Exploiting Biodiversity of Traditional Crops for Mainstreaming Nutrition Sensitive Agriculture in Nepal

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Abstract

Traditional crops cultivated and consumed over generations are important components of agrobiodiversity and support dietary diversity, productivity and livelihoods of marginalized populations in Nepal. This paper outlines the value of traditional nutrient dense crops to promote nutrition sensitive agriculture by exploiting rich biodiversity of these crops through nutrition sensitive value chain development. Use of traditional crop biodiversity for nutrition sensitive value chain development can play positive role by taking into consideration not only how diverse nutrient-dense foods are produced but also how they are processed, distributed, marketed and consumed to supply nutrient value for household nutrition security. However, presently value chains of biodiversity of traditional crops are weak, fragmented and not properly connected among sub-components of production, processing, marketing and consumption system. Considering this, focus of biodiversity-based value chain upgrading is suggested to improve their performance, efficiency and interlinkages in different sub-components. Creating enabling policy for investment in research, education, extension and value chain development is essential to exploit rich biodiversity of traditional nutrient dense crops. Promotion of organic and ecofriendly production, marketing and certification system linking with geographic indication and fair trading is suggested for mainstreaming traditional nutrient dense crops in national policies, program and institutions.

Key words: Biodiversity, traditional crops, mainstreaming, nutrition sensitive value chain

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Introduction

Food is a universal prerequisite for sustaining life and an essential determinant of healthy living. However, there is a great challenge today to secure adequate food that is healthy, safe and nutritious and to do so in an environmentally sustainable manner (Pinstrup-Andersen, 2009). The global and national food system is currently failing to meet the nutritional needs of a growing human population (FAO et al., 2015). Recent evidence shows that malnutrition is a major global problem, where presently more than two billion people suffer from micronutrient deficiencies (also known as "hidden hunger"); approximately one billion people suffer from protein deficiency and about two billion adults are classified as overweight or obese, with strong links to an alarming rise in the prevalence of non-communicable diseases (IFPRI, 2016; Ritchie et al., 2018). Malnutrition is also a major developmental problem in Nepal, where about 39% of the population are malnourished (NPC, 2016), with highest rate of stunting (54.5%) in the western mountains of Karnali province (NDHS, 2016). The households in the mountain region are also more vulnerable to food insecurity and chronic malnutrition as per capita food production is lower with higher food prices, poor connectivity and limited market availability.

One of the basic causes of malnutrition is an inadequate diet that lacks the sufficient nutrients, minerals and vitamins in terms of quantity and quality for healthy body growth and maintenance (Li & Siddique, 2018). Biodiversity in agriculture or agrobiodiversity is the key source of dietary diversity since it contributes to supply of culturally acceptable diverse, healthy and nutritious foods, while improving human health and nurturing environment (Frison et al., 2011; Bioversity International, 2017). Use of agrobiodiversity helps to identify which plant species or varieties contain important traits, such as nutrient density that can be cultivated for self-consumption or market supply or using them to breed new nutrient dense varieties for addressing malnutrition. Global evidence shows that agrobiodiversity has positive relation with nutrition as it contributes to improved diet diversity and quality (Jones, 2017; FAO, 2010). However, we have limited understanding about potential roles of traditional crop biodiversity and its links with nutrition for addressing malnutrition and sustainable food system development in Nepal. In this context, there is a great potential to exploit traditional crop biodiversity for nutrition sensitive agriculture to ensure that everyone has access to sufficient, safe and healthy nutritious foods. This paper, therefore, aims to unleash the potential of biodiversity of traditional crops for promoting nutrition sensitive agriculture using a recent experience from Nepal.

Biodiversity of Traditional Food Crops

Traditional crops cultivated and consumed over multiple generations in Nepal are important components of agrobiodiversity that support dietary diversity, productivity and livelihoods of marginalized populations in Nepal. Traditional crop biodiversity contributes to food and nutrition security of poor and marginalized communities by supporting diversified, nutrient rich diets while maintaining the health of ecosystems. Nepal has a high degree of variations in topography, slope, aspect and altitude owing to diverse agro-ecological conditions, socioeconomic settings and farming system resulting in high biodiversity in agriculture. Presently mountains of Nepal harbours globally important crop biodiversity of underutilized traditional crops such as amaranth, barley (both hulled and hull less), buckwheat, beans, different species of millets (finger millet, proso millet, foxtail millet) and high altitude cold tolerant rice, which have unique traits of cold, drought and disease tolerance through adaptation ine harsh

mountain environments (UNEP GEF, 2013). Smallholder farmers have been growing these traditional food crops organically over generations using integrated mixed farming system which have great potentials for improving national food and nutrition security (Gauchan et al., 2018). The intra-specific diversity of these crops is very high as most of these crops are either evolved or located at the center of diversity in Nepal Himalayas.

Many of the traditional food crops such as amaranths, buckwheat, barley, beans and different species of millets (finger millet, proso millet, foxtail millet) including traditional legumes and vegetables are often referred to as Himalayan Superfoods (www.himalayancrops.org) as they are nutrient dense and gluten free with high dietary fibers, antioxidants and vitamins. These food crops also contain higher protein content, rare amino acids and are rich in micronutrients (calcium, iron) as compared to major food staples such as rice, wheat, maize and potato (DFTQC, 2012). Table 1 provides comparative nutrient content of traditional crops in comparison to major food staples such as rice, wheat, maize and potato.

Table 1. Nutrient contents of traditional crops (per 100 gm) in comparison to major food staples.

Crops	Protein (g)	Fat (g)	Carbo-hydrate (g)	Mine-rals (g)	Fiber (g)	Energy (Kcal)	Cal-cium (mg)	Phos-phorous (mg)	Iron (mg)
Foxtail millet	12.3	4.3	60.9	3.3	8	331	31	290	12.9
Proso-Millet	11	4.2	72.9	3.2	1.0	378	8	28.5	3
Amaranth seed	9.4	7.2	68.1	2.6	2.2	375	37	529.1	5.2
Barley	11.5	1.3	69.6	1.2	3.9	336	26	215	1.7
Naked barley flour	9.6	2.6	76.7	1.9	2.0	369	-	-	1.4
Millet	7.7	1.2	70.1	2.9	3.7	322	288	276	49.1
Buckwheat flour	6.1	1.3	69.2	3.1	7.8	313	-	-	5.6
Bean	24.9	1.3	60.1	3.2	1.4	347	60	433	4.4
Rice (milled)	6.8	0.5	78.2	0.6	0.2	345	10	160	0.7
Maize flour	9.2	3.9	72.1	1.2	1.6	360	20	256	2.4
Wheat flour	12.1	1.7	69.4	2.7	1.9	341	48	355	4.9
Potato	1.6	0.1	22.4	0.6	0.6	97	10	40	0.46

Source: DFTQC (2012).

In addition to the higher micronutrient and protein contents compared to traditional crops, they are also tastier and healthier. Therefore, consumers in urban markets pay a price premium for food products derived from these crops as many of them are indigenous and produced organically in a mountainous agroecosystem (Gauchan, 2018). For instance, staple traditional meals (e.g. *Bhat*, *Dhido*) including modern recipes such as bread, porridge, snacks, pudding, sweets etc. prepared from these nutrient rich traditional crops are recently becoming popular in urban areas in Nepal due to their perceived health and nutritional benefits. They are also considered hidden treasures and "Future Smart Food" considering their great value for nutrition, local adaptation, climate resilience and risk diversification (Li & Siddique 2018). Furthermore, some of these crops such as finger millet, proso millet, foxtail millet and amaranth are photosynthetically more efficient (C4 crops), climate resilient and tolerant to various biotic (disease, pests) and abiotic stresses (cold, drought) and hence can be grown in harsh marginal lands with no or limited external inputs and water. As many of these crops are short duration (e.g. buckwheat, beans, foxtail and proso millets), they can escape drought and cold temperature and ensure food availability in lean seasons where cultivation season is very short due to long cold winters in the Himalayan mountains. These traditional crops, therefore,

provide globally important gene pools for nutrition, resilience and climate change adaptation for addressing chronic malnutrition and undernutrition in most impoverished areas of mountain regions in the world.

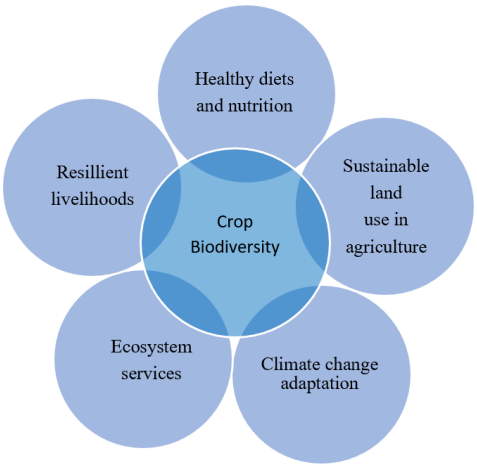
A growing evidence exists that biodiversity of traditional crops can support resilient livelihoods, healthy diets and nutrition and promote sustainable land use and ecosystem services and contribute to adaptation to changing climate (Figure 1). Hence, they have potential to support sustainable food system and nutrition sensitive agriculture through meeting multiple sustainable development goals (SDGs) for the benefit of humanity. These include end poverty (SDG1), zero hunger (SDG 2); good health and wellbeing (SDG 3), responsible consumption and production (SDG 12), climate action (SDG13) and life on land (SDG15). Among these goals, biodiversity of traditional crops is most directly related to meeting Sustainable Development Goal 2 (SDG 2: Zero Hunger) as it connects agricultural development to improved nutrition outcomes.

Declining Diversity of Traditional Crops

Trend of traditional crop biodiversity is shrinking fast, and humanity is losing food diversity to meet nutritional needs of increasing population. Present global food system has over-reliance on a narrow set of genetic resources, at the local, landscape and supply chain level. Scientific efforts since the Green revolution during early 1960s have focused primarily on major crops and staples, to the neglect of traditional crop diversity and associated knowledge, culture and traditions. The shrinking diversity is reflected in evidence that only 10 species of cereal grains, legumes and oilseeds currently dominate 80% of the world's croplands and three major food crops viz, wheat, rice and maize currently provide about 50% of the world's food energy intake (FAO, 2010) although more than 3,000 plant species have been identified as edible. This over reliance on a handful of major crops puts our food security at great risk, while losing diversity of traditional crop species and their wild relatives–the reservoir of genetic diversity. These genetic resources may become increasingly important in the future for feeding some 10 billion people by 2050, in a world shaped by climate change and changing market preference (Bioversity International, 2017).

Recently, the diversity of traditional mountain crops and their numerous varieties in Nepal are declining rapidly with commercialization, climate change and changes in food culture brought about by globalization, migration and modernization. Estimates show that just in the last few decades of agricultural development ,about 50% of traditional crop varieties grown in Nepal have been lost(Joshi et al., 2017) and many more are about to disappear. National statistics show that in the last three decades, the decline is particularly rapid in finger millet (CBS, 2012), while there is a noticeable decrease in barley and buckwheat (Figure 2). Most of these varieties of millet, barley and buckwheat are traditional, selected, evolved and conserved over generations by small farmers in the mountains of Nepal. Only a few varieties of finger millet, barley and one variety of buckwheat have recently bene released but they are grown by small number of farmers in a limited area.

Furthermore, during the last three decades, the average yield of these traditional food crops such as barley and millet have also remained very low (1 MT/ha) with low productivity growth (1%) as compared to relatively higher yield (> 2.5 MT/ha) and higher productivity growth (2%) for the major food staples such as rice, maize and wheat in Nepal (Table 2).



Adapted from Biodiversity International, 2017

Figure1. Potentials of crop biodiversity for meeting nutrition needs and sustainable food system.

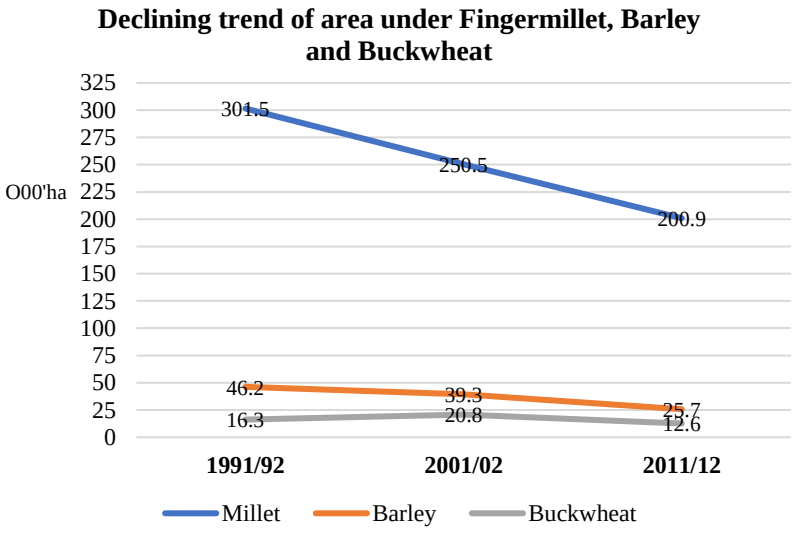


Figure 2. Trend of cultivated area in Nepal (1991-2011); Source: CBS (2012)

Table 2. Comparative yield and yield growth rates of Barley and Millets with major crops.

Yield and yield growth rates	Barley	Millet	Rice	Maize	Wheat
Yield (MT/ha) in 2014	1.03	1.16	3.36	2.52	2.59
Yield growth (%)/annum (1984-2014)	1.00***	0.43**	1.70***	1.95***	2.60***

Compound growth rate: (***) (**) & (*) significance at 1, 5 & 10 %: Source: MoAD (2016)

Evidence from the experience of conservation and promotion of traditional crop biodiversity in the Local Crop Project of the Global Environment Facility (GEF) and United Nation Environment Program (UNEP) in the Nepal Himalayas jointly implemented by the Bioversity International, Nepal Agricultural Research Council (NARC), Local Initiatives for Biodiversity Research and Development (LI-BIRD) and Department of Agriculture indicate that the improved technologies for production, processing and marketing are either limited or absent for traditional underutilized crops (Gauchan et al., 2019). Key factors behind the declining trend of production include low crop productivity, high labor requirement for manual processing, difficult post-harvest operations and lack of markets in the rural areas. Cultivation of traditional crops also increases women drudgery, since the post-harvest processing, handling and weeding are mainly women domain. The declining diversity is also due to low value addition and marketing, including poor incentives and support from public policies and neglect from research, extension and educational programs.

Mainstreaming Traditional Crop Biodiversity for Nutrition Sensitive Agriculture

Considering the high nutrition value of traditional mountain crops there is an urgent need to mainstream and promote them to enhance dietary diversity, health and nutrition of the growing population in Nepal. This can be possible through promotion and integration of nutrition sensitive agriculture in economic development program to achieve Sustainable Development Goals (SDGs) employing nutrition sensitive biodiverse value chain development of traditional crops. Integration of nutrition sensitive agriculture in economic development program will require development of value chain of traditional nutrient dense crops that can directly improve the livelihoods and nutrition security of poor farmers by increasing nutrient content of the crop yields,

decreasing losses during processing, adding value, improving market linkages and promoting consumption of nutrient rich traditional diverse foods (Gauchan et al., 2019). The pathways linking traditional crop biodiversity with nutrition are through household consumption of the diverse nutrient rich traditional food crops from self-production or purchase from market. Many of these traditional crops fall under the neglected and underutilized crop species (NUS), that require a viable market that creates incentives for local value chain actors to secure their continued cultivation, processing and marketing (Padulosi et al,. 2019).

Nutrition-Sensitive Value Chain Development

Value chains are a core element of the food system, which influence both the supply and the demand of foods. Nutrition sensitive biodiverse value chain development can play important role by taking into consideration not only how diverse foods are produced but also how they are processed, distributed, marketed and consumed, a process that is usually referred to as 'value chain' (IFAD, 2018; FAO, 2017; Gelia et al., 2015). There are different potential pathways suggesting ways in which value chain interventions can contribute to enhanced nutrition among the poor. One pathway is by enhancing access to, and consumption of foods that are naturally rich in micronutrients, such that overall dietary diversity increases (Maestre et al., 2017). The second route is through production and distribution of foods with increased nutritional value (Chen et al., 2013). Underutilized traditional crops such as amaranths, finger millet, foxtail millet, proso millet, barley/naked barley, buckwheat, beans, etc. fall on this group that are rich in micronutrients, dietary fibers and proteins as compared to major food staples such as rice, wheat and maize (DFTQC, 2012). The value chain approach is useful for identifying pathways and opportunities to shape food systems to be more nutrition sensitive by intervening at different stages of the value chain (IFAD, 2018). This can be done by improving demand and supply side interventions as well as improving interactions of demand and supply in each stage of value chain through holistic nutrition sensitive value chain development. Demand side interventions include promoting nutrient dense value of diverse traditional foods and food culture in consumption system through nutrition education and behavior change communication. The pathways for this can be by increasing own production of nutrient dense traditional crops or purchase from markets. Supply side interventions include mainstreaming of diversity rich solutions, technologies, methods and good practices to promote diversity in production, processing and marketing of nutrient dense traditional crops to make bioavailability of diverse micronutrients for human consumption.

Mapping of Value Chain Components, Actors and Constraints

Assessment and mapping of value chain components, actors and constraints for the traditional crops in Nepal mountains revealed the four major components in the value chains constituting production, processing, marketing and consumption systems, including policy system for creating enabling environment (Table 3).

Cooperatives, community seed banks and agro-entrepreneurs are not well developed and mobilized for the production, processing, marketing and promotion of traditional crops. Consumers are also not aware of the nutritional value with their easy access to consumption of locally produced and traded traditional crop diversity.

Table 3. Mapping of value chain component, actors, and constraints for traditional crops.

Value chain components	Actors	Constraints
Production system: seed quality, diversity, and availability cultivation, crop management, agro-advisory services	Custodian farmers, producers, farmers groups, community seed bank, R & D Professionals	Poor access to diverse choices of quality seeds and varietal diversity. Poor crop management and limited use and access to agri-extension services
Processing system: threshing, milling, grading and adding value	Farmers, cooperatives procurers, processors, R & D professionals	Laborious processing, women drudgery, poor value addition. Poor connection to processing
Marketing system: Local trading, exchange and formal marketing	Cooperatives, Agro entrepreneurs, traders, market agents, R & D professionals	Small-scale informal marketing, limited market linkage, absence of product standardization, grading, labelling, and branding
Consumption system: Preparation and use of food recipes and consumption of diet diversity from traditional foods	Consumers in both rural and urban areas including hotels; homestays, hospitals, school cafeteria	Poor awareness of nutrition value, lack of access to dietary diversity, poor quality of products, absence of technology for preparation and use.
Policy System: R & D investment, seed regulatory framework, subsidy, tax and price policy	Farmers, traders, planners, policy makers, R & D professionals	Poor R &D investment, unfavorable seed regulatory framework, lack of support & subsidy for traditional crops

Adapted from Gauchan et al. (2019).

The flow of knowledge, products and information and interaction among chain actors from production to consumption is low and weak particularly in processing, marketing and consumption chains. Poor investment in research and development (R&D), unfavorable seed regulatory framework for release and promotion of traditional underutilized crops and varieties and inadequate support and subsidy for traditional crops have hindered development of value chains (Gauchan et al., 2019). Therefore, available crop biodiversity of traditional crops is not well exploited, utilized and promoted for strengthening the value chain that can address nutrition to both producing and consuming households by enhancing their dietary diversity and creating enabling environment.

Strengthening Value Chains for Nutrition Sensitive Agriculture

Considering the weak, fragmented and poorly connected value chains of traditional crops, interventions are needed to upgrade and strengthen them focusing on crop biodiversity and nutrient dense value of these crops. In this context, we identified four key sub-components of the biodiversity-based value chain that constitutes production, processing, marketing and consumption systems for the promotion of nutrition sensitive agriculture (Figure 3).

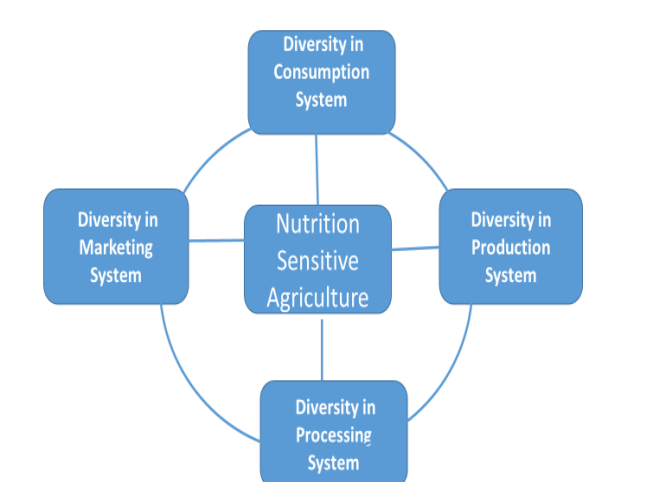


Figure 3. Components of biodiversity-based value chains for Nutrition Sensitive Agriculture

Focus of the value chain is on the use of their crop biodiversity to improve interlinkages and efficiency to promote nutrition value in each of the subcomponent of production, processing, marketing and consumption system in an interactive way with adequate support from enabling policy environment. The production system is focused with the use and promotion

of diverse species and cultivars of traditional nutrient dense crops in farms and landscapes. The processing system involves development of simplified and diversified processing methods that process diverse traditional nutrient dense crops into diverse forms and products as per the flow of products in the production and marketing systems. Diversity in market is also important to promote products of diversified traditional nutrient dense cop species and cultivars to match the food demand and supply. This requires promoting demand for dietary diversity in the consumption system and promoting food culture of traditional foods in both rural and urban areas. Therefore, the focus of diversity-based value chain development needs especial efforts in establishing channels for diverse product procurement, proper processing, transport, and storage and exposing crops to wider markets and ensure competitiveness. Enabling policy environment to improve interlinkages and service provisions that promote and strengthen performance is required to enhance positive and speedy flow of nutrition and health value among different value chain subcomponents.

Furthermore, value chain upgrading and strengthening requires a strong holistic integrated focus and smooth interlinkages on the use of biodiversity of nutrient rich traditional crops for their better efficiency and improvement in performances to promote nutrition sensitive agriculture (Gauchan et al., 2019). Mainstreaming of good practices and approaches of community-based biodiversity management (CBM) practices will play important role to promote diversity, food safety and quality in production, processing, marketing and consumption system. The improvement of value chain also requires souring, deploying and conservation of diversity and seed quality improvement and better research and management of crops and cropping patterns in production system. Establishment and operationalization of community seed banks and adoption of diversity-based farmers field schools can contribute in improving better management of eco-friendly production system. Special technological interventions are needed in improvement and simplification in processing system with better youth and women friendly processing machines suited to millets and other diverse traditional nutrient dense crops for their enhanced production and promotion. In addition, market development and value addition are critical for improving their product demand and supply for the diversified products in marketing system linking with agro-ecotourism (hotels, homestays), education (schools and university curricula) and the health and nutrition system (hospital food menu). The production and promotion of healthy organic food market chains (retail chains, urban food fairs, homestays and hotels) linking local entrepreneurs is essential to develop niche value chain of biodiverse traditional nutrient dense crops. Experience reveals that food and seed fairs are important in sensitizing and building capacity of the food actors including technical support in production, processing, marketing of traditional crops as organic healthy wholesome nutrient rich foods for promoting consumption (Gauchan et al., 2018). Special awareness program, investment in R & D and policy provisions and commitments from planners are therefore essential for promoting dietary diversity and quality of the diets by exploiting rich biodiversity of traditional nutrient dense crops.

Conclusions and Ways Forward

Mainstreaming nutrition-sensitive agriculture in policies, programs and institutions offers great potential for exploiting biodiversity of traditional nutrient dense crops to improved nutrition outcomes and sustainable food system development. Traditional crops are indeed hidden treasures and provide globally important gene pools for nutrition and climate change adaptation for addressing chronic malnutrition and undernutrition of poor farmers and communities in most

impoverished and vulnerable areas such as mid- and far-western mountains in Nepal. In addition, nutrient dense traditional crops also show great potential to address increasing obesity, diabetes and hypertension in urban and semi-urban populations caused by consumption of low dietary diversity mainly high energy micronutrient deficiency foods. Furthermore, promotion of intraspecific diversity of these crops will support conservation of agrobiodiversity for nutrition security, climate resilience and sustainable food system development as they are well adapted to diverse farming system, locally available and indigenous to Nepal mountains. Therefore, the nutrition sensitive value chain development is useful for identifying pathways and opportunities to shape food systems to be more nutrition sensitive and biodiverse by intervening at different stages of the value chain. Investment and interlinkages in research, education and extension of traditional crop biodiversity is critical in improving the efficiency and interlinkages in each chain of production, processing, marketing and consumption. Furthermore, nutrition sensitive agriculture will require design of biodiversity-based transformative food system development employing organic and ecofriendly production, marketing and certification system linking with geographic indication and fair trading. Most important is the creation of an enabling policy environment for investment in seed regulatory framework, subsidy, support and incentives for production, processing, marketing, value addition and consumption of locally sourced nutrient dense foods by exploiting rich biodiversity of traditional crops.

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