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INTEGRATED FARMING SYSTEMS FOR SUSTAINABLE AGRICULTURE IN GLOBAL MARKET

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Abstract: *Agriculture that is truly sustainable will not be business as usual. It will be a type of agriculture that will provide environmental, economic and social opportunities for the benefit of present and future generations, while maintaining and enhancing the quality of the resources that support agricultural production. This will not be the agriculture of to-day or of the recent past, with an emphasis on maximizing yields and economic returns, but rather one with the objectives of optimizing productivity and conserving the natural resource base. The objective of optimization implies trade-offs in the production systems to ensure maintenance of environmental quality and global, environmental, and life support systems. Experience indicates that these tradeoffs will be defined and implemented voluntarily by farmers and other rural land users, or they will be implemented through policies and legislation.*

Agricultural systems in transition recognize that farming systems are and always have been changing. In fact, it is this capacity to respond (rapidly) and to capture market, technology, environmental, and other opportunities, that will ensure sustainable systems in the future. Static agricultural systems are not sustainable systems. Major factors that shape current agricultural change are shifts towards global markets, important advances in science and technology, and the emerging shift of emphasis from food security to reduction of rural poverty.
Keywords: *Integrated Farming Systems, Sustainable Agriculture, Global Market, Environment Food Security and Production.*

Introduction: Globalization, liberalization of markets, novel agro-technologies, economic development, changing societal demands and climate change drive a continuous evolution of agricultural systems around the globe. Agricultural and societal stakeholders try to influence the evolution such that sustainability of agricultural systems themselves and contributions of agricultural systems to sustainable development at large are promoted. In this context and paper, sustainable development stands for meeting the needs of present generations without jeopardizing the needs of future generations – a better quality of life for everyone, now and for generations to come, both in terms of economic, environmental and social issues (World Commission on Environment and Development 1987).

Sustainable development, in this paper, is interpreted as a broader concept than sustainability of agriculture. The latter may imply developments within the agricultural sectors (or for specific types of farms) that are not positively contributing to sustainable development of society at large. The factors that can be varied to achieve the objectives associated to sustainable development are merely the adoption of novel agro-technologies, the (re-)design of agricultural systems, and introduction of agricultural, environmental and rural-development policies implemented at various hierarchical levels. Institutional changes are simultaneously required to create incentives and consistency between the multi-scale and multi-objective changes [1]. Despite the obvious trend of liberalization, there is consensus that policies are needed to support achievement of sustainability objectives, and that these must be cost-effective and efficient [2]. These policies, however, increasingly have an integrated nature: they are not solely targeted at agricultural issues, but try to achieve multiple objectives (e.g., 'cross-compliance' in the reform of the Common Agricultural Policy of the European Union). Agricultural policies are increasingly replaced by rural-development policies seeking to enhance the sustainability of agricultural systems and contributions from these systems to sustainable development of societies [3].

Sustainability and sustainable development are relative notions that are scale-dependent, i.e., what is good for the environment or economy at farm level may not be advantageous for the national or global environment or economy, or what is beneficial for the agricultural sector in general may not be desirable for the individual farmer. This implies the need for both multi-scale and integrated analysis that captures the effects of specific developments at field, farm, regional and even global level, and the effects in terms of economy, environment and social factors [4, 5, 6]. Usually such analyses make use of indicators that characterize the pressure on systems or characterize the attributes of sustainable development [7].

Integrated Farming Systems, by its very term, is characterized by higher use of inputs such as capital and labour for every unit land area that is cultivated, and this way, it is designed to produce higher yields. By using specific farming systems and techniques, intensive farming is able to produce higher yields and achieve economies of scale, and is thus synonymous with industrial agriculture.

Such industrial agriculture has been greatly supported through agricultural methods such as planting multiple crops a year, reducing the time period of leaving the land fallow, and increasing cultivars. (A cultivar is a plant or a group of plants selected for desirable characteristics that can be maintained through propagation, mostly produced by careful breeding).

Integrated Farming Systems also uses an increased amount of fertilizers and plant growth regulators, pesticides and even mechanization. Most of the meat, dairy, eggs, fruits and vegetables in the supermarkets, at least of developed nations, come from such agriculture. Under such an industrial agricultural system, all agricultural operations require a thorough and detailed analysis of growing conditions, including weather, soil, water, weeds and pests. Data collection and analysis is also carried out on a widespread basis, and this calls for a user-friendly mobile technological applications.

The Evolution of Integrative Agriculture: Let's look at how agricultural systems evolved and led to a situation that created such varied use for mobile technological applications. Between the 16th and 19th centuries, agricultural and industrial development complemented each other. New agricultural techniques emerged – such as enclosure, mechanization, four-field crop rotation and selective breeding. These were important innovations that increased agricultural production and net output, and it freed up a significant percent of the workforce to contribute instead to the industrial revolution.

With the advent of the industrial revolution, industrial agriculture surged. What were the different ways in which mechanization changed agricultural processes? As a first innovation, the horse-drawn harvester revolutionized harvesting and inventions such as cotton gin reduced the cost of processing. Threshers and tractors replaced draft animals. All of these made it possible for individual farmers to manage large farms.

Further, scientific experiments in plant growth revealed that nitrogen, potassium and phosphorous were critical factors in plant growth; and this knowledge was used in the manufacture of synthetic fertilizers – further increasing crop yields. The chemicals left over after World War II was used to produce synthetic pesticides. But within a few years of use of synthetic fertilizers and pesticides, the first concerns of serious side effects such as soil compaction, soil erosion and health concerns about toxins entering the food supply also became exposed. This eventually led to the idea of sustainable agriculture.

Sustainable Integrative Agriculture and Smallholder Farms: Rather than focusing on N-P-K, or nitrogen, potassium and phosphorous, sustainable intensive agriculture identified carbon as a critical factor in plant growth – especially the carbon present in humus, the decomposing plant matter. Farmers who adopted this approach became known as humus farmers or organic farmers. This kind of agriculture became adoptable not just for large industrial farms, but also smallholder farmers who chose to practise intensive agriculture through the use of high inputs and labour, while also using sustainable intensive methods which are referred to as 'appropriate technologies'. Although less widespread that large industrial farms, smallholder farmers too have their specific outlets to sell their produce, such as speciality farmer's markets.

The strongest driver of specialized modern agricultural production however, is economics. But today, both the farming community and the general consumer is increasingly questioning this industrialised production technique and asking questions about how food is produced and whether they are sustainable into the future. 'Sustainable agriculture' is thus an emerging way of farming, and even though it is strongly associated with the organic sector, it is also a great deal more than that.

When an agricultural production system is sustainable, it is resilient, adaptable to change and does not deplete the resource base. So, the comprehensive term called 'Sustainable integrated farming systems' comprises many dimensions-organic production, vertically integrated business, supply chain management and brand building. In some countries, even organic production has moved on from a cottage industry to a highly industrialized one, leading the way in integrated agriculture with some excellent learning opportunities for conventional production systems.

Integrated Farming Systems: Throw in livestock-rearing to the already existing intensive farming systems, and you have intensive integrated agriculture or farming systems. Combining agriculture and livestock is seen to have multiple benefits. It is also an ideal system for smallholder farmers, as it is much more economical for farmers to raise animals in an integrated farm. The fodder comes from the farm and thus meets the energy needs of the animals.

The dung can also be used as fuel in biogas plants. Apart from providing dairy products, the animals are also efficient in recycling organic and crop residues from the farm. Such integrated farming systems, or at least multi-cropped 'mixed' farms was once the backbone of all agricultural production systems in the western world. But they gradually separated in the 20th century owing to specialization of production systems. Almost all arable land through North America and Europe is not intensively and exclusively cropped and livestock production is separated and intensified. This was motivated firstly by the economic efficiency of specialization and secondly the advent of cheap synthetic nitrogen fertilizer. No longer was cropping reliant on animals as a source of fertility. But, the question is, just because some things can be separated, should they be separated?

Integrated and Specialized Farming Systems: Despite the gradual investment in agriculture by corporate investors, farms remain predominantly family-owned-and-operated around the world. The farming systems that have been able to keep up with change are those who have moved beyond commodity production and are directly engaging with the market; considering that market share is a better driver of production than absolute yield of a commodity.

Today's questions regarding agricultural systems, their sustainability and their contribution to sustainable development at large can only be addressed from a systems perspective. Agro-ecosystems are the interplay of ecosystems and human societies, and their behaviour is determined by interactions with the natural and human-resource base. This unavoidably leads to the conclusion that by definition the role of agronomy can only be partial in analysing and solving problems of agricultural systems at farm, regional and continental scale. Answers to agronomic questions provide only limited insight into behaviour of agricultural systems and are only part of the problem-solving package for most systems around the globe. This is clearly demonstrated for many cases in Africa [8], but it is not difficult to find equally illustrative examples from other continents. Well-known agronomic principles are not adopted because of socio-economic factors or only play a small role in the complex problems that farming communities face. At the same time, using agronomic knowledge in integrated assessment tools is indispensable: many future studies on natural-resource use, agricultural systems and their industries reduce the agro-ecological relationships to a mere econometric function, production function or, in general, statistical relationship between some set of inputs and output(s) [9, 10]. This hinders process-based analysis, explanation of systems' behaviour, interactions with the environment and identification of future alternatives that outperform current activities in terms of productivity and realization of positive or negative externalities. To assess performance of agricultural systems and their contributions to sustainable development and to identify promising alternative pathways, process-based knowledge of agro-ecological relationships is essential, but only to a certain degree of detail and tailored to integration with other factors and systems. This constitutes the challenge for agricultural research and its role in contributing to sustainable-development studies [11]. To what extent can we synthesize agronomic knowledge to the appropriate degree of detail for integration in interdisciplinary and multi-scale analysis of agricultural systems and their interactions with ecosystems and societies?

Methods to deliver agronomic knowledge into studies of an integrated nature are generally model-based and amongst the methods available two can often be found in literature: dynamic crop or cropping-systems simulation models with different levels of detail [12,13] and approaches generating and using so-called input–output coefficients of agricultural activities [14].

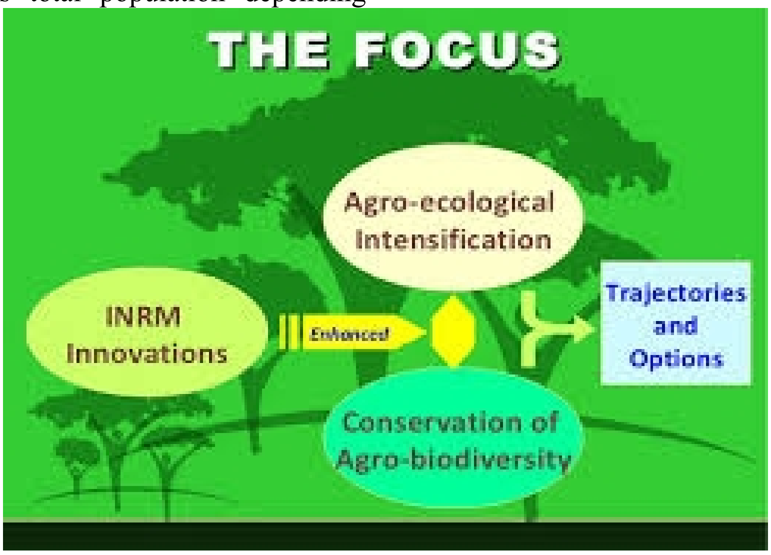
Model-based Assessment of Agro-ecological Innovations: Integrated policy assessment tools should be able to represent the fact that new techniques become available or feasible to farms within the time horizon of the study, such as introduction of genetically modified crops (e.g., herbicide-resistant maize), a new cropping technique promoted in the region, and a new market for certified products with ecological techniques. Will such agro-ecological innovations be selected by the farmer as a response to EU environmental directives or other policies? What will be the impact on water quality, on water use by agriculture, or on biodiversity in the regions where these techniques are adopted? What effects will they have on competitiveness of EU agricultural products in the world market? Following the approach of the cropping system is considered here as a combination of a biophysical subsystem [15] (a plants–soil–weeds–pests combination) for each field of the farm, and a technical system (a coherent combination of management options applied on each field and allocated within a farm). As shown by Wery and Ahlawat (in press) for an example with grain legumes in Europe and in India, this approach can be used for the integrated assessment of agro-technical changes on farming-systems' sustainability, but it requires specific models to represent the biophysical and the technical subsystems. For this purpose, agro-technical innovations can be clustered:

1. Changes in the management of inputs of the biophysical system, e.g., shifting from predetermined applications of water, pesticides and nutrients to split applications based on the actual status of the biophysical system;
2. Changes in the structure of the biophysical system, i.e., shifting from pure stands to mixtures of varieties, species or crops in the same field, including intercropping and agro-forestry;
3. Diversification of the biophysical and technical systems, through inclusion of more and other crops in the crop rotation or production enterprise;
4. Institutional changes, including specific markets providing technical support and economic value to technical systems targeted at the protection of the farm environment in a specific region. The certification of origin is a typical example but it is still mainly targeted at quality of the product with limited incentives to protect the environment; and
5. Combination of the previous clusters, where the institutional environment of the farm is organized to promote agro-ecological innovations and their recognition and economic valuation by the society. Despite its limitations, organic farming is still the best example of a form of agriculture forcing

farmers to adopt diversified crop rotations, crop associations, soil and nutrient management and providing recognition of these efforts and risks in a specific market.

Sustainable agriculture development integrates three main goals-environmental health, economic prosperity and livelihood sustainability. In other words, sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs. Therefore, stewardship of both natural and human resources is of prime importance. Stewardship of human resources includes consideration of social responsibilities such as working and living conditions of farm families, the needs of rural communities, and consumer health and safety both in the present and the future. Stewardship of land and natural resources involves maintaining and/ or enhancing this vital resource base for the long term.

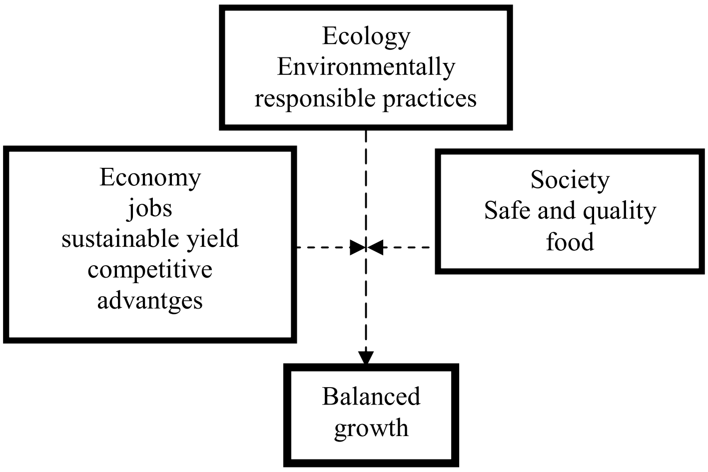
Sustainable development of Agriculture is one of the major thrust of the mission. Meghalaya is basically an Agricultural State with about 80% of its total population depending entirely on agriculture and its allied sector for their livelihood, but the state has also been experiencing distorted growth in this sector. Vast potential of state agriculture is contrasted by the low levels of productivity and entrepreneurship. The productivity of most of the field crops is much lower than the national averages, which determine the threats for food and nutritional security in the state. This warrants the necessity for an integrated approach and renewed initiatives for convergence while undertaking sustainable agricultural development and natural resources management. The Meghalaya Basin Development Authority would provide leadership and support to the various missions and facilitate platform for convergence and co-ordinated action. The Programme and Missions under the Integrated Basin Development and Livelihood would facilitate Participatory Integrated approach for the sustainable development of agriculture and its allied sector to meet the growing demand for food and nutrition security, and livelihood sustainability of rural households.



Integrated Farming System Approach: Integrated farming system approach not only fulfills the household needs but also ensures nutritional security for both human as well as animals being. It also generates employment and earning to the rural masses specially the marginal and small farm holders, which in turn ensures a better livelihood opportunity. This approach not only increases income and employment opportunity but also protect the environment through recycling of the crop and animal wastes at farm itself.

Need of Integrated Farming Systems: Protection and conservation of natural resources : Green revolution era witnessed a very high consumption of off-farm resources (Chemical fertilizers, pesticides, herbicides etc.) to raise the productivity of crops, which led to food contamination, ground water pollution and soil degradation problems. Such problems can be addressed by adopting IFS strategy due to its natural potential of recycling and reuse of farm and animal waste, which in turn less or no reliance on the off-farm resources and conservation of natural as well as financial resources of the country.

Sustainable Development of Agriculture

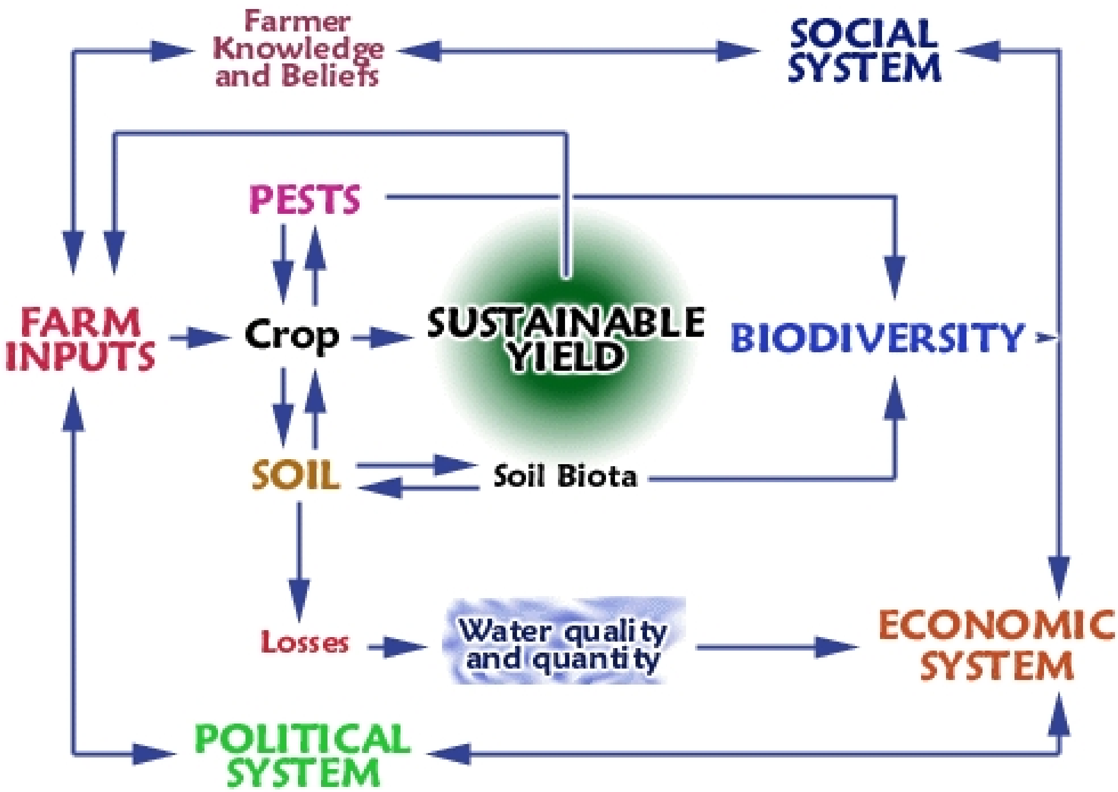


The goal of biologically integrated farming systems (BIFS) is to use biological and cultural farming practices to reduce chemical inputs such as pesticides and fertilizers, and thereby reduce the degradation of natural resources caused by these inputs. The promotion of these farming systems originated from partnerships formed between agriculturalists and environmentalists hoping to lessen the impact of agrichemical pollution. Increasing natural biodiversity has gained significant traction as a method for reducing chemical inputs and maximizing the benefits of ecosystem interactions. The methods aim to take advantage of existing interactions between the components of biological systems and mimic natural habitats where populations of different species are kept in balance. Some examples of biological and cultural practices promoted in BIFS projects include cover cropping, leaf nitrogen monitoring, and use of crop residues to reduce nitrogen fertilizer input and the need for herbicides to control weeds; use of pheromone mating disruption technology and planting of habitat for natural enemies to control insect pests while reducing pesticide use; and better monitoring practices and use of buffer strips to control pests.

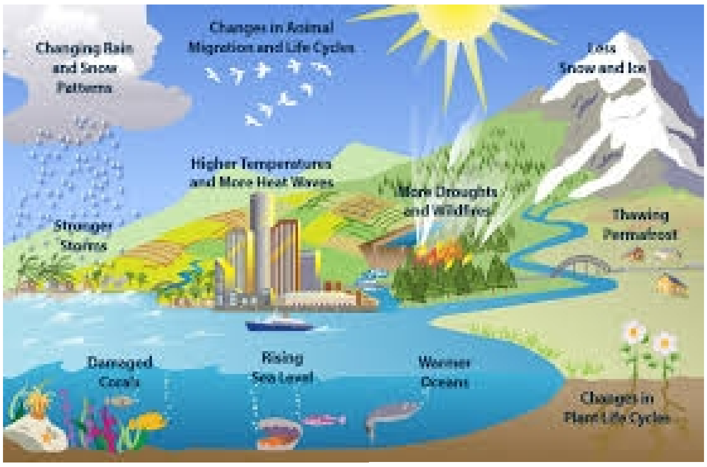
Source:http://asi.ucdavis.edu/programs/sarep/about/copy_of_what-is-sustainable-agriculture/practices/biologically-integrated-farming-systems

Integrated farming systems can be designed using a wide range of practices and techniques. These can be broadly categorized into those systems involving crop-livestock integration, and those systems that focus on whole-system cycling and mimicking nature to best enhance ecological processes.

Nature of Sustainable Agriculture



Protection from Environment and Climate Change: Integrated farming system could mitigate the adverse effect of climate change and environment to a greater extent because it ensures sustainable agricultural production, conservation and utilization of natural resources effectively and efficiently, scientific rearing of livestock, optimum land use for meeting the demands of food, fibre, fuel and fodder requirements under the existing and changing socio-economic condition.



Food and Nutritional Security: IFS ensures a balanced supply of food, fodder and other consumable products for the farming family round the year as it integrates various enterprises simultaneously, which in turn yield different component in sufficient quantity and proportions so as to meet the food and nutritional requirement (food grain, milk, egg, meat etc.).

Organic Farming Makes the Soil Fertile and Increases its Productivity: Soil which is cultivated naturally by several organic practices like composting, green manure, symbiotic associations and less tillage is more productive and fertile. Soil treated with organic fertilizers hosts billions of useful bacteria from around fifteen thousand species. These useful bacteria and fungi break down chemicals, plant residues, and livestock wastes into useful soil nutrients that improve soil binding and structural characteristics thereby delivering more stable systems [16].

Organic Farming Boosts Stable Biodiversity: Organic farmers are the custodians of resilient biodiversity. Use of traditional and non-conventional seeds, breeds and farming methods ensures resistance to infectious diseases and resilience to climate change. Organic farming minimizes erosion of agricultural biodiversity and enhances species richness and abundance by almost 30% as compared to inorganic farming methods. No chemical usage in the farms gives birth to a rich organic area for flora and fauna such as pollinators and pest predators [17].

Organic Farming Promotes Water Conservation and Water Management: For preventing water contamination, organic farmers don't allow water to get exposed to any toxins and also avoid using antibiotics for livestock. Soil rich in organic matter contains good moisture and improves water retention and water infiltration. Healthy soil acts like a sponge that keeps plants moisturised. Also, the organic farms recharge underground water up to twenty percent [18].

Air and Climate Change: Organic farming alleviates conventional energy use by minimizing agricultural chemical needs. Non-conventional farming methods address the issue of GHG emissions and global warming by sequestering carbon in the soil. Organic agriculture practices like reduced tillage, use of crop rotation, nitrogen fixing legumes etc. Maximise the carbon concentration in the soil. The more organic carbon stored in the soil the more mitigation ability of agriculture against climate change [19].

The Costs of Modern Agriculture: The process of agricultural modernization has had an important influence on farm productivity and improved living standards for many farmers. However, farmers need access to: modern seeds, water, labour, capital or credit, fertilizers and pesticides. Many poorer farming households simply cannot adopt the whole package. If one element is missing, the seed delivery system fails or the fertilizer arrives late, or there is insufficient irrigation water, then yields may not be much better that those for traditional varieties. Even if farmers want to use external resources, very often delivery systems are unable to supply them on time. Where production has been improved through theses modern technologies, all too often there have been adverse ecological and social impacts.

Ecological Costs: Many ecological problems have increased dramatically in recent years. These include:

- Contamination of water by pesticides, nitrates, soil and livestock wastes, causing harm to wildlife, disruptions of ecosystems and possible health problems in drinking water;
- Contamination of food and fodder by residues of pesticides, nitrates and antibiotics;
- Damage to farm and natural resources by pesticides, causing harm to farm workers and public, disruption of ecosystems and harm to wildlife;
- Contamination of the atmosphere by ammonia, nitrous oxide, methane and the products of burning, which play a role in ozone depletion, global warming and atmospheric pollution;
- Overuse of natural resources, causing depletion of groundwater, and loss of wild foods and habitats, and of their capacity to absorb wastes, causing water logging and increased salinity;
- The tendency in agriculture to standardize and specialize by focusing on modern varieties, causing displacement of traditional varieties and breeds;
- New health hazards for workers in the agrochemical and food-processing industries.

Social Costs: Agricultural modernization has also helped to transform many rural communities, both in the South and the North. The process has had many social impacts. These include the loss of jobs, the further disadvantaging of women economically if they do not have access to the use and benefits of the new technology, the increasing specialization of livelihoods, the growing gap between the well-off and the poor, and the cooption of village institutions by the state [20].

Impacts on Human Health: As with many industrial practices, potential health hazards are often tied to farming practices. Under research and investigation currently is the sub-therapeutic use of antibiotics in animal production, and pesticide and nitrate contamination of water and food. Farmer worker health is also a consideration in all farming practices.

Improved Agricultural Productivity and Resilient Productive Systems: The misperception or myth that organic production is of low yield is steadily disappearing. Yields of organic agriculture are comparable or even higher than conventional practice, particularly in marginal and rainfed areas where the poor usually reside. Given similar farm size, organic farmers enjoy higher incomes as shown in the case of Thailand. The difference is especially large for the smallest landholders. As input costs are low and productive bases are enhanced with organic agriculture practices, productivity of organic farmers is high [21].

By contrast, the high yields of conventional agriculture are unsustainable without steady water supply and higher inputs of fertilizer in succeeding planting seasons, as documented in some Asian countries, particularly in rice production. For example, as early as the 1980s, a mere 6.5% improvement in yield entailed quadrupling the amount of fertilizer and increasing pesticides by a factor of nine. Since 2000, yields have further declined to such an extent that grain production has actually fallen [22].

As conventional agriculture cannot be effectively applied in marginal areas with no irrigation and access to external inputs, organic agriculture poses as a key solution to improving yields in a sustainable way in marginal areas. Marginal lands are often ill-suited for conventional agricultural practices but respond well to low-input farming techniques that capitalize on biodiversity [23]. Moreover, the inexpensive chemical-free systems improve incomes and health of small farmers, and the state of the environment. In drylands, the addition of organic matter through organic practices can improve soil quality allowing the soil to supply plants with balanced nutrients [24]. While yields initially decline in the first year after transition from conventional to organic agriculture, yields are generally stabilized by the third year. Sophisticated organic farmers may even surpass previous yields using intensive farming techniques [25].

Protection of Genetic Resources: Genetic resources are rapidly declining worldwide due to changes in land use, climate change, and monocropping practice in conventional agriculture. Preservation of genetic resources by public sector in the form of ecological reserve or gene bank is costly and not effective [26]. At the same time, the majority of remaining diversified plant genetic resources resides in remote farms of poor farmers in developing countries who cultivate a wide array of traditional varieties of crops and livestock using organic methods. Most farmers in the ADBI study grow small plots of traditional varieties of rice and vegetables for their own consumption due to preference to taste and resiliency. These farmers are in fact providing invaluable services to humanity by operating a living gene bank that not only conserves genetic resources but also allow these genes to evolve with the changing climate. When provided with market access, these farmers could sell their traditional varieties as healthy organic products at premium prices, which can sustainable serve as a payment for their environmental services.

Improved Health: The inappropriate use of agrochemicals, including pesticides, herbicides, antibiotics, growth hormones, etc. and their residues in food stuffs are known sources of modern illnesses. Thus, the chemical-free farming practices of organic agriculture can improve the well-being of farmers and consumers. The ADBI study reflected this point in lesser out-of-pocket medical spending than conventional farmers. Case studies in north and northeast Thailand revealed that over 90% of respondents noticed improvement in the overall state of health after conversion to organic agriculture, and none felt worse off. The study revealed that organic farmers continue with organic practice despite erosion of price premium over time as more organic farmers enter the market, owing to non income benefits, especially on health.

In terms of catastrophic health expenditure, in the same medical expenditure category as a proportion of total household spending, organic farmers spend significantly less than conventional farmers at all expenditure levels. This indicates that organic farmers are less likely to incur medical spending beyond their income levels. This may imply better health conditions of organic farming households and better welfare as they have more to spend on other household necessities owing to lower health-related expenditures. Moreover, organic farmers tend to adopt a healthier lifestyle, e.g., quit smoking. Organic farming households spend less on tobacco than conventional farming households, highly significant at 1% in 2006 for Thai rice sample and significant at 10% in the PRC horticulture case. Health-conscious farmers may be self-selecting themselves into organic agriculture, but the fact remains that organic farmers lead healthier lives.

According to the World Health Organization (2011) conventional agriculture using chemical fertilizer, animal waste disposal, and land use changes have increased nitrate levels in surface and ground water. As such, organic agriculture which does not use chemical fertilizer can reduce the risks of increasing nitrates in drinking water that can lead to gastric, bladder, and esophageal cancers in adults and blue-baby syndrome in infants, particularly when nitrate levels are above 10 parts per million. It is acknowledged that conventional farming exposes vulnerable workers to harmful chemicals as landless laborers are often hired to perform health-hazardous tasks, such as pesticide spraying, which worsens the conditions of the poorest in rural areas. As the poor, including migrant workers, usually do not possess sufficient knowledge on the proper use of pesticides and herbicides, they often harm themselves through improper handling of chemical inputs. Hence, the practice of organic agriculture provides a safer alternative to avoid the health complications arising from exposure to agrochemicals.

Employment Opportunities: Women are often disadvantaged when it comes to employment opportunities. Examining rural employment generated by organic agriculture in terms of gender-specific opportunities, organic agricultural often increases women-friendly tasks such as weeding, as opposed to men spraying herbicides. The focus group discussions revealed that farmers perceive organic agriculture to provide safe employment opportunities for women, e.g., no exposure to pesticides enables women to work within the village rather than commute to other towns. Non government organizations that promote organic agriculture, as in Sri Lanka and Thailand, engage women in new organic agricultural activities, such as training women as inspectors for certification of organic produce. In a focus group discussion in Sri Lanka, a women happily mentioned that in working in organic agriculture, when she return home she can touch her children without having to take a shower to get rid of toxic agrochemicals from her body.

Improved Overall Productivity: The FAO (2011) estimates that if women farmers have the same access as men to productive resources such as land and fertilizers, agricultural output in developing countries could increase by as much as 2.5%–4% [27].

Improved Family's Well-being: Greater control over household incomes by women increases welfare as more resources are spent on food and education of children. This can enhance countries' growth prospects as revealed in Brazil, the PRC, India, South Africa, and the United Kingdom [28].

Delivered Basic Public Goods: Empowered women would advocate policy choices that provide for basic public goods at the local level, as was the case in India, which led to greater provision of water and sanitation, a necessity that mattered more to women [29].

Reduced Water Pollution: The practice of chemical-free farming of organic agriculture improves not only the health of humans but also that of the environment. With reduced chemical fertilizer application and proper soil management, runoff is minimized, as applied fertilizer un-recovered by crops leads to eutrophication. Pollution of ground waters, salinization, and water logging are also limited [30]. Water pollution arising from herbicides and pesticides runoff that are harmful to ecosystems are also mitigated in organic agriculture.

Integrated Farms: Organic agriculture can facilitate integration of its processes to reduce and/or eliminate wastes and produce its own renewable energy. This is particularly true for organic operations that include animals, whose wastes products are energy sources.

Safe Work Environment: Non exposure to harmful chemicals in organic farms has improved well-being of farm workers. As discussed, the study revealed organic farmers often continue with organic farming despite the erosion of premiums due to non income benefits, particularly to health. During field visits, when farmers were asked why they converted to organic farming, many replied that they were influenced by the death of neighbors at a relatively young age, which the farmers attributed to victims' frequent exposures to herbicides and pesticides.

Sustainable Livelihood: Organic agricultural practices enhance natural productive bases; hence productivity of lands can increase the longer organic practices are employed. Resilience of crops and farmlands is promoted under organic agriculture, which is a key adaptation strategy in a warming climate. Hence, farmers reduce risks of devastating crop failures and zero incomes under extreme weather conditions, which are likely to increase as global temperature increases.

Modernization of Organic Agriculture: The modernization of organic agriculture would involve further training as processes become automated, digitized, and standardized. Necessary infrastructure and facilities in terms of harvest and postharvest processes would need to be provided as the sector develops and expands. Large-scale farming and food processing using organic principles are expanding rapidly in both developed and developing countries as the sustainability of the production systems is assured. Growing consumer demand also led to proliferation of new innovative marketing strategies using information and communication technology to bypass traditional market chains. These innovative arrangements, such as advance payment for organic products and community support agriculture, often include risk sharing schemes between consumers and producers, leading to improved social cohesiveness and inclusive growth. For organic farms that have been contracted by agribusiness firms to produce according to their specifications, knowledge and understanding of certifications and traceability systems are important. Some agribusiness contractors provide various trainings and supervision to ensure compliance with requirements; this support can help farmers improve the quality of their produce and operations, making them more profitable in the market.

Integration of Small Organic Farmers into Global Markets: At the international level, some organic farmers have been contracted by agribusiness firms to produce crops according to their requirements. These farmers, often in remote and marginal areas, have the chance to partake of the benefits of globalization. Through the firms, small farmers are integrated into international supply chains that cater to global demands, giving them stable and higher incomes.

Stem Rural–Urban Migration: At the local level, greater employment opportunities from organic agriculture could help stem the tide of migration to urban areas and help ease overcrowding in the poor areas of cities. In a case study of integrated farmers in Thailand, in the 44.5% of households with a member who has migrated to urban areas in search for employment at the time of study, 12.4% have since returned to their villages because of organic farming.

Community-Supported Agriculture: Organic agriculture is often the motivation for supporting community-supported agriculture (CSA). CSA is a community of individuals who work on, support, and finance a farm operation wherein growers and consumers provide mutual support, and share the risks and benefits of food production. In return, members receive their share of harvests during the growing season. Most CSA groups are organic as members often choose this alternative route to ensure eco-friendly farms producing safe and healthy crops. By direct sales, farmers benefit as they receive better prices for their crops, gain some financial security, and are relieved of marketing their produce. Moreover, some CSA services offer additional farm products like honey, eggs, dairy, fruit, flowers and meat, all of which are produced responsibly and sustainable [31].

Reduce Waste and Recycle: Organic agriculture promotes the recycling of food and organic wastes through composting, such as vermicomposting (composting using worms) and composting to make natural fertilizers for urban agriculture. Composting is a key organic agriculture practice of adding organic matter to soil, which improves soil quality, hence productivity.

Mitigate Climate Change: GHG emissions of human activities are the drivers of climate change. Agriculture, the human food producing sector, contributed about 14% of global GHG emissions in the form of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) in 2004. N_2O and CH_4 have heat-trapping capacity that is 298 times and 24 times higher than CO_2, respectively, over a 100-year time horizon [32].

In the practice of conventional agriculture, fertilizer application to soil releases N2O, while CH_4 is released by the enteric fermentation by ruminants, manure management, and rice cultivation [33]. Two reports by the Consultative Group on International Agricultural Research (CGIAR) using estimates from 2005, 2007, and 2008 revealed that agricultural production releases 12,000 megatons (mt) of CO2 equivalent per year—up to 86% of all food-related anthropogenic GHG emissions; followed by the manufacture of fertilizer releasing up to 575 mt. The whole food system released 9,800–16,900 mt of CO_2 equivalent into the atmosphere in 2008, including indirect emissions from deforestation and land-use changes. A more recent study by the Food and Agriculture Organization revealed that in 2014, GHG emissions from agriculture, forestry, and fisheries have almost doubled in the last 50 years and will likely increase by 30% by 2050 given the current trend.

Under organic agriculture, the carbon footprint of the sector is reduced owing to the following: (i) synthetic fertilizers, which are fossil-fuel based and whose production is energy-intensive, are not used; (ii) organic operations perform better on a per hectare scale than conventional agriculture, with high level of efficiency of energy use [34] and (iii) organic practices build soil organic matter, which help sequester carbon from the atmosphere and enhance the carbon-storing capacity of soil.

Agribusiness Firms as Partners in Development: In the age of globalization, organic farmers have been contracted by agribusiness firms to produce according to their requirements. The requirements may not only include physical properties of produce but also sustainable production practices and high level of traceability. This changing structure of agricultural trade has become an integral part of effective rural development. Organic contract farming has emerged as a promising rural development strategy that has gained momentum in the Asian region. Contractors, often multinational agribusiness companies, provide technical training, production inputs, and market linkages to smallholders. Contracted farmers in turn benefit from a steady supply of consistent quality produce. Farmers in this contractual arrangement, especially small-scale farmers, have assured markets for their produce, providing a steady income stream. The arrangement is also evolving to better address the needs and capacities of all parties involved. Under contract farming of organic produce, poor farmers who naturally have a comparative advantage in terms of less polluted land in developing countries are linked to consumers who want safe and healthy food produce. Not only do the parties involved benefit, but the productive resource bases are also enhanced in the process.

Conclusion: Sustainable agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. It combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life. Sustainable agriculture includes ecological agriculture, organic agriculture, agro-ecology and regenerative agriculture. Sustainable agriculture practices include composting, mulching, crop rotations, inter-cropping, agro-forestry, biological pest control measures, green manures, nutrient recycling and integrating livestock into farming systems, preventing erosion, and water harvesting. Building strong soils and improving soil fertility is key to sustainable agricultural practices, and increases soil water retention and resilience to climatic shocks such as higher temperatures, droughts, floods and storms. Moreover sustainable agriculture, with its focus on building ago-ecological systems, promotes the use and further development of indigenous varieties, well adapted to local conditions and agricultural practices, and the associated knowledge. These traditional varieties are disappearing from farmers' fields worldwide at very high rates, and with them goes the associated wealth of traditional knowledge and culture.

Until now, productivity gain has been the key indicator to measure agriculture growth and its contribution to overall economic growth. However, serious concerns are being raised about the need to address negative externalities on health and the environment, and the GHG emissions of agriculture systems. In addition, the potential of agriculture in reversing climate change through enhancing soil as carbon sink remains to be supported. In the context of the SDGs, this paper describes and provides evidence on the multifunctional nature of agriculture, particularly organic agriculture, which is regenerative and climate-friendly.

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