ISBN: 987-602-72245-6-8
Prosiding Biologi Achieving the Sustainable Development Goals
with Biodiversity in Confronting Climate Change
Gowa, 08 November 2021
http://journal.uin-alauddin.ac.id/index.php/psb

Traditional Production Landscapes for Sustainable Development Mainstreaming Agricultural Biodiversity in East Java Indonesia

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ABSTRACT

Mainstreaming biodiversity in production landscapes ensures conservation and sustainable use of agricultural biodiversity. 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 East Java production landscapes to gage (i) the farming communities' response to institutional policies, programs and agricultural biodiversity-related activities in traditional East Java production landscapes and (ii) opportunities and challenges for sustainable development in smallholder traditional East Java farming systems. Results indicate that the top-down decision-making regime is the least effective towards achieving sustainable development in traditional East Java farming landscapes and that farmers' experiential knowledge on participatory biodiversity management, maintenance and use for sustainable development are of critical importance to East Java'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 East Java's agricultural policy are also highlighted.

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

INTISARI

Pengarusutamaan keanekaragaman hayati dalam lanskap produksi memastikan konservasi dan pemanfaatan berkelanjutan keanekaragaman hayati pertanian. Pengarusutamaan mengintegrasikan keanekaragaman hayati dalam program dan kebijakan yang ada atau baru, baik lintas sektoral maupun spesifik sektoral. Model konvensional produksi pertanian dengan keragaman terbatas dalam sistem produksi dan penggunaan input kimia yang tinggi telah memberi kita pelajaran berharga karena berdampak buruk pada lingkungan, jasa ekosistem penting, kesehatan tanah, dan keberlanjutan jangka panjang sistem pangan kita. Menggunakan pendekatan observasi partisipan kualitatif, penelitian kami menyelidiki empat lanskap produksi tradisional Jawa Timur yang berbeda untuk mengukur (i) respon masyarakat petani terhadap kebijakan kelembagaan, program dan kegiatan terkait keanekaragaman hayati pertanian di lanskap produksi tradisional Jawa Timur dan (ii) peluang dan tantangan untuk pembangunan berkelanjutan dalam sistem pertanian tradisional Jawa Timur yang dijalankan oleh petani kecil. Hasil menunjukkan bahwa rezim pengambilan keputusan dari atas ke bawah adalah yang paling tidak efektif untuk mencapai pembangunan berkelanjutan di lanskap pertanian tradisional Jawa Timur dan bahwa pengetahuan pengalaman petani tentang pengelolaan, pemeliharaan, dan penggunaan keanekaragaman hayati partisipatif untuk pembangunan berkelanjutan sangat penting bagi pertanian Jawa Timur, dan ekonomi masyarakat. Mengklaim kembali akar spiritual pertanian melalui pertanian organik dan pangan lokal muncul sebagai kunci, termasuk kebutuhan untuk merancang dan menerapkan sistem pangan yang lebih berdaulat. Meninjau kembali pertanian rakyat tradisional di bawah pandemi COVID-19 dan pembelajaran untuk mengubah arah kebijakan pertanian Jawa Timur juga dibahas pada penelitian ini.

Kata kunci: kedaulatan pangan lokal; mengubah arah kebijakan pertanian pasca-COVID-19; pengarusutamaan keanekaragaman hayati; pembangunan berkelanjutan; pengetahuan berdasarkan pengalaman petani

INTRODUCTION

Mainstreaming seeks to integrate biodiversity into the cross-sectoral and sector-specific policies and programs, where it has received limited attention (Petersen & Huntley, 2005). 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 (Mijatovic´ *et al*., 2018).

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 (Mabhaudhi *et al*., 2019). 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 (National Academy of Sciences, 1988). A recent publication (Gauchan, 2020), 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 (Gauchan, 2020). 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 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 (Kremen *et al*., 2012).

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.

East Java, 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 (Nyeleni, 2007) 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 East Java. 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 East Java owing just 47.3% of the total area sown to crops (FAO, 2017). 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 East Java. 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; 1. North-eastern region and the Eastern Himalayas; 2. 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 East Java'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 (FAO, 2017), 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 (Stuiver, 2004) 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 East Java production landscapes for sustainable development, with the following broad objectives:

1. Investigating the farming community response to institutional policies,

programs and activities related to agricultural biodiversity in traditional East Java production landscapes;
2. Smallholder traditional East Java farming: opportunities and challenges for sustainable development;
3. 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.

RESEARCH METHOD

In the present study, four unique farming production landscapes of East Java, viz. hill and mountain, hot arid desert, and the north-eastern region were represented. The specific study sites include representative agroecologies of the entire Banyuwangi until Pacitan. 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:

1. Farmers' response to policies, programs and activities related to agricultural biodiversity in traditional East Java production landscapes to understand how best the East Java institutional support has been operating under actual farming scenarios.
2. 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.
3. Adapting/redefining traditional smallholder farming in the time of the COVID-19 pandemic and lessons learned for repurposing East Java's agricultural policy.

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 Batu 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 Pacitan district (Pacitan state) in the western

arid region, parts of the Banyuwangi district (Banyuwangi state). 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.

RESULTS AND DISCUSSION

1. Policies, Programmes and Activities Related to Agricultural Biodiversity in Production Landscapes: East Java 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 East Java, 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 East Java. 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.

It is thus evident that the top-down decision making regime for traditional East Java 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 East Java 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.

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

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 resourcesfrom 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 East Java at ICAR-NBPGR, East Java 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

Traditional farming communities in the present study consider that institutional support towards conserving their rich farm and off-farm biodiversity has not been enough. 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 (Mijatovic´ *et al*., 2014). 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 (Gauchan *et al*., 2020). The potential of underutilized indigenous and traditional crops have also been recognized to bring about a transformative change to South Africa's food system (Mabhaudhi *et al*., 2019). 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 (Beltrame *et al*., 2019; Hunter *et al*., 2020).

In the present UNEP-GEF (East Java) 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.

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

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

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 East Java 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 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) Farmers' IK could be specifically documented in the following fields of community level biodiversity management:
Adaptation to climate change	• Agricultural and associated biodiversity conservation • 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 • 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 East Java 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.

The important characteristics of farmers' experiential knowledge and their application in sustainable agricultural development and management of natural resources are presented in Table 3. A major strength of the farmer's 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 East Java 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.

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 East Java alone.

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 East Java 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 East Java agroecologies are encouraged to practice organic farming. Although farming in all traditional East Java agroecologies is mostly organic by default, conscious organic farming has suddenly picked up across all East Java states.

The need of a new knowledge base is being strongly felt for transition towards more sustainable agriculture (Gemmill, 2001). The relevance of informal farmers' knowledge and learning practices in constructing alternative pathways to sustainable agriculture and strengthening agricultural resilience has been explored by Šu¯mane *et al*. (Nakashima *et al*., 2012). 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.

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 (ECPGR, 2017).

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 (Purcell, 1997).

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 (Biovision, 2020). 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 (UNEP, 2008).

On-farm conservation has been reported to result in a number of interlinked elements that supports agricultural biodiversity as part of a dynamic system (Toledo, 1990). 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.

Participatory forest management initiatives in all East Java 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 East Java 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 (Law, 1986).

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 (Leeuwis, 2000).

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 (Van der Ploeg, 1987). 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 (Scoones & Thompson, 1994) 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 (Eshuis, 2001) including evidently local ecosystems.

Incorporating farmers' experiential knowledge with formal agricultural knowledge is still being debated (Timmer, 1949) as the agricultural knowledge system has always been very closely connected to the modernization process in agriculture, the "scientification" of agriculture (Ikerd, 2019). 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 (Gemmill, 2001). 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 (Gemmill, 2001). 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 (Hughner *et al*., 2007; Manyi-Loh *et al*., 2018). 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 (Canavari & Olson, 2007). 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 (Nakashima *et al*., 2012).

b. 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 East Java alone.

Table 3. 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 maximization for sustainable production
2. Conserving biodiversity in production landscapes greatly matters for farmers 3. Conventional innovations and formal agricultural knowledge are least responsive to societal needs 4. The fragmented nature of conventional agricultural sciences and limitations of dominant epistemologies	
5. Yield optimization is a better approach than yield 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. 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	We, therefore, need to ensure that the voices of farming communities heard and the activities of scientists are responsive to their localized needs. 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

in production landscapes adapted to the local agroecological conditions. The adaptive nature of farming styles is the main rationale behind fostering sustainable agricultural development. 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 East Java farming context, the farmers have not been provided much opportunity to be involved in scientific innovations including funding arrangements for the research. interdisciplinary research approach. 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

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 East Java 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.

Table 4. Characteristics of inputs used in traditional East Java farming agroecologies*

Inputs	Hill and Mountain			North-Eastern
	Hot Arid	Central	Plateau	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

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 East Java agroecologies are encouraged to practice organic farming. Although farming in all traditional East Java agroecologies is mostly organic by default, conscious organic farming has suddenly picked up across all East Java states.

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 East Java farming agroecologies. 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.

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 (Long *et al*., 2000; Altieri, 2004).

Systems asfarmers 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 (Stolz, 2011).

Organic farming is important for East Java 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 East Java 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. East Java ranks worst in the world in terms of antibiotics in chicken (Carlson, 2016). 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.

Organic food is increasingly getting popular among consumers worldwide due to the absence of harmful chemicals and its sustainability for the environment (Gomiero *et al*., 1997; European Commission, 2014; IFOAM, 2016; Mie *et al*., 2016; European Commission, 2017). 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 (Giampietro, 2004; Gomiero, 2017a; Gomiero, 2017b). 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 (Cochrane, 1993; Hurt, 2002; Lang *et al*., 2009; Peterson, 2009; Giampietro *et al*., 2014; Ferdaus *et al*., 2019). A Non-governmental Organization (NGO)-backed organic farming model has been showcased in Bangladeshi that can become a default production system (Gomiero, 2015).

In all East Java 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 (Gerber *et al*., 2013; Smil, 2013; FAO, 2006;

Stuart, 2011; Native Diabetes Wellness Program, 2013; Ferdaus *et al*., 2019; NICOA, 2019).

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 (Bye, 2009). 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 (Gliessman, 2020; The New East Java Express, 2020). 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.

3. **Reinventing Traditional Smallholder Farming in the Time of the COVID-19 Pandemic and Lessons Learned for Repurposing East Java's Agricultural Policy**

The rural male youths, often not finding traditional farming economically rewarding, migrate from all East Java 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 East Java, 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 East Java'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 East Java 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 East Java economy.

Restrictive measures taken to curb the spread of the COVID-19 pandemic is forcing the government of East Java 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 East Java has set up a "Covid-19 agriculture track" (Phillips, 2015) to help the migrant workers who have returned to their native states and are willing to turn to farming. In a recent survey (Anderson, 2018) 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 East Java. In the small hill state of Banyuwangi, for example, about 71% (252,687) of returnee migrant workers have been effectively engaged in traditional crop farming, horticulture and animal husbandry interventions.

The vulnerable circular migrants have been the most distressed section of migrants in East Java (Taskforce, 2001), 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 East Java-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. The present food system of East Java 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. 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.

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 East Java production landscapes. Our study revealed that traditional East Java farming communities find the top-down decision-making approach adopted to date to be the most ineffective in terms of achieving sustainable development. 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 East Java as it explicitly fits well with East Java'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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