific knowledge system, institutional and extension services so as to maximize their reach among the farmers. An intra and inter levels of network of university, agricultural, and other scientific research institutions can be created so as to further enhance opportunities of testing and strengthening such scientific practices. This network can

Table 1. Major sustainable agricultural practices

Sustainable agricultural practice	Brief description
Crop rotation	Maintaining soil fertility, insect pressure, and biodiversity through rotating crops
Intercropping	Multi-cropping to improve nutrient utilisation, insect control, and productivity
Agroforestry	Trees and shrubs in agriculture and livestock systems increase soil health, preserve water, and sequester carbon
Organic farming	Using natural pest management, soil health, and avoiding synthetic pesticides and fertilizers
Conservation agriculture	Conserving soil and water by minimising soil disturbance, conserving soil cover and rotating crops
Integrated pest management (IPM)	Biological, cultural, and chemical pest management for economic and environmental sustainability
Cover crops	Planting fallow crops that cover the ground, promote soil health, inhibit weeds, and prevent erosion
Precision agriculture	Optimizing water and fertiliser use with technology to reduce waste and environmental effect
No-till/reduced-tillage farming	Reducing or eliminating tillage to limit soil disturbance, retain moisture, and reduce erosion
Sustainable livestock management	Promoting animal care, effective resource utilisation, and minimised environmental impact
Rainwater harvesting and water management	Rainwater collection, effective irrigation, and water resource management to reduce waste
On-farm biodiversity conservation	Diversifying farm crops, animals, and natural habitats to boost ecosystem resilience and productivity
Integrated nutrient management system	Optimizing organic and inorganic fertiliser sources to improve agricultural yield, soil fertility, and pollution
Integrated farming system	Combining crops, livestock, and agroforestry to produce a robust, sustainable production system
Renewable energy	Uses solar and wind energy to power farms and reduce greenhouse gas emissions
Drip irrigation	Directly waters plant roots, saving water and improving efficiency

help to train future agricultural scientists and extension agents, farmers and other stakeholders. In this regard, the extension services may further enable researchers and farmers to share the sustainable agriculture knowledge and technologies. Farmers can embrace such scientific sustainable agricultural practices to increase not only their agricultural production, but also may reduce environmental impacts, and improve resilience. The public and private sector collaboration can ease this process, and can also create sustainable agriculture policy and market incentives. Information technology has great role to enhance reach and enabling adaptations of sustainable agricultural practices. As a result, such technology can revolutionize the synergy among knowledge systems by providing more opportunities to farmers and other stakeholders to refine and experiment with various sustainable agricultural practices.

In recent past, the satellite imagery and remote sensing for precision agriculture, smartphone apps for agronomic guidance and market information, and online platforms for knowledge sharing and collaboration between farmers, researchers, and other stakeholders have proved in achieving success in sustainable agriculture. Additionally, the data analysis and modelling may further help scientific knowledge to maximize the agricultural operations and making farm level decisions. GIS, simulation models, and machine learning algorithms may help researchers and farmers examine complicated relationships between crops, soils, climate, and management approaches, improving resource efficiency and environmental effects. Therefore, modern information systems have considerable benefits, but making them accessible and relevant to farmers, especially smallholders in developing countries, is difficult. Scientific knowledge systems can help create a more sustainable and equitable global agricultural system by addressing challenges like the digital divide,

context-specific solutions, and participatory research where local resources including knowledge can be contextualized.

Promoting knowledge systems in sustainable agriculture: Role of G20

As a forum, the G20 countries have ample opportunities to share the science, technologies and knowledge systems to influence sustainable agriculture. With such process, the G20 members can maximize the share of different knowledge systems discussed above with establishing active collaboration. Neither formal nor informal knowledge systems alone can solve the regional and global environmental sustainability challenges. This may require partnerships and active collaborations among different stakeholders represented by G20 countries. This process can inculcate reciprocal learning on diverse knowledge systems, their refinement– if needed, and integration with policies to strengthen sustainable agriculture. As a result, this process can also provide further opportunities among different stakeholders of G20 countries for devising effective policies, innovative technology, and sustainable agriculture through dialogues, working groups, and forums. G20 policy and standards on sustainable agriculture are vital, and member countries can foster sustainable agriculture by coordinating rules, incentives, and standards. Therefore, this mechanism can lower the trade obstacles, help in transfer of technology, and encouraging sustainability cooperation. The G20 countries can identify some of the themes of local and scientific practices, which we have discussed earlier, with the aim of meeting challenges of sustainable agriculture, and be supported to strengthen research and development through funding mechanisms, and investment initiatives. Such collaboration and initiatives by the G20 countries on sustainable agriculture may

further be aligned with the FAO, World Bank, and IFAD activities and programmes. With these initiatives, the G20 countries can use their knowledge, resources, and networks of institutions to help member countries with capacity building, research, and technical assistance on sustainable agriculture. Raising awareness on diverse knowledge systems and technologies on sustainable agriculture and making required investment in it alongwith continued advocacy may generate sufficient resource-base to prioritize and encourage the sustainable agriculture. Overall, with similarities in environmental and socio-economic resources-base among some of the G20 members' countries provide further opportunities to have more intense coordination and grassroots level works to promote and replicate local and scientific knowledge in integrated form to strengthen sustainable agriculture. With this, the G20's may prove its leading role in ensuring sustainable food systems, environmental sustainability, and achieving the UN's Sustainable Development Goals.

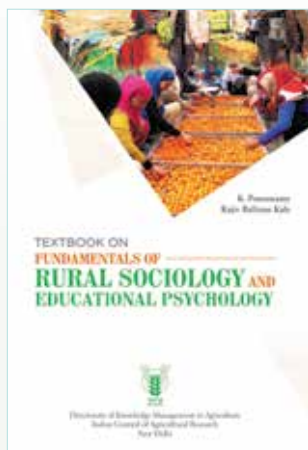
SUMMARY

The challenges posed by global environmental change have serious consequences on sustainable agriculture and farmers' livelihood. Such challenges cannot be achieved only either of scientific and

traditional knowledge systems. Both the knowledge systems can be used complementarily to minimize agricultural risks and enhance the sustainability. This can help the agrarian community to take better and collective decisions while increasing stakeholders' participation in the process of knowledge generation and its replication. Thus, the community may become more democratic in knowledge access, and use and make the agricultural enterprise more sustainable, creating a socially equitable and food-secure society. To achieve this, a multiple stakeholder's partnership can be built to get involve different level of players in the process of understanding and establishing synergy among knowledge systems. India's G20 Presidency have opened various agricultural avenues where multi-stakeholders with multiple institutors can work together to understand diverse knowledge systems. Such reciprocal learning among the stakeholders can ease the processes of understanding local to regional issues of sustainable agriculture where collective ideas and solutions can be developed and shared while achieving not only the agricultural sustainability among G20 countries, but also the several SDGs.

*Corresponding author's e-mail: ranjaysingh_jbp@rediffmail.com

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TECHNICAL SPECIFICATIONS

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