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Mainstreaming Agricultural Biodiversity in Traditional Production Landscapes for Sustainable Development: The Indian Scenario

Ishwari Singh Bisht [1,*], Jai Chand Rana [1], Rashmi Yadav [2] and Sudhir Pal Ahlawat [2]

[1] The Alliance of Bioversity International and CIAT, NASC Complex, Pusa Campus, New Delhi 110012, India; j.rana@cgiar.org

[2] ICAR-National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi 110012, India; rashmi.yadav1@icar.gov.in (R.Y.); sudhir.ahlawat@icar.gov.in (S.P.A.)

* Correspondence: bisht.ishwari@gmail.com

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Abstract: Mainstreaming biodiversity in production landscapes ensures conservation and sustainable use of agricultural biodiversity, the key objectives of the Convention on Biological Diversity (CBD) and the projects supported by the United Nations Environment Program (UNEP) Global Environment Facility (GEF). Mainstreaming integrates biodiversity in existing or new programs and policies, both cross-sectoral and sector-specific. The conventional model of agricultural production with limited diversity in production systems and use of high chemical input has taught us a valuable lesson as it is adversely impacting the environment, the essential ecosystem services, the soil health and the long term sustainability of our food systems. Using a qualitative participant observation approach, our study investigated four distinct traditional Indian production landscapes to gage (i) the farming communities' response to institutional policies, programs and agricultural biodiversity-related activities in traditional Indian production landscapes and (ii) opportunities and challenges for sustainable development in smallholder traditional Indian farming systems. Results indicate that the top-down decision-making regime is the least effective towards achieving sustainable development in traditional Indian farming landscapes and that farmers' experiential knowledge on participatory biodiversity management, maintenance and use for sustainable development are of critical importance to India's agriculture and economy. Reclaiming agriculture's spiritual roots through organic farming and locally grown food emerged as key, including the need for designing and implementing a more sovereign food system. Revisiting traditional smallholder farming under the COVID-19 pandemic and lessons learned for repurposing India's agricultural policy are also highlighted.

Keywords: mainstreaming biodiversity; sustainable development; farmers' experiential knowledge; indigenous food sovereignty; repurposing agriculture policy post-COVID-19

1. Introduction

Mainstreaming seeks to integrate biodiversity into the cross-sectoral and sector-specific policies and programs, where it has received limited attention [1,2]. Mainstreaming biodiversity in production landscapes addresses conservation and sustainable use of biodiversity as the major objectives of the Convention on Biological Diversity (CBD) and the projects supported by the Global Environment Facility (GEF) of the United Nations Environment Program (UNEP). The UNEP and GEF have made a major contribution to supporting agricultural biodiversity at the global level in the face of climate change [3].

The sustainability and resilience of production systems, human livelihood and wellbeing and environmental health essentially depend on biodiversity and many of the basic services provided

by the ecosystems. While the global agroindustrial food system is credited with increasing food production, availability and accessibility, it is also credited with giving birth to "new" challenges such as malnutrition, biodiversity loss and environmental degradation [4]. The potential of underutilized indigenous and traditional crops have been recognized to bring about a transformative change to the food system. A transdisciplinary approach to mainstreaming underutilized indigenous and traditional crops into the food system are expected to offer real opportunities for developing a sustainable and healthy food system besides achieving other societal goals of employment creation, wellbeing and environmental sustainability. The policy makers, however, need to bring about policy convergence in pursuit of a food system that includes smallholder famers, and where underutilized indigenous and traditional crops are mainstreamed into the food system.

Biodiversity in production landscapes, however, remains threatened, undervalued and neglected [5]. A recent publication [6] outlines initiatives and progress made for value chain development and mainstreaming traditional nutrient-dense crops for nutrition sensitive agriculture by exploiting rich biodiversity in Nepal. A biodiversity-based value chain development for mainstreaming nutrition sensitive agriculture has been advocated at the local and national level to improve their performance, efficiency and interlinkages [6]. Use of traditional crop biodiversity for nutrition sensitive value chain development can play a 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 nutritious food for household nutrition security.

The methodology of mainstreaming biodiversity into national and global policy instruments for addressing food and nutrition security has been explored in a multi-country initiatives of Biodiversity for Food and Nutrition (BFN) Project led by Brazil, Kenya, Sri Lanka and Turkey [7]. This successfully demonstrates how the approach can be adapted to suit specific country contexts and how a multi-level, cross-sectoral partnership-based approach can connect food biodiversity conservation and sustainable use to address critical problems in our current food systems, and create an enabling environment for mainstreaming biodiversity to improve nutrition [8].

The conventional current model of agricultural production, based on limited diversity and high chemical inputs, undermines the long-term sustainability of our food systems and compromises with the essential ecosystem services produced in agricultural landscapes. The much needed transition to diversified, sustainable and resilient production systems will, however, depend on our ability to leverage the transformative force of agricultural biodiversity [9].

We feel that there is a need for more responsible and resilient farming system. Agroecology tries to meet this need because it aims to produce a more sustainable and ecological farming system. One of the best ways to mitigate climate change is to create sustainable food systems based on sustainable agriculture. The conventional agricultural practices has an enormous environmental footprint and sustainable agriculture is a more holistic approach to farming as it relies on ecosystem services and is typically much less detrimental to the surrounding landscapes. Furthermore, sustainable agriculture provides a potential solution to enable agricultural systems to feed a growing population within the changing environmental conditions.

India, with a large landmass and varied ecosystems and representing nearly 7–8% of the recorded species, is one of the 17 recognized mega-diverse countries of the world. It represents 4 of the 36 Conservation International designated globally identified biodiversity hotspots. Besides, there are 22 recognized agrobiodiversity hotspots [10] that harbor the diversity of native and naturalized crops, their wild and weedy relatives, and crop associated biodiversity in agroecosystems.

The smallholder farming in all recognized agrobiodiversity hotspots is mainly subsistence and highly labor-intensive. Outmigration of rural youth, the main labor force, in search of off-farm employment; adverse impact of global warming and climate change; loss of biodiversity in production landscapes and forces of globalization are all challenges faced by native farming communities that negatively impact sustainability of smallholder farming and food systems.

Agriculture is the biggest land user and the biggest employer in India. Nearly 55% of the population relies on agriculture and related activities for their livelihood. Smallholder and marginal farmers account for 86.2% of all farmers in India owing just 47.3% of the total area sown to crops [11]. The major development goals of the country include the economic viability of agriculture, social and economic equity for farmers, food and nutrition security for all and ensuring quantity and quality food at affordable prices.

The UNEP-GEF project "Mainstreaming agricultural biodiversity conservation and utilization in agricultural sector to ensure ecosystem services and reduce vulnerability" is presently operative in India. The project is designed to implement activities in a set of intervention sites distributed across four contrasting agroecosystems, viz. 1. North-Western Himalayas including the cold arid tract; 2. north-eastern region and the Eastern Himalayas; 3. western arid/semi-arid region and 4. central tribal plateau region of Madhya Pradesh and adjoining tract of Chhattisgarh, each of which possesses valuable and unique but threatened agricultural biodiversity. These four contrasting agroecosystems were selected because each agroecosystem has its unique crops and their associated diversity adapted to diverse agricultural practices, weather pattern and socioeconomic systems. Therefore, working on these contrasting ecosystems will help develop models, which can be replicated and upscaled to other sites nationally and globally.

The UNEP-GEF project will directly support India's contribution to the CBD's Strategic Plan and the Aichi Targets adopted at the 10th Conference of the Parties (CoP) of the CBD. Most directly it will contribute to the sustainable management of areas under agriculture (Target 7) and to the maintenance of the diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socioeconomically and culturally valuable species (Target 13). The CBD's Strategic Plan and the Aichi Biodiversity Targets [12], especially Target 7 and Target 13 greatly recognizes the importance of ensuring the conservation and sustainable use of biodiversity in production systems. However, the work of the project will also make material contributions to other targets through, for example, integrating biodiversity values into national and local development and poverty reduction strategies (Target 2), and improving the provision of essential services from ecosystems (Target 14). The UN Sustainable Development Goals (SDGs) also recognize the importance of biodiversity in production systems. The importance of securing sustainable production and conservation of biodiversity has also been duly addressed by Targets 4 and 5 of SDG 2 [13] with increased emphasis on mainstreaming biodiversity into production landscapes.

The present exploratory research survey, using the above project funds, documents information on mainstreaming agricultural biodiversity in traditional Indian production landscapes for sustainable development, with the following broad objectives:

(i) Investigating the farming community response to institutional policies, programs and activities related to agricultural biodiversity in traditional Indian production landscapes.
(ii) Smallholder traditional Indian farming: opportunities and challenges for sustainable development.
(iii) Reinventing traditional smallholder agriculture, post COVID-19 pandemic.

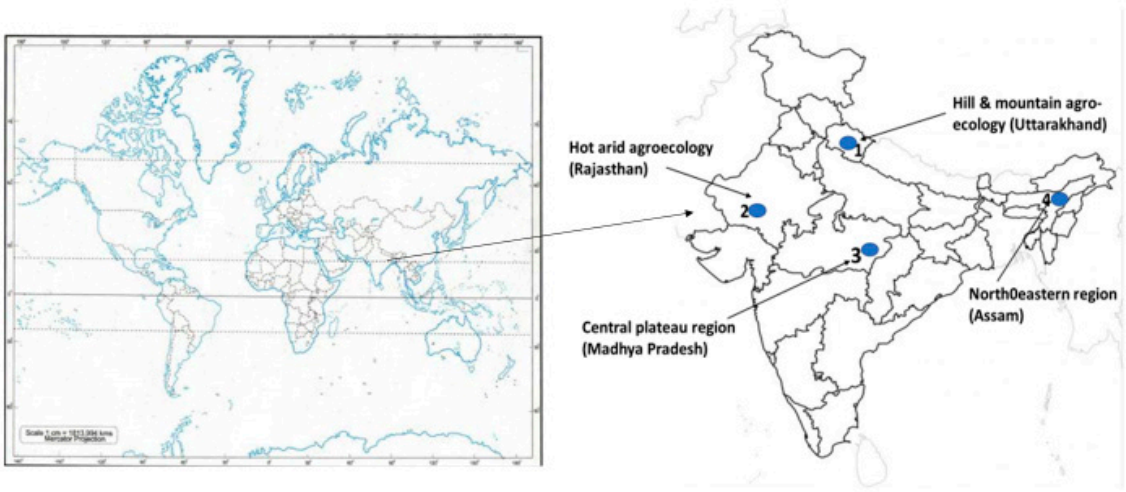
The present study outcomes will provide us with the necessary inputs to reorient agriculture towards sustainable production by mainstreaming biodiversity in traditional agricultural production landscapes. The exploratory survey research will indicate specific areas where we can generate empirical research data through well planned case studies, which will add value to the project outcomes of the above UNEP-GEF project.

2. Materials and Methods

In the present study, four unique farming production landscapes of India, viz. hill and mountain, hot arid desert, central tribal plateau and the north-eastern region were represented. The specific study sites include representative agroecologies of the entire Uttarakhand hills (part of the North-Western Himalayas); parts of rural Jodhpur in Western Rajasthan (hot arid desert); parts of the tribal Umaria

district in Madhya Pradesh (central tribal plateau) and parts of Assam-Golaghat district (north-eastern region; Figure 1). A total of 26 focus group discussion (FGD) meetings, involving about 1000 farmer households (HHs) were organized in 2018–2019, to document the following specific aspects:

- Farmers' response to policies, programs and activities related to agricultural biodiversity in traditional Indian production landscapes to understand how best the Indian institutional support has been operating under actual farming scenarios.
- Merits of smallholder traditional farming for: (i) bringing sustainability to food and farming systems, particularly the importance of farmers' experiential knowledge in managing, using and conserving biodiversity in production landscapes for sustainability and resilience in agriculture and (ii) reclaiming the spiritual roots of agriculture for sustainability in food and farming operations. Seeking opportunities to promote indigenous food sovereignty were also explored.
- Adapting/redefining traditional smallholder farming in the time of the COVID-19 pandemic and lessons learned for repurposing India's agricultural policy.



1. **Hill & mountain agroecology (Uttarakhand)**
2. **Hot arid agroecology (Rajasthan)**
3. **Central plateau region (Madhya Pradesh)**
4. **North-eastern region (Assam)**

Figure 1. Study sites representing four distinct agroecologies of India.

We conducted a total of 26 FGD meetings involving about 1000 farmer household representatives from all four agroecologies of the above stated UNEP-GEF project. A total of 20 FGD meetings were conducted in the Uttarakhand state (North-Western Himalaya) alone, as part of several studies conducted in the past 2–3 years viz. crop landrace diversity and population structure; food-based approaches towards community nutrition and health under econutrition framework; community seed system, farmers rights and indigenous food sovereignty; localized marketing of native crop produce and possibilities of value chain development for the food crop resources; wild plant food resources in agricultural systems; impact of globalization on household food and nutrition intake, etc. Altogether, a sum of about 700 farm households representatives were involved in these FGD meetings from the specific niche sites, 30–35 household representatives participating in one FGD meeting. In Uttarakhand hills, three are three representative agroecosystems, 10 FGD meetings were conducted in the mid-hills with 70% of the arable land where crop–livestock small scale mixed-farming is predominantly practiced and 5 FGD meetings each were conducted in the remaining two agroecosystems, i.e., high mountainous regions/mountain meadows adjoining Tibet with nomadic pastoralist communities, and the river valleys where improved agriculture is practiced under assured irrigation with about 10–15% of the arable land each. The relevant data have been used in the present communication.

Two FGD meetings each were, however, conducted from the other three agroecologies of the above UNEP-GEF project, parts of the Jodhpur district (Rajasthan state) in the western arid region, parts of the Umaria district (Madhya Pradesh state) in the central tribal plateau and parts of the Golaghat district (Assam state) in the north-eastern regions. A total of about 300 household representatives participated in these six FGDs with about 50 farmer household representatives involved in each meeting, respectively. For conducting the two FGD meeting in each of these three agroecologies, we selected a core village where specific project interventions are taking place under the above stated UNEP-GEF project and another village outside the core village where no formal interventions are taking place under the project, for impact assessment at a later stage, if any. As the qualitative participant observation approach was adopted for eliciting information on different aspects, we purposely selected group of individuals rather than a statistically representative sample of a broader population. The sample size was, therefore, not of much consequence and altogether about 1000 farm household representatives were involved in the present study from all four agroecologies.

We elicited this information through informal in-depth discussions without structured questionnaires except for few indicators where semistructured questionnaires were used. A qualitative participant observation approach of data collection was mainly adopted in the present study with direct interaction with individuals in group settings. Full involvement of the researcher was ensured in the entire interaction process in the FGD meetings. Focus group discussions were specifically helpful in documenting indigenous knowledge-based information on a range of issues.

Broader areas on which in-depth discussions were held during the FGD meetings are presented in Appendix A.

All care was taken to involve elderly and knowledgeable farmer HH representatives. Due representation of farmer HHs was also ensured based on age, gender, education, wealth status, social status and ethnic group. On average, about 50% representation was of the elderly people, >50 years of age, both men and women farmers equally represented. About 30% representation was of the farm households between 30 and 50 years age group and the remaining 20% were the young adults, <30 years of age.

As the research design of the present study was based on an exploratory survey, all analysis and interpretations were based on researchers' subjective judgments. For limited quantitative data, recorded as a percentage, particularly for species and within-species (genetic) diversity, and agricultural inputs used in different farming agroecologies, original values without transformation and a normality test are presented. As the researcher is fully involved in the interaction process, using our expert knowledge we arrived at an average value and getting the value validated from the farmer household participants for the limited quantitative data recorded. In the participant observation approach of the data collection, we recorded information from individuals in a group setting and not recording the data using structured questionnaires from the individual participants separately.

3. Results

3.1. Policies, Programmes and Activities Related to Agricultural Biodiversity in Production Landscapes: Indian Scenario

As custodian of agrobiodiversity, the native farming communities play a significant role for the preservation and conservation of these resources in production ecosystems. Yet, the surveyed farming communities' responses indicated that the majority of HHs across the agroecologies are not aware of any formal institutional projects or programs implemented for surveying and monitoring of agrobiodiversity, crop associated biodiversity and the wild plant food resources in production landscapes (Table 1).

Despite the mechanisms put in place by the government of India, it appears from our survey results (Table 1) that a mainly non-participatory approach was adopted in planning and decision making while developing institutional policies, programs and activities related to agricultural biodiversity in production landscapes. Farming communities are also ignorant about other national legislations/regulatory frameworks, which are directly or indirectly impacting the Farmers' Rights

under the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act 2001 of India. Farmers appear to be comfortable with informal seed exchange at community level and apprehensive about restricted exchange, if any, of the farmer varieties/native landraces under the Intellectual Property Rights (IPR) Regime.

Table 1. Institutional policies, programs and activities related to agricultural biodiversity in production landscapes in India.

Policies, Programs and Activities	Farmer HHs Response
Biodiversity assessment and monitoring	
• Documenting the status of agricultural biodiversity in traditional production landscapes. • Documenting population sizes and threats to crop associated biodiversity species in and around traditional agricultural and food production systems. • Population sizes and threats to wild food species.	Farmer households (HHs) in all the agroecologies are not aware of any formal institutional projects or programs implemented for surveying and monitoring agrobiodiversity, the crop associated biodiversity, and the wild food species in production landscapes.
Conservation and sustainable use of biodiversity in production landscapes	
• Protecting agricultural biodiversity and implementation of conservation measures for crop associated biodiversity and wild plant food resources from climate change and other disasters, natural or human induced. • Using agricultural biodiversity to cope with climate change and other disasters. • Maintenance and use of traditional knowledge of agricultural biodiversity and wild foods. • Developing mechanisms for improved access and ensuring the fair and equitable sharing of benefits arising from the use of agricultural biodiversity.	No institutional support initiatives were reported by farmer HHs for on-farm conservation and sustainable use of agricultural biodiversity. Farmer HHs, however, report often contributing the seed samples/planting material for ex situ conservation in the National Genebank of India at ICAR-NBPGR, New Delhi. Farmer HHs also report that the institutional crop improvement efforts have limited relevance to traditional rainfed farming landscapes in all agroecologies.
Agrobiodiversity policies and capacity building	
• The national policies affecting the conservation and sustainable use of agricultural biodiversity, crop associated biodiversity and wild plant foods. • Regulatory frameworks or national legislations for agricultural biodiversity, crop associated biodiversity, wild foods and ecosystem services. • Collaboration with other stakeholders involved in the management of agricultural biodiversity (e.g., farmers, forest dwellers, plant breeders, government agencies, research institutes and civil society organizations). • Public awareness and capacity building programs on the management of crop associated biodiversity and ecosystem services in food and agriculture production systems.	The awareness level of farmers HHs on the institutional efforts for agricultural biodiversity policies and capacity building initiatives is low. Farmer HHs are not much aware of any regulatory frameworks or national/ international legislations on biodiversity for food and agriculture, crop associated biodiversity, wild foods and ecosystems. Few formal institutional capacity building initiatives were reported by the farmer HHs.

It is thus evident that the top-down decision making regime for traditional Indian farming communities has been ineffective in achieving sustainable development. There is, therefore, a need to engage traditional farming communities in participatory planning and allocation of budgetary resources. However, as custodians of native diversity, traditional farming communities are de facto managing, using and maintaining enough diversity in production landscapes. Ex situ (off-farm) conservation has been the major emphasis until now in Indian national plant genetic resources management system. Deploying more diversity in production landscapes is, however, considered a better approach for sustainability of farming systems, which provides opportunity for generating novel variations in the climate change regime. Ex situ collections in genebank, on the other hand have limited use and management is highly resource intensive.

3.2. Smallholder Traditional Farming: Opportunities and Challenges for Sustainable Development

3.2.1. Farmers' Experiential Knowledge Is the Key to Sustainability and Resilience in Agriculture

Farmers' indigenous or traditional knowledge or local ecological knowledge refers to the knowledge and expertise accumulated and renewed across generations, which guides societies in their innumerable interactions with their surrounding environment.

Modern industrial agriculture is based on a model that encouraged farmers to become more integrated in markets and dependent on the use of external inputs, technologies and capital. It was projected as the only route to success and it encouraged a more uniform pattern of farming. As such, it weakened the linkages between farming and local ecology.

For the successful mainstreaming of biodiversity in production landscapes, farmers' experiential knowledge must be recognized from a holistic perspective and cannot be studied and understood in isolation, studying its application sector by sector, as it stems from experience and is applied in all of the following interlinked fields as described in Table 2.

The biological diversity in farming systems can be studied at three levels: (i) the diversity of agricultural systems (agroecosystems), (ii) the diversity in the number of crop species grown in a particular agroecosystem and (iii) the diversity of different varieties of these crop species. In agrobiodiversity, the genetic diversity within one species is as important as the diversity between different species. Diversity between major staple food crop species and within species in the different agroecologies studied is presented in Table 3, revealing that the average level of genetic diversity (different varieties) maintained per crop by farming communities at the community level is considered acceptable, with an approximate ratio of an average three varieties per crop. At the population level, about 55% are rare landraces. The crop landrace diversity or within-species varietal diversity has been created and maintained with the active intervention of native farmers. Loss in traditional farming landscapes has been reported more for crop species diversity compared to within-species genetic diversity in all traditional agroecosystems. Traditional production landscapes, therefore, have the capacity to conserve more diversity on-farm in the farming system.

Native communities in all Indian agroecologies are particularly exposed to climate change impacts due to their resource-based livelihoods and remote environmental locations. As farming communities have been coping with the environmental uncertainties and climate change impacts over generations, they have demonstrated their resourcefulness and response capacity in the face of global climate change. Agroforestry diversification has also provided a buffer against environmental variability and change.

Table 4 lists the main agroforestry species of the different farming agroecologies. The agroforestry system varies in structural complexity and species diversity, home gardens, homestead cultivations and plantation-based agroforestry systems are commonly found across the different Indian agroecologies.

The important characteristics of farmers' experiential knowledge and their application in sustainable agricultural development and management of natural resources are presented in Table 5. A major strength of the farmers indigenous knowledge is that it is holistic in approach compared to the reductionist approach of the modern agrarian science and therefore has great relevance for agricultural sustainability and resilience.

It was revealed that conserving crop diversity in production landscapes greatly matters when the aim is to foster sustainability drawing upon the adaptive nature of farming styles. In traditional Indian farming context, we find limited responsiveness of modern science to the societal needs. The gap between experts' knowledge and traditional innovations in actual farming situations was more pronounced when sustainability issues are being considered. Sustainability of the traditional smallholder farming, therefore, requires a holistic approach and an interdisciplinary research style.

Table 2. Farmers' experiential knowledge and various management actions related to mainstreaming biodiversity in production landscapes.

Management Areas	Management Actions Based on Farmers' Indigenous Knowledge (IK)
Agricultural and associated biodiversity conservation	Farmers' IK could be specifically documented in the following fields of community level biodiversity management: • Management of domesticated and wild farm biodiversity • Local community-level on-farm and off-farm vegetation management including forestry resources • Managing biodiversity in sacred groves/sacred landscapes • Cultivation of medicinal plants.
Adaptation to climate change	• The multiple and diversified livelihood skills of farmers is a source of resilience in times of uncertain weather and climate change. • Maintaining species and genetic diversity in fields provide a low-risk buffer in uncertain weather and the diversity in production landscapes is considered a necessity rather than a choice.
Agroforestry	• Indigenous knowledge on traditional agroforestry offers opportunities to farmers for sustainable management of resources and support socioecological and socioeconomic benefits. • The traditional/cultural knowledge embedded within the rural communities in different agroecologies is the inherent identity that is unique and diverse in all respects to traditional agroforestry management and conservation. It is reflected in their cultivation system, ethnobiology and health and nutrition management.
Traditional medicine	• Use of herbal medicines was reported by native farming communities of all Indian agroecologies. Traditional medicines are used to cure different ailments. Herbal formulations were administered either internally or applied externally depending on the type of ailment.
Customary resource management	• Traditional knowledge, innovations and practices duly supported by spiritual beliefs and customary laws are developed and nurtured over many generations. The natural resource-based livelihood of native communities enables them to live within the natural limits of specific territories, areas or resources upon which they depend for livelihoods and wellbeing.
Applied anthropology	• Indigenous knowledge and institutions are contributing to more culturally appropriate and sustainable development. It is also based on the realization that native communities are not only more keenly aware of their needs than are outside development agencies but that those needs are culturally defined, demanding a substantive rather than a formal appreciation.
Impact assessment	• Indigenous knowledge can assist in bringing awareness about the potential impact of a project and steps taken to prevent adverse effects to the existing environment but there are currently no guidelines on how indigenous knowledge should be integrated into impact assessments.
Natural disaster preparedness and response	• Indigenous knowledge can be transferred and adapted to other communities in disaster management, it encourages community participation and empowers communities in reducing disaster risk.

Table 3. Major staple food crop species and within-species (genetic) diversity in different agroecologies *.

Agroecology	Crop Species Diversity (nos.)	Within-Species (Genetic) Diversity (nos.)	Area Share of Common Landraces (%)	Area Share of Rare Landraces (%)	Loss of Species Diversity (%)	Loss of Genetic Diversity (%)
1. Hill and mountain	17	52	40	60	15	5
2. Hot arid	12	37	47	53	20	5
3. Central tribal plateau	14	41	52	48	20	8
4. North-eastern region	21	61	45	55	25	10

* Diversity estimates were made per village, as a unit of study.

Table 4. Main agroforestry species of the different Indian farming agroecologies.

Agroecology	Main Crops	Main Tree/Shrub Agroforestry Species
Hill and mountain	Rice, wheat, minor millets (ragi, barnyard millet, foxtail millet), black-seeded soybean, urd bean, horsegram, mustard, sesame, pseudocereals (amaranths, buckwheat), miscellaneous vegetables, temperate fruits, etc.	Main agroforestry species for high quality fiber are *Ficus semicordata*, *Grewia oppositifolia*, *G. asiatica*, etc., and for edible fruits are *Celtis australis*, *Grewia oppositifolia*, *G. asiatica*, *Ficus auriculata*, *F. palmata*, *F. semicordata*, *F. nemoralis*, *Pyrus pashia*, etc., beside several others.
Hot arid	Pearl millet, mung bean, sesame and cluster bean	*Prosopis cineraria*, *Ziziphus nummularia*, *Capparis decidua*, *Acacia senegal.*
Central tribal plateau	Rice, wheat, pigeon pea, mung bean, urd bean, soybean	Forestry species: *Acacia nilotica*, *Leucaena leucocephala*, *Gmelina arboria*, *Dalbergia sissoo*, *Millettia pinnata*, and as fruit trees: *Syzygium cumini*, *Psidium guajava*, *Moringa oleifera*, *Phyllanthus emblica*, *Annona reticulata*, *Artocarpus heterophyllus.*
North-eastern region	Rice, tea, vegetables, sugarcane, jute, cotton, black gram, lentil, green gram, gram, pigeon pea, linseed, castor, sesame, rapeseed and mustard, banana, papaya, orange, pineapple, areca nut, coconut, chili, turmeric, ginger, potato, sweet potato, etc.	*Aquilaria agalacha* (Agar), *Areca catechu*, *Schima wallichii*, *Cassia nodosa*, *Cassia seamea*, *Albizzia procera*, *Piper betel*, *P. longum*, bamboos, canes, timbers and other shade trees.

3.2.2. Reclaiming the Spiritual Roots of Agriculture for Sustainability in Farming and Food Systems

Spirituality is not new to agriculture. People, in general gave thanks to God for their "daily bread" and for a bountiful harvest at thanksgiving. By growing and eating food, people experienced a spiritual realization of their connectedness to each other, the land and to God or their concept of ultimate reality. There are as many as 18 different festivals related to crop harvesting in India alone. As India is a land of great biodiversity, different states celebrate many harvest festivals, which include Bhogali Bihu, Gudi Padwa, Nuakhai, Makar Sankranti, Baisakhi, Onam and Pongal, among others. Harvest festivals are marked with celebrations and prayers.

Farmers' sense of responsibility for meeting the basic everyday food needs, while ensuring equal opportunities for future generations, arises from a sense of spiritual connectedness with other people—other farmers, neighbors, consumers, society and with other living and non-living things of the earth. Farmers and consumers who collaborate to create sustainable food systems do so because it is the morally and ethically "right thing to do". The future of agriculture and of humanity depends on farmers and consumers guided by a spiritual sense of rightness and goodness.

Organic agriculture and local food systems in all Indian agroecologies are deeply rooted in spirituality and sustainability principles. For a sustainable agricultural development, efforts are now underway to find ecologically sound, economically viable and technologically improved methods of agricultural farming. Organic food is attracting the interests in view of food quality and safety, better health and the concerns of environmental sustainability.

As organic agriculture has shown itself to be the viable alternative countering the aftereffects of the high-input chemical-rich agriculture practiced since 1960s, farming communities in all Indian agroecologies are encouraged to practice organic farming. Although farming in all traditional Indian

agroecologies is mostly organic by default, conscious organic farming has suddenly picked up across all Indian states.

Table 5. Important characteristics of farmers' experiential knowledge and the lessons learnt for its application to sustainable biodiversity management in production landscapes.

Farmers' Experiential Knowledge		Lessons Learnt for Management Actions
1.	Farmers' knowledge has local agroecological and socioeconomic context and is holistic in approach	Farmers' learn by doing and implement through learning. Farmers indigenous knowledge have thus developed the art of developing agriculture in local context and rebalancing naturally available resources and services that affect agriculture creating these local conditions. Much of the farmers' indigenous knowledge remain tacit or implicit, farmers often are unable to verbalize what they know. Farmers' knowledge is an integrated knowledge and tends to be holistic compared to scientists' tendency towards a reductionist approach.
2.	Conserving biodiversity in production landscapes greatly matters for farmers	The six important reasons why conserving crop diversity in production landscapes matters for farmers are (i) ensuring food security, (ii) adapting to climate change, (iii) reducing environmental degradation, (iv) protecting nutritional security, (v) reducing poverty and (vi) ensuring sustainable agriculture. Differential farming styles are, in fact, deployment of biodiversity in production landscapes adapted to the local agroecological conditions. The adaptive nature of farming styles is the main rationale behind fostering sustainable agricultural development.
3.	Conventional innovations and formal agricultural knowledge are least responsive to societal needs	The conventional "linear model of innovation" has specific task division between various actors: the scientists, the extension agencies and the farmers. Farmers' role is merely to apply the innovation. We find deviations, from the linear model, in most of the successful farming innovations in traditional production landscapes that occurred without the involvement of scientists. Hence, we feel that the innovations require close cooperation of a network of actors and the farmers' creative role needs to be integrated in the innovation processes. In traditional Indian farming context, the farmers have not been provided much opportunity to be involved in scientific innovations including funding arrangements for the research. We, therefore, need to ensure that the voices of farming communities heard and the activities of scientists are responsive to their localized needs.
4.	The fragmented nature of conventional agricultural sciences and limitations of dominant epistemologies	The conventional agricultural research and education system is structured around disciplines and classical agricultural sectors (e.g., crop husbandry, animal husbandry, dairy farming, pig farming, fish farming, etc.). Thus, many agricultural institutions are segmented and organized accordingly and the scientists have therefore become experts in their own field that only addresses a very narrow element of agriculture. Furthermore, the epistemological culture, which tends to reduce the complex wholes to their component parts often results in limited approaches to sustainability. The decision making in sustainable farming research, therefore, requires a holistic and an interdisciplinary research approach.
5.	Yield optimization is a better approach than yield maximization for sustainable production	The application of conventional agricultural knowledge tends to focus more on yield maximization based on the scientific experiments conducted under controlled environments. These models often fail under real farming situations when sustainability issues are being considered, making the scientific experts' knowledge of limited practical value to the farmers.

With the sizable acreage under default organic cultivation, all traditional agroecologies have tremendous potential to grow crops organically and emerge as the main supplier of organic products in the local, regional, national or world organic market. The types of inputs used in different Indian farming agroecologies are presented in Table 6. It is clear from Table 6 that mostly local crop landraces are cultivated in all the agroecologies, with negligible use of purchased inputs and limited farm mechanization. As farming is mainly subsistence, there are only a few non-food crops grown. Table 7 lists the important crops grown in the four Indian farming agroecologies that have the potential to fetch premium prices in local, regional and global markets.

Table 6. Characteristics of inputs used in traditional Indian farming agroecologies *.

Inputs	Hill and Mountain	Hot Arid	Central Plateau	North-Eastern Region
1. Use of farmer varieties or traditional landraces (%)	90	80	80	72
2. Use of purchased inputs (%).				
- Seeds	5	10	15	15
- Inorganic Fertilizer	-	5	10	10
- Pesticides	-	-	-	-
3. Use of improved modern farming practices (%)	-	10	15	15
4. Area share of crops that have non-food uses (%)	5	5	5	10

* Percent of households in a village, as a unit of study.

Table 7. Organically grown crops with high marketing potential grown in the four Indian agroecologies.

Agroecology	Organic Crops with High Marketing Potential
Hill and mountain	Common bean, soybean (local black-seeded), black gram, horse gram, finger millet, barnyard millet, buckwheat, amaranths, aromatic (including basmati) and red rice.
Hot arid	Coriander, fennel, fenugreek, mung bean, pearl millet, sesame.
Central tribal plateau	Sharbati wheat grown in Vidisha, Sagar and Sehore; durum wheat of Malwa region, Pigeonpea of Hoshangabad and Narsinghpur district of Narmada plateau; Kodo-Kutki of Mandla and Dindori district; Basmati/aromatic rice of Raisen, Bhopal, Jabalpur, Mandla, Ambikapur and Balaghat, and organic cotton of Nimar and Malwa is in great demand nationally/internationally.
North-eastern region	Joha (aromatic) rice, ginger, turmeric, chili, oranges, black pepper and pineapples.

3.2.3. Promoting Indigenous Food Sovereignty

At the Forum for Food Sovereignty, held in Sélingué, Mali on 27 February 2007, about 500 delegates from more than 80 countries adopted the "Declaration of Nyéléni", which, in part, states: "Food sovereignty is the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems. It puts those who produce, distribute and consume food at the heart of food systems and policies rather than the demands of markets and corporations. It defends the interests and inclusion of the next generation. It offers a strategy to resist and dismantle the current corporate trade and food regime, and directions for food, farming, pastoral and fisheries systems determined by local producers. Food sovereignty prioritises local and national economies and markets and empowers peasant and family farmer-driven agriculture, artisanal fishing, pastoralist-led grazing, and food production, distribution and consumption based on environmental, social and economic sustainability" [14].

The traditional farming landscapes of India in all agroecologies mostly rely on household production and dietary diversity with limited surplus for local marketing. These subsistence farming landscapes are expected to set the stage for future research that demonstrates how these local foods contribute to a sustainable agriculture–food–nutrition strategy. It will also set a stage for future research demonstrating its contribution for food security, nutrition and health, economic resilience, cultural heritage and self-preservation of native communities. A sustainable food system requires a more radical transformation of agriculture, one guided by the notion that ecological change in agriculture cannot be promoted without comparable changes in the social, political, cultural and economic arenas that help determine agriculture. The organized peasant and indigenous-based agrarian movements such as the international peasant movement La Vía Campesina and Brazil's Landless Peasant Movement (MST) have long advocated for genuine agrarian reforms to access and control of land, water and biodiversity that are of central importance for communities in order to meet the growing food demands.

3.3. Reinventing Traditional Smallholder Farming in the Time of the COVID-19 Pandemic and Lessons Learned for Repurposing India's Agricultural Policy

The rural male youths, often not finding traditional farming economically rewarding, migrate from all Indian agroecologies to other areas in search of better livelihood options through farm/non-farm employment. There was large-scale reverse migration due to COVID-19 pandemic immediately after the lockdown imposed on 25 March 2020 in India, which provided an opportunity to the local administration and policymakers to engage the returned laborers in gainful employment at the community level.

The reverse migration of laborers to India's remote areas is having a differentiated impact across regions. While agricultural operations in the well-endowed regions, particularly agriculturally well-developed north-western plains, are about to suffer, the traditional remote farming areas will have received an excess supply of work force, throwing up new challenges and opportunities.

Reverse migration due to COVID-19 lockdown and restrictions provides an opportunity for the local administration in remote areas to engage the returned laborers in gainful employment, and the only short-term option is to direct that towards leveraging the economic potential of traditional subsistence agriculture. Especially labor-intensive sectors, like livestock, fisheries, poultry, food processing, agroforestry and agroecotourism, have not developed over the years, and the laborers who have returned can be used to reverse this trend. In this context, it is worthwhile revisiting the role played by agriculture in economic development, to throw light on the policies the sector will need to adopt to facilitate its recovery.

In terms of sustainability of smallholder traditional farming, promoting organic farming in traditional production agroecologies, linking organic farm produce to localized marketing interventions viz., Community Supported Agriculture, Midday (School) Meal Scheme and value chain development of local food resources are being suggested. The above interventions will result in the creation of enough jobs at the community level for rural youths. Retaining rural youth at the community level will bring much needed sustainability in traditional farming and food systems, which is highly labor-intensive and often fails to provide year-round employment.

COVID-19 could reinvent the importance of the smallholder Indian agricultural sector as the one on which our rural labor force can fall back on at a time of crisis. Reviving this sector will be the key to driving/boosting the post-COVID-19 phase of the Indian economy.

The Himalayan state, Uttarakhand, in North-Western India, has been facing the problem of large scale migration of rural youths in search of education and employment. This has negatively impacted the traditional hill farming, which is highly labor-intensive. The COVID-19 nationwide lockdown has resulted in a reverse migration of these migrant laborers to return home. The village youths might go back to their cities once the COVID-19 pandemic is over. However, if these reverse migrants could be retained in their communities of origin through government-initiated opportunities and schemes for gainful employment, this would be an opportunity for the traditional hill farming to be sustainably revived.

The state government has, however, launched a scheme to provide self-employment opportunities to the youths and the returning migrants. According to a study done by the government's Rural Development and Migration Commission Team, of the 252,687 (71% of the total returnees) migrant workers who stayed back, 12% have started their own ventures, 33% have taken up agriculture (crop husbandry), 38% turned to animal husbandry and 17% have enrolled themselves under the Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA) scheme. This is a positive outcome of the efforts put in by the state government in past six months.

4. Discussion

4.1. Policies, Programmes and Activities Related to Agricultural Biodiversity in Production Landscapes: The Indian Scenario

Traditional farming communities in the present study consider that institutional support towards conserving their rich farm and off-farm biodiversity has not been enough. Despite the many laws in place ((the Wildlife Protection Act, 1972; the Forest (Conservation) Act, 1980; the Environment (Protection) Act, 1986; the Protection of Plant Varieties and Farmers' Rights Act, 2001; the Biological Diversity Act, 2002; the Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006)), the native communities openly recognize that there is a lack of effective enforcement of the laws to protect and sustainably use biodiversity. Whichever the biodiversity conservation and sustainable use interventions being implemented, all efforts can be attributed de facto to native farming communities.

Under the sui generis systems, the Biological Diversity Act, 2002, an Act of the Parliament of India for preservation of biological diversity in India, provides a mechanism for the equitable sharing of benefits arising out of the use of traditional biological resources and knowledge. Another Act, The Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act, 2001 provides for the establishment of an effective system for protection of plant varieties, the rights of farmers and plant breeders and to encourage the development of new varieties of plants. The act duly recognizes and protects the farmers' rights in respect of their contribution made in conserving, improving and making available plant genetic resources for the development of new plant varieties. Despite, these national legislations in place, traditional farming communities have limited awareness about these developments and implementation of these acts is a big concern.

The UNEP/GEF-supported projects implemented in the past 17 years have provided a rich body of experiences on the many different aspects of ensuring effective conservation and use of agricultural biodiversity globally [3]. A biodiversity-based value chain development for mainstreaming nutrition sensitive agriculture has been advocated at the local and national level to improve their performance, efficiency and interlinkages in Nepal [6]. The potential of underutilized indigenous and traditional crops have also been recognized to bring about a transformative change to South Africa's food system [4]. A transdisciplinary approach to mainstreaming traditional crops into the food system are expected to offer real opportunities for developing a sustainable and healthy food system besides achieving other societal goals of employment generation and environmental sustainability. A political will for policy convergence is, however, essential in pursuit of a food system, which includes smallholder famers, and where underutilized indigenous and traditional crops are mainstreamed into the food system. A multilevel, cross-sectoral partnership-based approach has been advocated to connect food biodiversity conservation and sustainable use to address critical problems in the current food systems, which creates an enabling environment for mainstreaming biodiversity to improve nutrition [7,8].

In the present UNEP-GEF (India) project, capacity and awareness building are considered an essential requisite of mainstreaming biodiversity in production landscapes. Policy-related activities will largely be focused on ensuring that more agricultural biodiversity is deployed in production landscapes as a component of community's food and nutritional security, and climate change adaptation.

4.2. Smallholder Traditional Farming: Opportunities and Challenges for Sustainable Development

The modern agriculture with increased use of purchased inputs in the form of a fertilizer, irrigation, seed, pesticides and machinery all played a major role in the growth of agricultural production during the Green Revolution regime since 1960 onwards. However, the past several decades of industrial farming has taken a heavy toll on our environment and serious concerns are now being raised about the future of food production [15,16].

4.2.1. Farmers' Experiential Knowledge Is Key to Sustainability and Resilience in Agriculture

The need of a new knowledge base is being strongly felt for transition towards more sustainable agriculture [17]. The relevance of informal farmers' knowledge and learning practices in constructing alternative pathways to sustainable agriculture and strengthening agricultural resilience has been explored by Šūmane et al. [18]. Farmers greatly value local experiential knowledge as they see it as having practical and local relevance. The potential of farmers' experiential knowledge, however, is not being optimally used and a better strategy to integrate various forms of knowledge is needed [18].

Agricultural ecosystems are environments whose natural processes are being "disrupted". They are usually managed by farmers; many aspects of crop diversity would not survive without this human interference. Biological diversity is essential to life, providing the raw material for evolution and strengthening ecological stability. This also applies to crop diversity as without it, crop improvement is impossible, been regarded as a natural capital that can be drawn upon in order to contribute to strengthening people's livelihoods [19].

The diverse and locally adapted farming systems developed by native farmers world over with ingenious practices have helped address community food security and conservation of agrobiodiversity. The novel agroecosystem designs appropriate to smallholder farmers have already been modeled on successful traditional farming systems [20].

In traditional production landscapes, farmlands and domestic crop diversity cannot be seen in isolation. Forestry, agroforestry and other wild diversity are integral to domesticated biodiversity (crop diversity). Farmers, however, have been the sole custodians of the genetic wealth of the landraces they use. Conservation is especially important in the case of disappearing, specially adapted varieties, calling for renewed efforts to support farmers as custodians of biodiversity and genetic resources [21]. We need policies that engage native communities, as key partners, in climate change research and adaptation plans. Such collaboration between holders of indigenous knowledge and mainstream scientific research will result in coproduced knowledge relevant to implementing effective adaptation action on the ground. An increasing number of native communities and indigenous peoples (particularly in developed countries) are moving towards the creation of formal adaptation plans. However, adaptation planning and research is not evenly distributed across all regions [22].

On-farm conservation has been reported to result in a number of interlinked elements that supports agricultural biodiversity as part of a dynamic system [23]. The traditional landraces differing in morphological characters have been effectively used by farmers as markers for taste, texture, cooking quality, resistance to biotic/abiotic stresses, etc., besides yield per se.

Participatory forest management initiatives in all Indian traditional agroecologies have been a great success fulfilling the sociocultural needs of local communities. The Joint Forest Management (JFM) approach, which is based on the principle of the rights of local communities in forests, has been successfully used as an effective mechanism to manage the state owned forest appropriated by local communities. JFM approach has evolved in a unique property rights regime that ensures long-term sustainability of the community forestry resources in a mutually supportive manner.

Farming communities reported a loss of about 10–15% of forestry species during the past 2–3 decades due to habitat destruction, urbanization and agricultural expansion. Threat of extinction to several other crop associated biodiversity contributing to the productivity of agriculture, such as beneficial insects and fungi, was also reported.

Native farming communities in all Indian agroecologies are especially vulnerable to weather uncertainties and climate change. Whatever community level climate change adaptation plans are in operation are mainly rooted in Western scientific knowledge and the traditional farmer innovations have been largely ignored. As farmers have been adapting to the effects of climate change on a daily basis, incorporating indigenous knowledge into Western science-based climate change adaptation plans is an untapped opportunity that the policymakers can easily integrate into climate change adaptation plans and legislate accordingly.

Customary resource management initiatives, the culture-based system of self-governance, in all traditional agroecologies, ensure that both biodiversity and communities are prospering equally. Local communities have developed and consolidated close and profound connections with their territories or resources over generations. The community-specific practices such as zoning the arable and pasture land, selective harvesting, rotational or shifting cultivation, migratory grazing, etc., are highly knowledge-based that enable communities to interact with and use biodiversity in a sustainable manner.

Much of the ground-breaking work in applied anthropology is centered around issues of agricultural and environmental practices, both areas of immediate concern for survival. There has been increasing recognition that capitalist transformation has threatened local communities and ecological systems and is therefore unsustainable. The survival of indigenous peoples and indigenous knowledge depends on the recognition that a culturally relevant definition of satisfaction of needs is crucial for the most contested or threatened resources, i.e., land resources base and healthy environment. In this process two tendencies have become clear. One is emphasis on the study and use of indigenous knowledge itself, and the other is an ecologically sustainable development perspective [24].

In environmental impact assessment, while Western science tends to be quantitative and partitions it into discrete components, the indigenous knowledge tends to be qualitative and focuses on the holistic view of the environment and prioritizes the connections between different ecological and social components. Besides the tangible values of biophysical resources, it also encompasses less tangible resources like social, cultural, spiritual and knowledge-based values that are often associated with the identity of native communities.

The Food and Agriculture Organization of the United Nations (FAO) "Biodiversity for Food and Agriculture" report asserts the enormous contribution of biodiversity to protecting ecosystems from external shocks, such as extreme weather caused by climate change. This goes hand in hand with securing food production. Fragile ecosystems are severely strained by the excessive use of chemicals, monocultures or the negative effects of globalization such as air and water pollution. In its report, FAO primarily attributes the causes of these disruptive factors to unsuitable agricultural practices. Furthermore, traditional knowledge of land management and water use is being lost due to increasing urbanization, industrialization and migration. For various reasons, among which are economic, educational and a lack of environmental awareness, the trend has shown people increasingly migrating into cities and looking for promising industrial jobs, ending the long-standing knowledge of many farming families [25].

The payments for ecosystem services (PES) interventions often do not correctly reflect the social, environmental, economic and cultural aspects of the environmental services that farmers and farming communities deliver. In this paper, we outlined some of the key issues for consideration by policymakers to ensure the continued engagement of farmers in conservation and the use of agrobiodiversity [26]. We posited that it is crucial that farmers are encouraged to continue farming rather than moving to non-farming activities as the mainstay of their livelihoods. This requires the support of policymakers and the introduction/application of some form of incentive mechanism for farmers. The conservation of agrobiodiversity is a necessary investment for countries and governments to make in view of the importance of the services provided by agroecosystems. Farmers and farming communities can benefit from the design of PES mechanisms to encourage them to continue farming. Moreover, most agricultural biodiversity occurs in areas where subsistence farming is practiced due to difficult growing conditions and farming is an important low-risk option.

Ecological sustainability depends to a greater extent on the diversity in bioresources, farming styles, agroecosystems, etc., that needs to be looked upon both as an opportunity and as a challenge. Farmers' knowledge is considered a better resource for managing ecosystems [27] that gives insight on designing social systems mesh better with the ecosystems. The differential farming styles are, in fact, forms of adapting to the diversity within local ecosystems. Farming styles are an outcome

of "co-production" that is the ongoing interplay and mutual transformation of the social and the technical [28], including evidently local ecosystems.

Incorporating farmers' experiential knowledge with formal agricultural knowledge is still being debated [29], as the agricultural knowledge system has always been very closely connected to the modernization process in agriculture, the "scientification" of agriculture [30]. We now understand that the formal agricultural knowledge system is not epistemologically well-equipped, and that the agricultural system should be studied as a complex "wholes" not just as a sum of their component parts [17]. In the Cartesian view of manipulating the world by technical interventions, a relevant whole (e.g., a farm or farming style) is understood as the sum of its constituent elements, being studied as a separate unit in isolation from its biophysical and social environment at a research station with controlled environments. This approach often gives rise to limiting approaches to sustainability [17].

Furthermore, the science-based model advocating yield maximization, for example, often fail in actual farming situations and farmers normally find that experts' knowledge is of limited practical value [31,32]. This gap between theory and practice becomes even more pronounced when the sustainability issues need to be considered and calls for a new mode of working that enables scientists to optimize knowledge within and for different local conditions. Moreover, the modern conventional agricultural research and education is organized around disciplines and classical agricultural sectors, the scientists have become experts in their own field that addresses a very narrow element of agriculture [33]. Farmers' knowledge, on the other hand, is all-inclusive and comprehensive, which is hard to link with the scientific practice of individual disciplines. In order for agriculture to become sustainable and resilient, there is a need of the knowledge networking that facilitates knowledge exchanges, joint learning and the generation of new more integrated solutions [18].

4.2.2. Reclaiming the Spiritual Roots of Agriculture for Sustainability in Farming and Food Systems

As farmers began to gain a sense of dominance over nature, farming became an economic enterprise rather than a social and spiritual way of life. Farmers began to be guided by the economic bottom-line rather than a sense of rightness or goodness. That being said, the rise of industrial agriculture was not simply a consequence of farmers pursuing their economic self-interests. The world over, it was also the consequence of a premeditated shift in agricultural policies. Providing domestic food security has been the fundamental purpose of agricultural policy in the past. The independent family farmers in the U.S., for example, also had traditional spiritual values initially from the 1930s to 1960s and the farm policies were premised to keep them on the land [34].

Organic farming is important for India as we spend a huge amount of taxpayer money on the inputs, especially fertilizer. Further, organic production is labor-intensive, a factor relevant employment opportunity for rural youths. It fits well with small holder Indian farming and over time will be less water-intensive, if combined with crop rotation. The health concerns are also important, farmers exposed to conventional pesticides have high cancer risks, and unabated use of antibiotics in livestock rearing is a major cause for drug-resistant infections. India ranks worst in the world in terms of antibiotics in chicken [35]. Unless, we make a rapid shift towards organic farming, the cost in terms of environmental degradation and health costs arising from agriculture could rise sharply. The environmentally sustainable advances in the productivity and profitability of the organic production system will help to generate both livelihoods and income.

As organic farming becomes economically rewarding in all Indian agroecologies, parts of Uttarakhand, Madhya Pradesh, Rajasthan and Assam will all have tremendous potential to fetch premium prices for organic produce and will benefit from overall sustainability in farming and food systems.

Organic food is increasingly getting popular among consumers worldwide due to the absence of harmful chemicals and its sustainability for the environment [36–40]. In Europe and North America, the organic market is expanding rapidly attaining a growth rate of about 10–15% per year. In some European countries, the organic food now represents 6–7% of the market, which is likely to grow

further [41–43]. Addressing the functioning of the whole food system, and the relationship between the food system and the functioning of society will, however, determine the sustainability of organic production methods [44–49]. A Non-governmental Organization (NGO)-backed organic farming model has been showcased in Bangladeshi that can become a default production system [50].

In all Indian agroecologies, about 80% of the dietary intake is derived from plant-based foods, except for nomadic pastoralists of Uttarakhand hills and parts of the north-eastern region where animal-based foods are also consumed substantially. Organic farming is, however, considered a welcome initiative in all smallholder traditional agroecologies.

Organic farming is seen as an effective alternative to high-input conventional farming of industrialized countries. To get rid of surplus produce, these developed economies are subsidizing the crop production in several million hectares of land, producing biofuels for minimal energy gain. Further, a substantial proportion of the cereal and almost all the soybean production in developed economies, at the global level, is used to feed livestock [46,51–56]. The disproportionate number of animals has negative impact on water resources, enhanced greenhouse gas (GHG) emissions and posing serious threats to human health. The FAO [57] reports that 14.5% of the total human-induced GHG emissions are due to livestock production of which 60% are from beef and cattle for milk.

A substantial food waste along the food chain, accounting for more than 30% of the agricultural production, is also a big concern at the global level [58,59]. It is high time that agricultural policies pay more attention to restructuring of the food system, and the countries, particularly of the industrialized world, adopt organic, agroecological and low-input agricultural practices with the goal of overall agricultural sustainability and reducing the risks for human health.

4.2.3. Promoting Indigenous Food Sovereignty

In traditional Indian agroecologies, without any formal interventions, food sovereignty exists de facto. Reintroduction of indigenous food production practices will help restore food sovereignty to native communities [60]. Traditionally, the native farming communities have enough cultivated and wild-sourced food available. However, the forces of globalization, ignorance to traditional farming and outmigration of village youths to urban areas, loss of traditional knowledge, loss of farm and natural diversity due to habitat degradation, urbanization and climate change, etc., are negatively impacting indigenous food sovereignty endeavors. Food sovereignty initiatives will empower traditional farming communities grow and consume their own healthy food that would contribute to enhanced human health and wellbeing.

The food sovereignty initiatives, world over, are community-led. There are reports that many tribal communities in the USA are regaining control of their food supply, they are growing traditional foods and collaborating with the federal government to retain rights for hunting and gathering [61]. According to the U.S. Food Sovereignty Alliance (http://usfoodsovereigntyalliance.org/), "Food sovereignty goes well beyond ensuring that people have enough food to meet their physical needs. It asserts that people must reclaim their power in the food system by rebuilding the relationships between people and the land, and between food providers and those who eat".

In India, there is no formal awareness about indigenous food sovereignty movements and no formal partnerships with native farming communities doing their part to address the challenges linked to ensuring indigenous food sovereignty. Formal Food Sovereignty Alliances need to put the traditional farming communities at the centre of decision-making on policies, strategies and natural resource management [62,63]. Need of a national research institution is greatly felt that would undertake research, build knowledge and understanding of native agriculture and food systems issues and help promote native communities' innovative ideas and best practices.

4.3. Revisiting Traditional Smallholder Farming in the Time of COVID-19 Pandemic and Lessons Learned for Repurposing India's Agricultural Policy

Restrictive measures taken to curb the spread of the COVID-19 pandemic is forcing the government of India to review its policies with regard to traditional smallholder farming. The local administration has the realization that there is a need to productively engage the migrant workers returning to their native homes in remote areas in primary agricultural and rural livelihood settings.

The government of India has set up a "Covid-19 agriculture track" [64] to help the migrant workers who have returned to their native states and are willing to turn to farming. In a recent survey [65], about 45% migrant laborers who travelled to their native places during the nationwide lockdown wish to return to their respective cities. Those who wish to stay back, therefore, need to be productively engaged in agriculture and allied activities at the community level. This is a better opportunity for the local administration to revive traditional farming in many remote marginal settings of India. In the small hill state of Uttarakhand, for example, about 71% (252,687) of returnee migrant workers have been effectively engaged in traditional crop farming, horticulture and animal husbandry interventions beside enrolling themselves under the Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA) schemes operative at the community level for several other allied activities [66]. The MGNREGA has, however, had a mixed track record in terms of providing adequate employment to those who need it the most, the quality of asset creation and adequacy of wages offered [67].

The vulnerable circular migrants have been the most distressed section of migrants in India [68], which include both short-term seasonal and long-term (semi-permanent) occupationally vulnerable workers. The number of occupationally vulnerable workers is estimated at about 128 million workers whose livelihoods may have been adversely impacted with the onset of COVID-19. About 111 million of these 128 million migrants were estimated to be a part of the workforce in urban India—the epicenter of COVID-19. A little less than half of these 111 million workers—52 million—were interstate migrant workers.

The COVID-19 crisis has forced the local administration to look at short-term solutions, but the pandemic also opens the opportunity to push forward with long-term transformational change. The ecosystem approach of agroecology offers a way to bring into effect deep and transformative change to all parts of our agricultural and food systems [69]. The present food system of India served well during the pandemic but the fragility of industrial food system got exposed in view of the inequities in food supply, distribution and access [70]. The pandemic taught us a lesson to think for designing and implementing a more sovereign food system, one that values food providers, localizes food systems, brings control locally and engages better with nature [71].

5. Conclusions

Biodiversity is essential for bringing much-needed sustainability in farming and food systems. It sustains agricultural productivity; it satisfies basic human needs for food, fiber, water and clean air; it supports human health and wellbeing; it mitigates and provides resilience to climate-induced shocks and also provides many other ecosystem services. It is, therefore, necessary to use biodiversity in a sustainable manner to ensure that the needs of present and future generations are duly met. By adopting the CBD, governments commit themselves to integrate conservation and sustainable use of biodiversity into their policies and programs at the national level.

Native communities are key to the management of biodiversity, in general, and for agrobiodiversity in particular (as its sole custodians), therefore the need to engage native communities in participatory planning and budgetary provisions has emerged as vital to the process. It appears that, to date, a mainly non-participatory approach has been adopted in planning and decision-making regarding developing institutional policies, programs and activities related to biodiversity management in Indian production landscapes. Our study revealed that traditional Indian farming communities find the top-down decision-making approach adopted to date to be the most ineffective in terms of achieving sustainable development.

As farmers' experiential knowledge is considered a valuable resource for biodiversity management and sustainable development of farming systems, we hope that integrating the same into biodiversity management interventions can potentially result in radical changes to agriculture and its knowledge network. Farmers' knowledge and traditional innovations, therefore, need to be given space and recognition for sustainable conservation and use of biodiversity in production landscapes. We need to explore various ways to make farmers' knowledge more robust, more explicit and use it as a resource for (interactive) scientific research [17,72,73].

Reclaiming the spiritual roots of agriculture through the enhanced popularity of organic and locally grown food can bring much needed sustainability to farming and food systems. Organic farming is important for India as it explicitly fits well with India's smaller farm sizes. It is more labor-intensive and thus is extremely relevant for the gainful employment of rural youths and redeployment of labor forces migrating away from urban and peri-urban areas.

Further, the COVID-19 pandemic has forced us to design and implement a more sovereign food system, one that values food providers, values localized food systems, focuses on food for people and works with nature.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Broader areas for in-depth discussions in the focus group discussion (FGD) meetings

- ❖ Policies, programs and activities related to agricultural biodiversity in production landscapes and awareness about various national legislations in place

  - Farmers' response about past projects, programs, policies on conservation and sustainable use of biodiversity in production landscapes and natural settings.
  - Farmers' awareness about regulatory frameworks or various national legislations for bioresource management (National Biodiversity Act-2002 of Govt. of India), protection of farmers' rights (FR) under Protection of Plant Varieties and Farmers' Rights Act Act-2001 of Govt. of India, and other related national acts (Geographical Indication Act, Patent Amendment Act, the Seed Bill, etc.) that impact bioresource management and their sustainable use, etc.
  - State of farmers' awareness about collaboration with other stakeholders involved in the management of agricultural biodiversity.
  - Farmers' response on institutional capacity building initiatives.

- ❖ Agroecology, sustainable farming and farmers' experiential knowledge on bioresource management and their sustainable use in farming and food systems

    - Interactions on farmers' understanding of sustainable agricultural systems based on diversified practices aimed at optimizing the natural processes favorable to production and ensuring the sustainability of the resource.
    - Farmers' understanding of agroecological transition, need of combining local know-how/traditional farming knowledge developed to cope with the particular situation in a particular agroecology, and new scientific knowledge generated by scientific research.
    - Farmers' experiential knowledge and various management actions related to mainstreaming biodiversity in production landscapes.
    - Indigenous knowledge on traditional agroforestry offering opportunities to farmers for sustainable management of resources and support socioecological and socioeconomic benefits.
    - Spiritual beliefs and customary laws developed and nurtured over generations and understanding the natural resource-based livelihood of native communities.
    - Understanding drawback of "linear approach of innovation dissemination" and use of farmers experiential knowledge with particular reference to climate change adaptation, and insight on how integrating informal and formal knowledge enhances sustainable and resilient agriculture.

- ❖ General farming practices, community seed system and traditional innovations

    - Crop species and within-species (genetic) diversity in production landscapes. Is diversity a necessity or choice for farmer households?
    - Crop/landrace diversity loss in production landscapes and need of repatriation of lost diversity, if any.
    - Community level informal seed system (ISS) and its role on sustainable conservation of landrace diversity in specific agroecosystems.
    - Is lack of farmer varieties (FV) seed availability contributing to landrace diversity loss? How willing are farmers introduce new diversity in production systems?
    - Are farmers really constrained for quality seed production, maintenance, and storage of seeds of native crops/FVs?
    - Will IPR protection of FVs restrict informal exchange of FVs?
    - Frequency of climatic shocks in recent and distant past and its impact on crop/landrace diversity and farmers' approach to repatriate the lost diversity.
    - Documenting customary sustainable use of biodiversity that particularly refers to the communities' traditional knowledge, innovations, and practices enabling them to interact with and use biodiversity in sustainable ways. The following questions are intended as guides only for broader discussion within native communities about the issues raised: (i) what natural resources or species are particularly important to your community? (ii) what role do they play in your identity and cultural traditions? (iii) what customary laws, values, or social norms influence your relationship with these resources? (iv) how do you determine who uses the resources? (v) how do you determine how, when, and for what purposes they are used?
    - Use of purchased inputs: seeds, inorganic fertilizer, pesticides, etc.
    - Nutrition transition and farming of cash crops in agroecosystems, if any.
    - Types of farmers' traditional innovations.
    - Use of improved modern farming practices (mechanization), if any.

- ❖ Spirituality in farming and food systems

- Default organic production in different agroecologies.
- Organically grown crops with high marketing potential grown in different Indian agroecologies.
- Dependence of local communities on diverse plant resources including wild plants that ensures protection of the plant species, and in this way an effective mechanism of sustainability that indigenous communities can employ to maintain a cosmic balance with the ecosystem.

❖ Indigenous food sovereignty

- Farmers understanding of sustainable food systems, and on agrarian reforms to access and control of land, water and biodiversity that are of central importance for communities in order to meet growing food demands.

❖ Information on migrant workers

- Agriculture workforce (%): men/women.
- Seasonal outmigration of rural youths for non-farm work (percent of households sending youths to urban areas and average numbers/household).
- Contribution of migrant workers to household cash flow (%).

Permanent outmigration of households (%), if any.

References

1. Petersen, C.; Huntley, B. *Mainstreaming Biodiversity in Production Landscapes*; Working Paper 20; Global Environment Facility: Washington, DC, USA, 2005.
2. Huntley, B.J.; Redford, K.H. *Mainstreaming Biodiversity in Practice: A STAP Advisory Document*; Global Environment Facility: Washington, DC, USA, 2014.
3. Mijatović, D.; Sakalian, M.; Hodgkin, T. *Mainstreaming Biodiversity in Production Landscapes*; United Nation Environment Programme: Nairobi, Kenya, 2018.
4. Mabhaudhi, T.; Chibarabada, T.P.; Chimonyo, V.G.P.; Murugani, V.G.; Pereira, L.M.; Sobratee, N.; Govender, L.; Slotow, R.; Modi, A.T. Mainstreaming underutilized indigenous and traditional crops into food systems: A South African perspective. *Sustainability* **2019**, *11*, 172. [CrossRef]
5. NAS (National Academy of Sciences). *Biodiversity*; The National Academies Press: Washington, DC, USA, 1988. [CrossRef]
6. Gauchan, D.; Joshi, B.K.; Bhandari, B.; Manandhar, H.K.; Jarvis, D.I. (Eds.) *Traditional Crop Biodiversity for Mountain Food and Nutrition Security in Nepal*; Tools and Research Results of the UNEP GEF Local Crop Project, Nepal; NAGRC, LI-BIRD and the Alliance of Bioversity International and CIAT: Kathmandu, Nepal, 2020.
7. Beltrame, D.; Eliot, G.E.E.; Güner, B.; Lauridsen, N.O.; Samarasinghe, W.L.G.; Wasike, V.W.; Hunter, D.; Borelli, T. Mainstreaming biodiversity for food and nutrition into policies and practices: Methodologies and lessons learned from four countries. *Anadolu Ege Tarımsal Araştırma Enstitüsü Derg.* **2019**, *29*, 25–38. [CrossRef]
8. Hunter, D.; Borelli, T.; Gee, E. (Eds.) *Biodiversity, Food and Nutrition: A New Agenda for Sustainable Food Systems*; Routledge: Abingdon, UK, 2020.
9. Kremen, C.; Iles, A.; Bacon, C. Diversified farming systems: An agroecological, systems-based alternative to modern industrial agriculture. *Ecol. Soc.* **2012**, *17*, 44. [CrossRef]
10. Nayar, M.P.; Singh, A.K.; Nayar, K.N. *Agrobiodiversity Hotspots in India: Conservation and Benefit Sharing*; Protection of Plant Varieties and Farmers' Rights Authority Government of India: New Delhi, India, 2009.
11. Agricultural Census 2015–16. *All India Report on Number and Area of Operational Holdings*; DAC&FW, Ministry of Agriculture & Family Welfare, GoI: New Delhi, India, 2018.
12. CBD (Convention on Biological Diversity). *Strategic Plan for Biodiversity 2011–2020*; Aichi Biodiversity Targets; CBD (Convention on Biological Diversity): Rio de Janeiro, Brazil; New York, NY, USA, 2020. Available online: https://www.cbd.int/sp/ (accessed on 18 September 2020).
13. UN (United Nations). *The Sustainable Development Goals Report 2019*; United Nations: New York, NY, USA, 2019. [CrossRef]

14. Nyeleni. Declaration of Nyeleni. 2007. Available online: https://nyeleni.org/IMG/pdf/DeclNyeleni-en.pdf (accessed on 25 April 2017).
15. FAO. *The Fu adature of Food and Agriculture—Trends and Challenges*; FAO: Rome, Italy, 2017.
16. FAO. *The State of Food and Agriculture—Leveraging Food Systems for Inclusive Rural Transformation*; FAO: Rome, Italy, 2017.
17. Stuiver, M.; Leeuwis, C.; van der Ploeg, J.D. The power of experience: Farmer's knowledge and sustainable innovations in agriculture. In *Seeds of Transition: Essays on Novelty Production, Niches, and Regimes in Agriculture*; Wiskerske, J.S.C., van der Ploeg, J.D., Eds.; Royal van Gorcum: Assen, The Netherlands, 2004; pp. 93–117.
18. Šumane, S.; Kunda, I.; Knickel, K.; Strauss, A.; Tisenkopfs, T.; des los Rios, I.; Ashkenazy, A. Local and farmers' knowledge matters! How integrating informal and formal knowledge enhances sustainable and resilient agriculture. *J. Rural Stud.* **2018**, *59*, 232–241. [CrossRef]
19. Long, J.; Cromwell, E.; Gold, K. *On-Farm Management of Crop Diversity: An Introductory Bibliography*; Overseas Development Institute for ITDG: London, UK, 2000; 42p.
20. Altieri, M.A. Linking Ecologists and Traditional Farmers in the Search for Sustainable Agriculture. *Front. Ecol. Environ.* **2004**, *2*, 35–42. [CrossRef]
21. Gemmill, B. *Managing Agricultural Resources for Biodiversity Conservation. A Guide to Best Practices*; UNEP/UNDP Biodiversity Planning Support Programme; Environment Liaison Centre International: Nairobi, Kenya, 2001.
22. Nakashima, D.J.; Galloway McLean, K.; Thulstrup, H.D.; Ramos Castillo, A.; Rubis, J.T. *Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation*; UNESCO, and Darwin, UNU: Paris, France, 2012; 100p.
23. ECPGR. *ECPGR Concept for On-Farm Conservation and Management of Plant Genetic Resources for Food and Agriculture*; European Cooperative Programme for Plant Genetic Resources: Rome, Italy, 2017.
24. Purcell, T.W. Indigenous knowledge and applied anthropology: Questions of definition and direction. *Hum. Organ.* **1998**, *57*, 258–272. Available online: https://www.jstor.org/stable/44127271 (accessed on 22 February 2018). [CrossRef]
25. Biovision. *Why Preserving Soil Diversity Can Save Us from the Next Famine*; News 26.3.2019; Biovision Foundation for Ecological Development: Zurich, Switzerland, 2020.
26. UNEP. *Farmers and the Future of Agrobiodiversity*; COP 9 MOP 4; Bonn, Germany; 2008. Available online: https://www.un.org/en/ecosoc/docs/pdfs/farmers.pdf (accessed on 12 April 2019).
27. Toledo, V.M. The ecological rationality of peasant production. In *Agroecology and Small Farm Development*; Altieri, M.A., Hecht, S.B., Eds.; CRC Press: Boston, MA, USA, 1990; pp. 53–60.
28. Law, J. Power, Action and Belief, a New Sociology of Knowledge? Routledge: London, UK, 1986; 280p.
29. Leeuwis, C. Learning to be sustainable. Does the Dutch agrarian knowledge market fail? *Eur. J. Agric. Educ. Ext.* **2000**, *7*, 79–92. [CrossRef]
30. Van der Ploeg, J.D. *The Scientification of Agricultural Activities*; Wageningen LU: Wageningen, The Netherlands, 1987; 336p. (In Dutch)
31. Scoones, I.; Thompson, J. *Beyond Farmer First: Rural People's Knowledge, Agricultural Research and Extension Practice*; Intermediate Technology Publications: London, UK, 1994.
32. Eshuis, J.; Stuiver, M.; Verhoeven, F.; van der Ploeg, J.D. *Good Manure Does not Stink: A Study on Slurry Manure, Experiential Knowledge and Reducing Nutrient Losses in Dairy Farming*; Studies van Landbouw en Platteland No 31; Circle for Rural European Studies, Wageningen University: Wageningen, The Netherlands, 2001; 138p. (In Dutch)
33. Timmer, W.J. *Agricultural Science, a Philosophical Essay about Agriculture and Agricultural Science as a Basis of Renewal for Agricultural Higher Education*; Buitenzorg: Java, Indonesia, 1949; 306p. (In Dutch)
34. Ikerd, J.E. Agriculture and Spirituality. In *The Routledge International Handbook of Spirituality in Society and the Professions*; Zsolnai, L., Flanagan, B., Eds.; Routledge: Abingdon, UK, 2019.
35. Manyi-Loh, C.; Mamphweli, S.; Meyer, E.; Okoh, A. Antibiotic use in agriculture and its consequential resistance in environmental sources: Potential public health implications. *Molecules* **2018**, *23*, 795. [CrossRef] [PubMed]
36. Hughner, R.S.; McDonagh, P.; Prothero, A.; Shultz, C.J., II; Stanton, J. Who are organic food consumers? A compilation and review of why people purchase organic food. *J. Consum. Behav.* **2007**, *6*, 94–110. [CrossRef]
37. Canavari, M.; Olson, K.D. (Eds.) *Organic Food: Consumers' Choices and Farmers' Opportunities*; Springer: New York, NY, USA, 2007.

38. Stolz, M.; Stolze, M.; Hamm, U.; Janssen, M.; Ruto, M. Consumer attitudes towards organic versus conventional food with specific quality attributes. NJAS—Wageningen. *J. Life Sci.* **2011**, *58*, 67–72.
39. Carlson, A.; Jaenicke, E. *Changes in Retail Organic Price Premiums from 2004 to 2010*; Economic Research Report Number 209; United States Department of Agriculture: Washington, DC, USA, 2016. Available online: https://www.ers.usda.gov/webdocs/publications/err209/59472_err209.pdf (accessed on 22 April 2019).
40. Mie, A.; Kesse-Guyot, E.; Kahl, J.; Rembiałkowska, E.; Raun Andersen, H.; Grandjean, P.; Gunnarsson, S. *Human Health Implications of Organic Food and Organic Agriculture*; European Parliament Research Service: Brussels, Belgium, 2016. Available online: http://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_STU581922 (accessed on 22 October 2019).
41. EC (European Commission). *Facts and Figures on Organic Agriculture in the European Union*; European Commission, DG Agriculture and Rural Development, Unit Economic Analysis of EU: Brussels, Brussels, 2017. Available online: https://ec.europa.eu/agriculture/sites/agriculture/files/rural-area-economics/briefs/pdf/014_en.pdf (accessed on 12 December 2019).
42. EC (European Commission). *The Rapid Growth of EU Organic Farming. Key Facts and Figures*; EU Agricultural Markets Briefs, No 3, July 2014; European Commission, DG Agriculture and Rural Development, Unit Agricultural Modelling and Outlook: Brussels, Brussels, 2014. Available online: http://ec.europa.eu/agriculture/sites/agriculture/files/markets-and-prices/market-briefs/pdf/03_en.pdf (accessed on 12 December 2019).
43. IFOAM (International Foundation for Organic Agriculture). *The World of Organic Agriculture 2016*; Research Institute of Organic Agriculture (FiBL) and IFOAM—Organics International: Bonn, Germany, 2016. Available online: http://www.organic-world.net/yearbook/yearbook-2016.html (accessed on 12 December 2019).
44. Gomiero, T.; Giampietro, M.; Bukkens, S.M.; Paoletti, G.M. Biodiversity use and technical performance of freshwater fish culture in different socio-economic context: China and Italy. *Agric. Ecosyst. Environ.* **1997**, *62*, 169–185. [CrossRef]
45. Gomiero, T. Food quality assessment in organic vs. conventional agricultural produce: Findings and issues. *Appl. Soil Ecol.* **2017**, *123*, 714–728. [CrossRef]
46. Gomiero, T. Large-scale biofuels production: A possible threat to soil conservation and environmental services. *Appl. Soil Ecol.* **2017**, *123*, 729–736. [CrossRef]
47. Giampietro, M. *Multi-Scale Integrated Analysis of Agroecosystems*; CRC Press: Boca Raton, FL, USA; London, UK, 2004.
48. Lang, T.; Barling, D.; Caraher, M. *Food Policy: Integrating Health, Environment and Society*; Earthscan: London, UK, 2009.
49. Giampietro, M.; Aspinall, R.J.; Ramos-Martin, J.; Bukkens, S.G.F. *Resource Accounting for Sustainability Assessment: The Nexus Between Energy, Food, Water and Land Use*; Routledge: New York, NY, USA, 2014.
50. Ferdaus, Z.; Zulfiqar, F.; Datta, A.; Hasan, A.K.; Sarker, A. Potential and challenges of organic agriculture in Bangladesh: A review. *J. Crop Improv.* **2019**, 1–24. [CrossRef]
51. Cochrane, W.W. *The Development of American Agriculture: A Historical Analysis*, 2nd ed.; University of Minnesota Press: Minneapolis, MN, USA, 1993.
52. Hurt, R.D. *Problems of Plenty: The American Farmer in the Twentieth Century*; The American Ways Series; Ivan R. Dee: Chicago, IL, USA, 2002; 192p.
53. Peterson, E.W.F. *A Billion Dollars a Day: The Economics and Politics of Agricultural Subsidies*; John Wiley & Sons: Hoboken, NJ, USA, 2009.
54. Gomiero, T. Effects of agricultural activities on biodiversity and ecosystems: Organic versus conventional farming. In *Handbook on the Globalisation of Agriculture*; Robinson, G.M., Carson, D.A., Eds.; Edward Elgar Publishing: Cheltenham, UK, 2015; Chapter 3; pp. 77–105.
55. Smil, V. *Should We Eat Meat? Evolution and Consequences of Modern Carnivory*; Wiley-Blackwell: Oxford, UK, 2013.
56. Gerber, P.J.; Steinfeld, H.; Henderson, B.; Mottet, A.; Opio, C.; Dijkman, J.; Falcucci, A.; Tempio, G. *Tackling Climate Change Through Livestock ? A Global Assessment of Emissions and Mitigation Opportunities*; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2013; Available online: http://www.fao.org/3/i3437e.pdf (accessed on 19 January 2020).
57. FAO (Food and Agriculture Organization of the United Nations). *Livestock's Long Shadow*; FAO: Rome, Italy, 2006. Available online: http://ftp.fao.org/docrep/fao/010/a0701e/a0701e.pdf (accessed on 19 January 2020).
58. Stuart, T. *Waste: Uncovering the Global Food Scandal*; Penguin Books: London, UK, 2009.

59. FAO (Food and Agriculture Organization of the United Nations). *Global Food Losses and Food Waste: Extent, Causes and Prevention*; Study Conducted for the International Congress SAVE FOOD! At Interpack, Düsseldorf, Germany; FAO: Rome, Italy, 2011. Available online: http://www.fao.org/docrep/014/mb060e/mb060e00.Pdf (accessed on 25 November 2019).
60. NICOA (National Indian Council on Aging). *The Importance of Food Sovereignty*; NICOA: Albuquerque, NM, USA, 2019. Available online: https://www.nicoa.org/the-importance-of-food-sovereignty (accessed on 15 June 2020).
61. Native Diabetes Wellness Program. *Traditional Foods in Native America: A Compendium of Stories from the Indigenous Food Sovereignty Movement in American Indian and Alaska Native Communitie*; Native Diabetes Wellness Program, Centres for Disease Control & Prevention: Atlanta, GA, USA, 2013.
62. Bye, B.A.L. Native Food Systems Organizations: Strengthening Sovereignty and (Re)Building Community. Master's Thesis, Iowa State University, Ames, IA, USA, 2009. Graduate Theses and Dissertations 11121. Available online: https://lib.dr.iastate.edu/etd/11121 (accessed on 15 June 2020).
63. Gliessman, S. Confronting Covid-19 with agroecology. *Agroecol. Sustain. Food Syst.* **2020**, *44*, 1115–1117. [CrossRef]
64. The New India Express. Available online: https://www.newindianexpress.com/nation/2020/nov/04/uttarakhand-managed-to-absorb-most-migrants-who-returned-home-survey-2219072.html (accessed on 4 November 2020).
65. Firstpost. Available online: https://www.firstpost.com/india/over-45-migrant-labourers-who-travelled-back-home-wish-to-return-to-cities-finds-survey-8668931.html (accessed on 3 August 2020).
66. The Economic Times. Available online: https://economictimes.indiatimes.com/news/politics-and-nation/covid-19-agri-track-to-help-migrant-workers/articleshow/76309334.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst) (accessed on 11 June 2020).
67. Vasudevan, G.; Singh, S.; Gupta, G.; Jalajakshi, C.K. MGNREGA in the Times of COVID-19 and Beyond: Can India do more with Less? *Indian J. Labour Econ.* **2020**, *63*, 799–814. [CrossRef] [PubMed]
68. Srivastava, R. *Understanding Circular Migration in India: Its Nature and Dimensions, the Crisis under Lockdown and the Response of the State*; Centre for Employment Studies Working Paper Series-WP 04/2020; Institute for Human Development: Delhi, India, 2020. Available online: http://www.ihdindia.org/Working%20Ppaers/2020/IHD-CES_WP_04_2020.pdf (accessed on 29 July 2020).
69. Phillips, J.L. *Native Agriculture and Food Systems Initiative (NAFSI): A Final Evaluation Report of 2012–2014 Program Activities*; First Nations Development Institute: Longmont, CO, USA, 2015.
70. Anderson, F. Food Sovereignty Now! European Coordination via Campesina. 2018. Available online: https://viacampesina.org/en/wp-content/uploads/sites/2/2018/02/Food-Sovereignty-A-guide-Low-Res-Vresion.pdf (accessed on 15 May 2020).
71. Loker, A.; Francis, C. Urban food sovereignty: Urgent need for agroecology and systems thinking in a post-COVID-19 future. *Agroecol. Sustain. Food Syst.* **2020**, 1118–1123. [CrossRef]
72. Van der Ploeg, J.D. *The Virtual Farmer*; Van Gorcum: Assen, The Netherlands, 1999; 482p. (In Dutch)
73. Taskforce. *To a Valuable Agriculture*; Wageningen University and Research Centre: Wageningen, The Netherlands, 2001; 35p.