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REPORT

Technological Solutions for Sustainable Agriculture

Pradyot Ranjan Jena*

The detrimental effects of climate change are beyond debate as are its serious ramifications for agricultural production and food security (Kalli and Jena 2022; Mendelsohn 2014). A broad range of sustainable agricultural practices have been advanced by the agricultural scientific community to adapt to climate change, which are known as climate-smart practices (FAO 2011; Tanti and Jena 2023). In parallel, technological solutions have also emerged to mitigate the climate change effects of agriculture and increase food productivity sustainably.

A series of three online workshops were organized by the National Institute of Technology Karnataka in February 2021 and April 2022 to discuss various issues associated with global climate change and the urgent need to focus on agricultural sustainability in India. Sixteen invited speakers presented their studies, and a total of 500 scholars participated in these three workshops. The studies presented cut across several themes pertaining to sustainable agriculture. I have summarized the themes and the findings of these discussions in what follows.

1. TECHNOLOGICAL INTERVENTIONS IN SUSTAINABLE AGRICULTURE

A shift in consumer demand from traditional protein- and nutrient-rich food products, such as *jowar*, *bajra*, and other millets, to wheat and rice tilted the market price and government policies in favour of the latter. The minimum support price (MSP) at which the government procures food products has been increased repeatedly for rice and wheat in the past few years, leaving the coarse cereals in the lurch. Some of the speakers emphasized the need to promote cultivation of these nutrient-rich cereals by increasing their MSP and providing specific subsidies for these crops. In this context, the flagship initiative by the government of India—"Millet Mission"—is a step in the

* National Institute of Technology Karnataka, pradyotjena@nitk.edu.in

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right direction to enhance food security and satisfy nutrition requirements by promoting millets as a part of the food basket. Furthermore, the large MSP-induced increase in rice acreage in some river basins, such as the Cauvery and Teesta basins, has created ecological distortions and thereby put severe stress on groundwater availability. This can be corrected by increasing the acreage of dry crops such as sorghum and other millets.

In this context, the need to shift focus to some neglected yet highly nutritious potential food crops, such as jackfruit, taro, yam, moringa, and common bamboo, is highlighted. One of the presenters showed how his team of researchers have turned two forsaken vegetables—yam and taro—into fast-selling food products. He opined that a significant hindrance to the adoption of such crops by farmers is their economic viability. Taro and yam are disliked by consumers due to their considerable acridity, caused by high concentrations of calcium oxalate, which makes them unfit for direct consumption. Traditionally, tamarind is used to remove the oxalate content, but it changes the colour of the vegetable. The researchers used an enzyme-based technology to remove the oxalate content without changing the colour of the vegetable. A company in Bangalore commercialized this technology and is selling the low-oxalate-content yam and taro in the form of ready-to-cook, cleansed, and cut cubes. This has not only made yams easily available to consumers, but it has also increased the demand for the highly acrid yams cultivated in Tamil Nadu and Andhra Pradesh. He concluded by saying that incremental changes in post-harvest technologies have the potential to bring about profound changes in nutrition and farmer income, and scientists must have a clear understanding of the problem from the perspective of farmers and consumers.

2. THE INTERNET OF THINGS (IOT) AND SATELLITE-BASED DATA IN AGRICULTURE

Under this theme, several speakers discussed integrating climate change and sustainable development strategies into agricultural practices. There is an urgent need for the development of a climate change risk management database to successfully implement modern agricultural technologies. Using soil analyser machines, farmers can get insights into the quality of soil in their land and the crops that are suitable for the soil. For example, if the pH level is lower than average in a certain soil type, then the soil is considered acidic, and if it is higher, it is alkaline. Both acidic and alkaline soil are not suitable for many crops. This kind of information helps farmers take corrective action. Along with soil analyser machines, farmers can also be trained to utilize hand-held IoT machines, which can be used for weather forecasting. One speaker highlighted the development of controlled-environment agriculture, including hydroponics and vertical farming. Hydroponics is a modern farming method of growing plants and crops without relying on soil. This method has certain benefits such as lower water requirements, less susceptibility to changes in climate, higher plant density, and fewer pest-related issues. However, it also has drawbacks: it is expensive and vulnerable to power outages. Hence, it will not suit farmers who have financial constraints and those whose farms are in localities where electricity access is limited.

A few speakers discussed the use of satellite data in environmental and resource economics. Since sustainable agriculture is closely related to aspects such as climate change, greenhouse gas emissions, and forest cover, research on the former would require reliable data on the latter. Data obtained from satellites on these parameters can be leveraged and used in climate change and public health research. Researchers have made use of satellite imagery from the NASA database to study diverse issues, such as the green cover in various parts of the world, malaria incidence, COVID-19 disease outcomes and its relation to the mental health of people, and so on.

3. COMBINING TRADITIONAL KNOWLEDGE WITH MODERN SUSTAINABLE FARMING METHODS

Two speakers from the Department of Agriculture, Government of Karnataka, highlighted the status of agriculture and the various problems faced by farmers in Karnataka, in particular, as well as in India. Various approaches—such as the integrated farming system (IFS), integrated resource management (IRM), and integrated crop management (ICM)—that are crucial for sustainable agriculture were discussed. They also talked about low-cost modern agricultural techniques such as tank silt application, transplanting young seedlings, intercropping, utilization of organic manure, pheromone trapping systems, and so on. In addition, they described various forms of traditional storage systems utilized by farmers across India for storing different crops. Furthermore, the speakers argued that there is a need to strengthen the direct marketing systems by which farmers can sell their products directly to consumers. This could help them avoid sales-related bottlenecks that they possibly face when they sell products through middlemen such as wholesalers and retailers. Direct marketing has the potential to increase their profit margin and encourage them to invest in sustainable agricultural practices.

4. REPOWERING THE AGRICULTURE–ENERGY TRANSITION FOR AN AGRICULTURAL TRANSFORMATION

The conundrum of providing electricity subsidies vis-à-vis sustainability in agriculture and the rural economy has baffled many. Currently, nearly 75%

of the power generated in India is from coal-fired sources. More than one-sixth of this power is used for agriculture. The policy of subsidizing agricultural power consumption has a long past. These policies, though necessary during the green revolution era, have depleted groundwater due to over-pumping. Two speakers suggested key interventions in the power sector, such as rationalization of power subsidies in agriculture, with a greater focus on small and marginal farmers, to promote sustainable agriculture. Metering of agricultural electricity connections is necessary, though this may put lawmakers in a difficult spot. However, when bundled with multiple interventions such as crop choice—for example, choosing non-irrigation-intensive crops such as millets over irrigation-intensive crops such as paddy—it could lead to favourable outcomes. Irrigation of millets can be managed with micro-irrigation systems such as drip and sprinkler systems, easing the strain on the water table. Additionally, a simultaneous thrust on renewable energy systems, such as solar energy, will not only help farmers become self-reliant in terms of power, but it would also generate income for farmers when they sell the excess power generated to state power grids. Farmers can avail a 60% subsidy from central and state governments for the installation of solar power systems. Finally, the cost savings gained by state electricity boards through the withdrawal of subsidies on agricultural electricity connections could be used for rural welfare, such as in public health, education, and generation of livelihoods through the establishment of industries for agro-processing. The latter would augment farmers' incomes during the off-season, simultaneously fetching a higher value for their produce through value addition. These interventions result in multiple benefits: saving groundwater, reducing carbon emissions, addressing global food security through crop choice, sustaining farmer livelihoods through agro-processing, and finally, reducing the subsidy burden on the state.

5. THE ROLE OF INSTITUTIONAL FACTORS IN CLIMATE-SMART TECHNOLOGY ADOPTION IN AGRICULTURE

The role of institutional factors in sustainable agriculture was highlighted in the workshop presentations. Climate-smart agriculture (CSA) is an integrated approach for managing cropland, livestock, forests, and fisheries and addresses the interlinked challenges of food security and climate change (The World Bank 2021). Factors influencing farmers to use climate-smart agricultural practices were studied. Access to multiple sources of energy influenced farmers to adopt crop diversification, agroforestry, and crop rotation. Extension services such as support from government officials, farmer-to-farmer extension, training, subsidies for machinery and seeds, and credit facilities from co-operative societies and public banks had a positive impact on the adoption of climate-smart agricultural practices. Farmers' knowledge of climate variables through access to regular weather updates helped them to adopt sustainable agricultural practices. The barriers identified were lack of financial and technical support, lack of market access, and low literacy levels, especially among small-holder farmers.

Some of the presenters stressed the impacts that increase in temperature and changes in precipitation would have on health, agriculture, migration, and labour productivity, all of which influence economic output and growth. The impact assessment approaches in agriculture—namely, the Ricardian approach, integrated crop modelling approach, climate versus weather-panel models, and long-difference (LD) models—were explained.

The workshop provided a forum to discuss the pressing issues of sustainability in agriculture, the environment, and the rural economy by touching upon areas related to government initiatives, policies, environmental conservation, public health and nutrition, technology interventions in food processing, the electricity–agriculture conundrum, sustainable food practices, and sources of reliable environmental economics data.

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