7.1 Nepal's Agricultural Sector: Issues, Priorities, and Digital Remedies

Issues: Poor access to agricultural input and supply

Priorities:

Provide soil health cards to farmers through the Agriculture and Livestock Service Centers of rural towns.

Supply fertilizers, seeds, and agriculture machinery and tools.

Digital Remedies:

Mobile applications for weather, market, price, and crop information

Make use of digital technology (such mobile apps) to rent or buy agricultural equipment and supplies

A program of distance learning to impart best practices and technical knowledge

Issues: Low yields and declining productivity

Priorities:

Proposals to prolong the Agriculture Modernization Project of the Prime Minister

Reach independence in the production of fish, grains, and eggs, milk, and meat in two years

Digital Remedies:

- Precision agriculture seeks to boost productivity by tracking and regulating crop development in real time using satellites, drones, and soil sensors.

Equipment monitoring employs sensor technology and the IoT to guarantee resource utilization.

3.Issues: Insufficient accessibility to distribution centers, transportation, and markets

Priorities:

The government uses cleaning and grading machinery, gathering centers, and storage facilities to assist farmers and cooperatives in collective selling under the Agriculture Development Strategy (ADS).

Digital Remedies:

To track trucks and obtain location updates, sensors and logistics systems are employed.

Matching platforms are provided to help grade the quality of the produce.

- Radio frequency identification (RFID), tracking systems, and traceability are used in smart packaging.

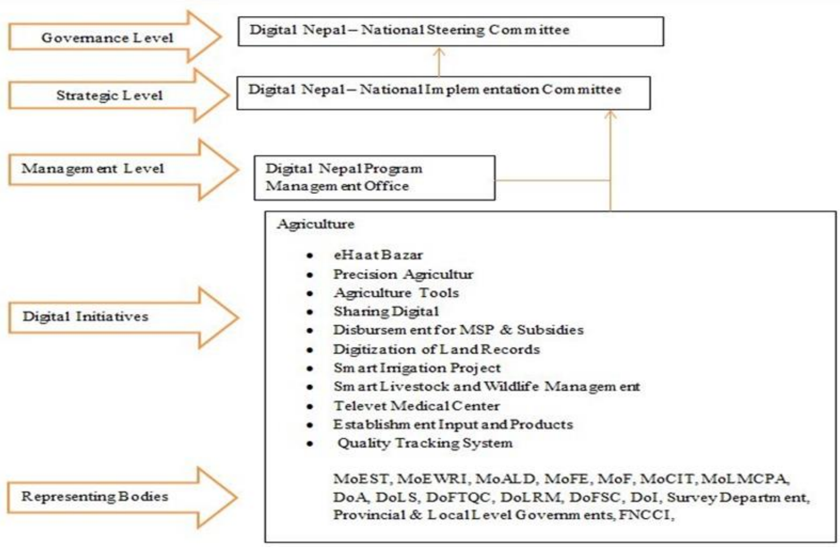

Figure 1: A recommended institutional setup calls for the Prime Minister to preside over the National Steering Committee for Agriculture in Digital Nepal.

8. Major Potential and Comparative Advantages of Grassroots Breeding

Grassroots breeding, as evidenced in instances like rice bean and chilly cultivation, offers a pathway to enhance community resilience by leveraging local Plant Genetic Resources (PGR) strategically. This approach addresses the limitations of local varieties and production systems while fostering a deeper understanding of PGR for local adaptation, as observed in the cultivation of culturally valued local cauliflower varieties. At the institutional level, grassroots breeding enhances comprehension of small-scale farmers' needs among official breeders and scientists. Notably, significant progress can be achieved without complex selection techniques, primarily by identifying and utilizing locally valued genetic resources or employing simple selection methods. By prioritizing grassroots breeding over the use of modified germplasm, farmers and researchers can better appreciate the importance of local PGR, potentially offering a more effective strategy for bolstering community resilience compared to methods like Participatory Variety Selection (PVS) and Participatory Plant Breeding (PPB), which predominantly emphasize improved germplasm dissemination (Sthapit et al., 2013). The case studies of Jethobudho and Kalajeera rice demonstrate how local varieties that become scarce following a fall in their quality can be consolidated as varieties through PGE, therefore regaining their popularity with farmers and consumers and becoming once again abundant (Chaudhury and Swain, 2013; Silwal et al., 2013)

9. Call for Collaborative Efforts in Sustainable Agriculture in Future

In order to address the desire for a more sustainable agriculture, a variety of philosophical approaches to agricultural management and unique agronomic techniques have been suggested and applied over the previous few decades.

9.1 Agroecology

Over the last 80 years, the scales and dimensions of agroecological investigations have shifted from the plot and field scale to the farm and agroecosystem scale (Gomiero et al., 2011). Some experts claimed in the 1980s that in order to move toward more sustainable agriculture, a whole-farm holistic approach needed to be adopted. Such an approach is the foundation of the science of agroecology (Altieri, 2002; Altieri et al., 1983; Conway, 1999; Gliessman, 1990). It focuses on the structure, dynamics, and functions of their interactions, as well as the processes in which they are involved (Gomiero et al., 2011). The new concept and technique achieved widespread acceptance among academics, establishing agroecology as a legitimate scientific topic in its own right (Altieri, 2002; Altieri et al., 1983; Altieri and Nicholls, 2018; Bohlen and House, 2009; Francis et al., 2003; Giampietro, 2003; Gliessman, 2013; Paoletti, 2001).

9.2 Agriculture Intensification

There are two conflicting solutions proposed: (1) wildlife-friendly farming, which increases wild population densities on farmland but may reduce agricultural yields; and (2) land sparing, which reduces demand for farmland while increasing output by improving crop efficiency (Green et al., 2005; Pretty, 2008, 2013; Tilman et al., 2002; Trewavas, 2001). Increased nitrogen utilization and water efficiency, as well as better soil quality, are critical variables in avoiding agriculture growth into natural ecosystems while fulfilling human demands. However, such an issue is quite complex, and simple models, such as the notion that technology advancement can contribute to land conservation, have been proven false in a number of occasions (Perfecto and Vandermeer, 2010). Perfecto and Vandermeer for the instance of tropical agriculture and forest conservation, assert that social environment influences the direction and extent of agricultural intensification's impact on deforestation (Perfecto and Vandermeer, 2010). However, whether rising agriculture intensity (crop yield) leads in less farmed area is debatable, as some writers find no association between agriculture intensification and land sparing (Ewers et al., 2009). For instance, researchers argue that in developing countries there is a tendency for the area used to grow crops other than staples to increase in the countries where staple crop yields increased (Ewers et al., 2009). There remained a weak tendency in developing countries for the per capita area of all cropland to decline as staple crop yield increased, a pattern that was most evident in developing countries with the highest per capita food supplies.

9.3 Integrated Agriculture

Integrated agriculture is a farming method that blends conventional and organic farming management practices. When possible, animal feces can be utilized instead of chemical fertilizer. Pest management (integrated pest management) combines multiple strategies, including crop rotation, the release of parasitoids, the cultivation of pest-resistant cultivars, and the use of various physical procedures, with pesticides used only as a last option (Altieri and Nicholls, 2018). Tillage and cultivation practices, competitive cultivars, crop diversification, and other factors can be employed to limit weed germination, development, competitive ability, reproduction, and dissemination. Arthropod and microbial bio control agents can also be successfully introduced (Gliessman, 2013)

9.4 Organic Agriculture

A different alternative to sustainable agriculture has been proposed and implemented by the organic agriculture movement. Although sustainable agriculture practices are adopted by an increasing number of farmers only organic agriculture is regulated by laws and needs to strictly follow a specific set of norms. Such norms, among other, forbid the use of agrochemicals and strictly regulate the use of drugs in animal rearing; they also forbid the use of GMO. The organic movement emerged in Europe in the 1920s and in the United States in the 1940s, representing farmers and residents who refused to use agrochemicals and were ready to stick to traditional agricultural practices (Conford and Dimbleby, 2001; Lockeretz, 2007; Lotter, 2003). Organic production systems are based on specific and exact production standards that attempt to achieve optimal agro ecosystems that are socially, environmentally, and economically sustainable (Alimentarius, 2004). Other than agricultural yield, organic agriculture attempts to preserve soil fertility, reduce soil erosion, conserve water, biodiversity, landscape, ecological functionality, and mitigate global change (Crowder et al., 2010; Kristiansen et al., 2006; Mäder et al., 2002; Niggli et al., 2009; Pimentel and Burgess, 2014; Reganold et al., 1987). Organic agriculture can be a valuable choice for working toward a more sustainable agriculture, and it merits extensive experimentation to fully investigate and appreciate its potentials as well as constraints and limitations (Gomiero et al., 2011).

9.5 Permaculture

Permaculture focuses on management design and the integration of landscape features, taking into account the evolution of the landscape over time. Permaculture's purpose is to create an efficient, low- input integrated culture of plants, animals, humans, and structure that can be used at all scales, from home garden to large farm. One issue with permaculture is that biomass from nearby places is used to fertilize the permaculture sites. As a result, resources in the surrounding areas are being depleted (Gomiero et al., 2011).

9.6 Precision Agriculture

Precision agriculture refers to agricultural management approaches that meticulously tailor soil and crop management to each field's unique characteristics (Gomiero et al., 2011). Precision agriculture is an agricultural management system that uses information and technology such as remote sensing, geographic information systems, global positioning systems, and robotics to identify, analyze, and manage site soil spatial and temporal variability within fields for maximum profitability, sustainability, and environmental protection (Gebbers and Adamchuk, 2010).

9.7 Perennial Crops

Because of the dramatic effects of plowing on soil conservation, some authors in the United States have proposed shifting from an agriculture based on annual crops to an agriculture based on perennial crops, in order to avoid or at least greatly reduce the negative effects of soil tillage and agrochemical use (Glover, 2005; Glover et al., 2007; Jackson, 1980; 2002). To reduce nitrogen loss and improve soil conservation, perennial crops such as Intermediate wheatgrass (*Thinopyrum intermedium*) and other perennial Th. species, Maximilian sunflower (*Helianthus maximiliani*), Illinois bundle flower (*Desmanthus illinoensis*), and Flax (a perennial species of the Linum genus) have been proposed. They are thought to have the potential to help limit climate change (Glover et al., 2007; Glover, 2010a;2010b). Because perennial crops do not need to be replanted every year, they require fewer passes of farm machinery as well as fewer pesticide and fertilizer inputs, which reduces fossil-fuel use (Gomiero et al., 2011). Glover reports herbicide expenses for annual crop production may be 4 to 8.5 times those for perennial crop production, therefore less inputs in perennial systems mean reduced financial expenditures for farmers (Glover, 2007).

9.8 Transgenic Technology

Technological advances in genetics have enabled the manipulation of gene expression and the operation of gene transfers from one organism to another (Gomiero et al., 2011). Many people see genetically modified organisms (GMOs) or transgenic organisms (TOs) as a way to meet food demand while also maintaining the environment and decreasing agriculture's environmental effect (Gomiero et al., 2011). Many authors believe that GMOs could usher in a new "green revolution," particularly for developing countries facing food scarcity, by increasing agricultural productivity and coping with new environmental challenges such as climate change and soil exhaustion, while also benefiting natural resource conservation (Conway, 1997; Ejeta, 2010; Fedoroff et al., 2010; Gilbert, 2010). A toxin-encoding gene from the bacteria *Bacillus thuringiensis* was successfully transferred to maize to protect it from the stem borer (*Ostrinia nubilalis*), a common corn pest, in Bt corn. Since the introduction of Bt cotton, they have displaced bollworms as the dominant pest in the southeastern United States (Benbrook, 2009).

10. Conclusion

In conclusion, the Seeds of Innovation call for collaborative efforts in sustainable agriculture. Integration of AI and IoT holds transformative potential, necessitating a comprehensive policy framework. At its core, grassroots breeding challenges traditional practices by empowering communities to innovate sustainably. Amidst global challenges like climate change and food security, grassroots breeding emerges as a beacon, harmonizing tradition with innovation and prioritizing local community empowerment. Challenges in Nepal's agriculture require digital solutions and collaborative initiatives for a balanced and sustainable future. In essence, the Seeds of Innovation offer a roadmap for a sustainable future where tradition meets innovation. Custodian farmers have a vital role in strengthening communities, establishing local institutions, and upholding the rights of farmers since they are the ones who provide household gene banks and community seed banks locally. These farmers serve as a central location for field testing, propagation, and dissemination of items that have been recognized as promising through national research and extension initiatives. Through grassroots breeding and technology integration, agriculture can navigate modern complexities while preserving local wisdom. The journey toward sustainability demands collective commitment, where innovation and tradition unite for resilient agricultural systems benefiting present and future generations.

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