

Agroecology and Sustainability of Agriculture in India: An Overview

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Abstract

Agroecology is the application of ecological concepts and methodological design for long-term enhancement and management of soil fertility and agriculture productivity. It provides a strategy to increase diversified agro-ecosystem. So it is benefiting the effect of the incorporation of plant and animal biodiversity, nutrient recycling; biomass creation and growth through the use of natural resource systems based on legumes, trees, and incorporation of livestock. These all make the basis of a sustainable agriculture and aim to improve the food system and societal sustainability. The agroecology supports production of both a huge quantity and diversity of good quality of food, thread and medicinal crops, together with family utilization and the market for economic and nutritionally at risk populations. Sustainable agricultural practices have to tackle the conservation of biodiversity, enhanced ecological functions, social tolerance, self-reliance, fairness, improved quality of life and economic productivity of crops and live- stock. Sustainability of agriculture is viewed critically from the point of food and ecological security at the regional scale. The aim of this article is to give an overview to identify the ideal conditions of best agriculture practices and the implications and future prospects of agro-ecology for sustainable agriculture in India.

Keywords: *Agroecology; Sustainability; Agriculture; Agroecosystem; Prospects*

Abbreviations: GDP: Gross Domestic Product; SRI: System of Rice Intensification

Introduction

India is a predominantly agro-economy based country with 70-75% people depending on agriculture [1]. Agriculture and food production are the foundation of life and the economy plays a pivotal role in construction and the sustainability of healthy societies. However, the benefits of agriculture are not fully harnessed in Indian scenario and thousands of people have no access to food every day due to the following two most apparent reasons:

1. Lack of application of modern scientific methods, tools and implements coupled with limited agricultural land resources
2. A rapidly increasing population

Consequently, a major population suffers from malnutrition in spite ushering in green revolution in major parts of the country. The public policies were made in the 1960s, to use pesticides for increase in crop production; however, the negative consequences and adverse ecological and environment impacts were realized quite later. Although the green revolution has increased the crop productivity, it has negative impacts on ecological system (e.g., degradation of land, refuse in soil fertility, salinization, soil erosion, health hazards, poor sustainability of agricultural lands, degradation of biodiversity and loss of organic matter, nitrogen mineralization and microbial biomass [2,3,4]. Hence, an introduction of new technologies has been realized with great emphasis.

India had 0.33 ha of available land per capita in 1952, which was reduced to 0.12 ha by the end of year 2004 [5]. According to India's Central Statistics Office, the share of agricultural products in GDP was 51.9% in 1950-51, which has now inclined to 13.7% in 2012-13 [6]. This indicated main concern about the Indian agricultural condition.

Agro-ecology is an emerging ecological concept and principle for designing and the management of agricultural functions whilst providing a methodological framework to properly execute this task. As a scientific discipline, the agro-ecology defines, classifies, and studies agricultural systems from an ecosystem's perspectives, recognizing the close relationship of these systems to surrounding social and economic environments [7]. It is less about farms and their management practices, and more about ecological systems and their sustainability in the face of exploitation. The reduced productivity could be compensated or retrieved using the agro-ecology approach that helps in enhancing the productivity. With the application of agro-ecological base farming the farmers of Bihar, Uttar Pradesh and Karnataka states have obtained the world record production of rice and potato [7]. Approx 500 million small farm holding families support agro-ecological farming system all over the world. It can renovate the food system, convey income to farmers and healthy food to customers, and reduce climate change. The need of the sustainable agriculture to fulfill the growing demand of food has been realized by India and several other developing countries [8]. Recently in corporate sector too sustainable agriculture is included by the Indian government for successful operation of business [9].

Sustainability of agriculture could be maintained via two key factors the reduced expenses and increased soil fertility. The capturing of rainwater and its scientific management to maximize the water utilization and vermin leads to larger income generation ensuring the diversified farming systems and synergistic benefits. Agro-ecology is emerging as a potential option to ascertain sustainability as it does not involve the traditional farming practices, rather is a constant process to gradually evolve the farming patterns to farm well in a smarter way and to improve life [10]. Indeed, the agro-ecological practices are also environment-friendly. Farms and communities are more flexible to climate change and shocks such as hurricanes, droughts and food or fertilizer price shoots. Organic matter enriched soils have more carbon sequestration due to the integration of trees into farming systems.

Globally per capita demand for crops, when measured as caloric or protein content of all crops combined, has been a similarly increasing function of per capita real income since 1960. This relationship forecasts a 100 – 110% increase in global crop demand from 2005 to 2050 [11]. Cumulatively, the agriculture and economy of a nation address the crucial societal and environmental challenges, such as hunger and poverty, climate change and environment, and community health, income and employment. A transition to greener, more productive, agro-ecological farming allows local people to lead in creating solutions [12].

The main focus of this article is to identify the best practices and policies so as to achieve sustainability of agriculture in India.

Agroecology and Sustainability

The term 'Agroecology' was first time coined in two scientific publications by Bensing [13,14] and recently by Gliessman [15] and Warner [16]. It is the scientific discipline that uses ecological theory to study, design, manage and evaluate sustainable agriculture systems that are productive and also resources conserving. Drawing on the natural social sciences, agroecology provides a framework for assessing four keys [17] and hence its importance is greatly realized by the dominant food policy and agricultural research bodies around the world.

Agro-ecology provides a framework for assessing four key systems properties of agriculture: productivity, resilience, sustainability and equity. The approach of agro-ecology that involves the advanced use of the latest plant and soil science, as also the social science helps in developing to "vigorous, productive and reasonable" food systems, aimed towards biologically rich, ecologically and environmentally sound, and locally sensitive agricultural practices. Cultivation practitioners claim that the approach of agro-ecology is both, a science that "studies agricultural systems from an ecological and socio-economic view" and a movement, like organic farming [18] In practice, agro-ecology can be borrowed from perm culture [19] to create closed systems, or occupy rediscovering onwards techniques that mimic or work with, rather than seek to dominate and defeat, environment. A change to greener, more productive, agro-ecological

farming allows local people to lead in creating solutions. Sustainability of agriculture plays a vital role in creating healthy societies via upgraded standard of life and prospered economy (Figure 1), and also addresses the key issues of hunger and poverty, unemployment, community health, and environmental pollution, especially in developing nations.

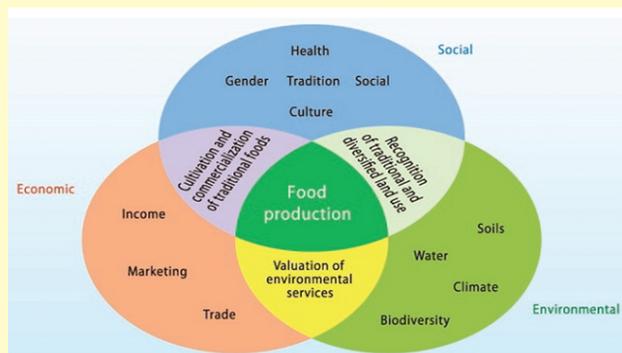


Figure 1: The inescapable interconnectedness of agriculture's different roles and functions.

Source: IAASTD, Global Summary for Decision Makers [12, 20].

The concept of sustainability is based on the principle that the well-being of people and their communities depends on three basic pillars, called the “bottom line components”- the social, economic, and environmental systems that are in constant interaction and equilibrium among these pillars is necessary for the benefits of society today and in future. Sustainability is a model to challenge and to reflect on proposed strategy, events, expenditures, and decisions. It is a way of looking at a community or a society or a planet in the broadest possible context, in both time and space [21]. Though it adopts a large perception, the recognition of sustainability is mainly a limited effort because every community has different social, economic, and environmental needs and concerns.

Sustainability has six principles that can help a community to ensure that its social, economic, and environmental systems are well integrated. Although, the list of principles is useful, each of the listed items has the potential to overlap and inter-relate with some or all of the others.

1. Quality of life

Quality of life is assessed based on several components, which include:

- a. Income
- b. Education
- c. Health care
- d. Housing
- e. Legal rights
- f. Exposure to pollution, disease, disaster, and other risks

The quality of life or “liveability” is the discretion of people depending on their requirements and believes it can achieve, for now and for future generation and differs from community to community. One community may have the proper safety, education, and surroundings, while another has job opportunities and historical heritages what make the place an attractive to live. Each locality must define and plan for the quality of life it wants and believes it can achieve, for now and for future generation.

2. Economic vitality

An adequate level of economic vitality of the local community is essential to sustainability. This component of sustainability depends on job opportunities, sufficient agricultural infrastructure, adequate tax support and benefits to support family along with the available basic infrastructure facilities (such as communications and services, and an appropriate market atmosphere).

3. Social and intergenerational equity

A sustainable community’s income and opportunities exist to everybody, despite of civilization, age, gender, artistic conditions, faith, or other individuality.



Figure 2: Agricultural sustainability for sustainable development of Indian Agriculture.

4. Congenial environment

A substantial eco-friendly environment and the congenial co-existence is the focus of sustainable community. The protection of already existing resources and recover or restore the damaged ecosystem (such as mining impacts, land use changes) may be required to sustain the congenial environment for achieving sustainability.

5. Disaster resilience

Sustainability options also involve community flexibility and resilience towards risks and disasters, either natural (hurricanes, earthquakes, floods, fire and drought) or anthropogenic (mining or industrial processes). The resilient community further takes liability for the risks, to the extent possible, is self flexible.

6. Congenial participatory process

Participatory actions play very crucial role in sustainability of community. It results in the creation of significant awareness, and diffusion information to support wisdom of community building a sense of rights and the broader understanding towards the importance of sustainability.

Agro-ecology: Agro-biodiversity perspectives

Globally, agro-biodiversity erosion has been a major issue of debate, as this is a key consequence of [22,23]

- (a) Unsustainable utilization of resources
- (b) Deteriorated management practices
- (c) Monoculture of highly flexible varieties
- (d) Market forces

- (i) Land use changes
- (ii) Environmental destruction , and
- (iii) Changing behavior of stakeholders

In developing countries, particularly in India the basic problem of production is rural poverty and hunger. The agro-ecology could be used to solve the hunger problem via focusing on a system that may change small yield survival sloping agriculture to a large yield, profitable, and highly sustainable agriculture [24]. The sustainable agriculture supports high production and diverse crops, whilst addressing the high risk of economic and nutritional issues associated with non-viable techniques of farming and the crop there from. The emerging field of agro-ecology may also provide a strategy to increase diversified agro-ecosystems, plants and animals (e.g., of systems based on legumes, trees, and incorporation of livestock).

One of the most practiced ways to enhance crop productivity using agro-ecology in different agro-ecosystems is the palliation, which allows benefits to the second crop through the first crop via changing the environmental conditions for second crop. For example, the environment created by the first crop lowers the critical herbivore population, releases nutrients in soil available to the second crop [25]. Even under the high competitiveness between the crops, palliation can facilitate high yield. The agro-ecology techniques, even in complex agro-ecosystems, could maintain high vegetative cover along with a useful soil and water conserving measure.

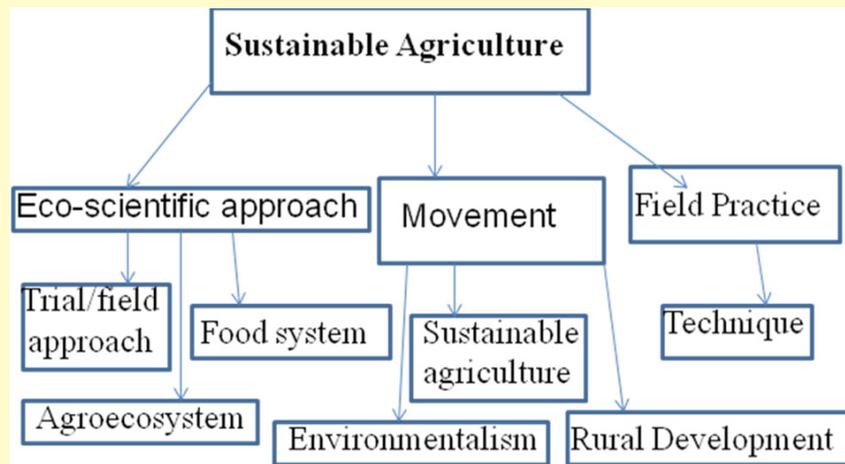


Figure 3: Diversity of present type of agro-ecology [after 21].

Sustainable Agriculture: How different than conventional agriculture?

Sustainable agricultural practices are aimed towards the conservation of biodiversity, enhanced ecological functions, social tolerability, self-reliance, improved quality of life and economic productivity of crops and livestock. This is distinct from the conventional agriculture in point of resource best recycle use of nutrients and organic matter, closed energy flows, water and soil conservation and stability, pest-natural adversary populations. Agricultural sustainability is viewed critically from the point of food and ecological security and the agricultural diversity could be restored in time and space via various techniques, such as crop rotations, cover crops, intercropping and gather mixtures [26].

The idea of sustainability emerged in response to the undesirable (e.g., environmental and economic) impacts of conventional agriculture (Figure 3).

The key focus of agricultural sustainability should be the maintenance of integrity, social acceptability and economic viability. Indeed, the effectiveness of sustainable agriculture practices could be assessed and analysed through three basic elements:

- a) Maintenance of environmental quality
- b) Synergistic interaction of plant and animal productivity, and
- c) Social and economic benefits [27].

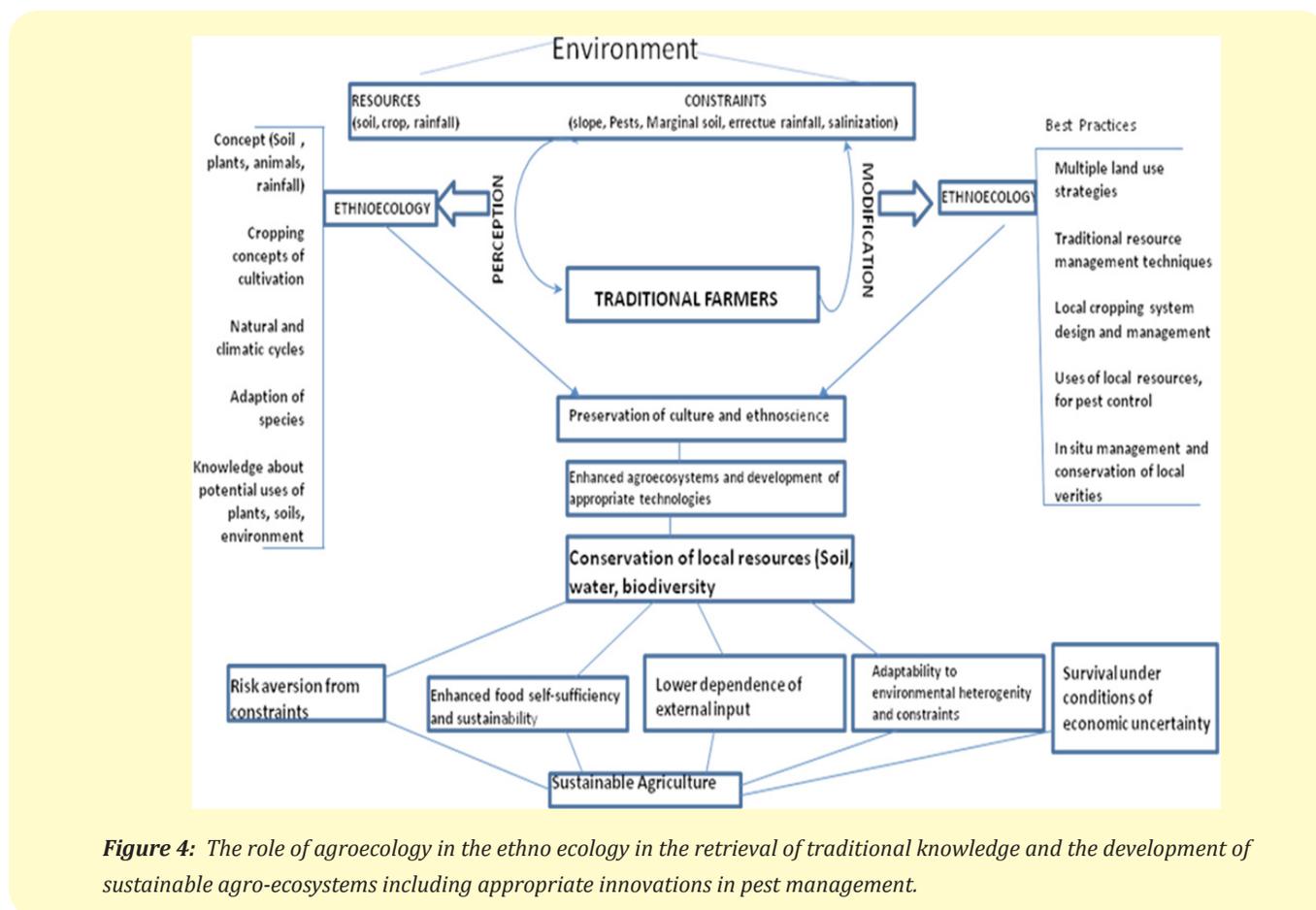


Figure 4: The role of agroecology in the ethno ecology in the retrieval of traditional knowledge and the development of sustainable agro-ecosystems including appropriate innovations in pest management.

Source: *Agriculture, Ecosystems and Environment* [after 28].

Benefits of sustainable agro-ecology

An agro-ecological approach recognizes the multidimensional aspects of agriculture and facilitates a broad range of sustainable benefits as below:

1. An eco-friendly agriculture
2. Increased ecological resilience and reduced risk of environmental degradation
3. Natural resource conservation
4. Improved health and nutrition (reduced incidence of pesticide poisoning)
5. Economic stability
6. Climate change management (via reduced fossil fuel consumption, increased energy-efficiency, increased carbon sequestration and moisture retention in soil)
7. Increased social resilience and stability

The apparent benefits of sustainable agro-ecology in India have been realized through the System of Rice Intensification (SRI) that uses smaller amount of water and chemicals whilst increasing the yields up to 68% [29]. The reduced price of crops and enhanced income of the cultivators by 15% and involvement of a total of 305 beneficiaries in value addition in various commodities in Tamilnadu are the added advantages [30]. Over the history of 60 years, the use of agro-ecological approach in agriculture has led to an exceptional global revolution and management of natural habitats, together with local agricultural practices and food systems.

Future prospects of agro-ecology

An analytical assessment of the performance of food production systems in the face of changing conditions and developing an understanding towards a sustainable agriculture can help to explore the future prospects of agro-ecology. Sustainability of agro-ecology would require fundamental changes for agricultural benefits and bringing structural solutions to meet out the global challenges and huge land degradation and desertification issues. There is also a growing awareness that earlier strategies of generating and promoting technologies have contributed to serious and widespread problems of environmental and natural resource degradation. This implies that in future the agro-ecological technologies must result not only in increased agricultural productivity level but also ensure that the quality of natural resource base is preserved and enhanced. Cumulatively these all lead to sustainable improvements in agricultural production and enhancement of social economy. Further, the future prospects also include the enabling of farmers to develop their skills and expertise, whilst sustaining their use of agroecology farming practices. It also requires to carefully watching the experience of farmer.

The agricultural sustainability should be addressed from the perspective of maintenance of ecological integrity, social acceptability and economic viability. It plays a crucial role to mitigate global food problems, land degradation and desertification, and consequently the eradication of poverty in future.

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