AGRICULTURE IN THE WESTERN GHAT REGIONS OF KERALA:

AN AGRO-ECOSYSTEM ANALYSIS IN WAYANAD DISTRICT

Dr. N. P. Kumari Sushama
Dr. C. Bhaskaran
Dr. G. Sobhana
Dr. B. Seema
Ms. Geetha G. Nath

Department of Agricultural Extension
College of Agriculture
Vellayani, Thiruvananthapuram

with best compliments from author

KERALA AGRICULTURAL UNIVERSITY

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FOREWORD

The Western Ghats is a long narrow range of hills stretching along Peninsular India parallel to and close to the west coast through the States of Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala. The Western Ghat tract is supposed to cover more than 1 lakh sq. km. area collectively. Excepting the 45 km wide Palakkad Gap, the entire eastern half of the State of Kerala falls within the Western Ghat tract.

The Western Ghat Development Programme (WGDP) was started over twenty years ago by the Government of India as part of the special programmes for hill areas of the country. Though initially 'development' of hill areas was also conceived on conventional lines, the dangers of such an approach were recognised within few years and eco-development became the goal of WGDP.

Projects are being sanctioned for implementation under the Programme with this objective.

One such project sanctioned under the WGDP is "Socio-technical system analysis of tribal and settler farmers in the Western Ghat regions of Wayanad District in Kerala" which looks into the socio-technical system constraints in farming experienced by the tribal and settler farmers of Wayanad. This project is funded by the Planning and Economic Affairs (E) Department, Government of Kerala.

In this project, a detailed analysis of the agro-ecosystem of Wayanad was done to study the perception and practices of agro-ecosystem dimensions such as productivity, stability, sustainability and equitability.

Among the districts covered by the Western Ghat region in Kerala, the 'ecological degradation' is much pronounced and 'economic deprivation' of the tribals is most serious in Wayanad district.

Agro-ecosystem analysis is a systematic workshop procedure based on system analysis for determining research and development priorities in rural development. The agro-ecosystem analysis process sharpens farmers' skills in the areas of observation and decision-making and helps develop their power of critical thinking. The workshop uses information on the target area, which is collected and partially analysed before hand.

The document focuses the action plan based on agro-ecosystem analysis using workshop procedure for implementing this project in Wayanad District. I hope this document which gives an idea about the agro-ecosystem analysis carried out at Wayanad, will give guidance to further research efforts and working out action plans for problem oriented technological interventions.

Dr. C. Sundaresan Nair
Dean
College of Agriculture

Vellayani.
8th Feb 2006

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CHAPTER I

INTRODUCTION

Agriculture is more than an economic activity designed to produce a crop or to make as large a profit as possible on the farm. Farming is now viewed as a much larger system with many interacting parts; including environmental, economic and social components (Gliessmain, 2001; Flora, 2001). It is the complex interactions and balance among all these parts which will give sustainability. To move towards this broader goal, the agro-ecological perspective is being focussed. Sustainable agro-ecosystem is the answer to achieve such long-term objectives.

Much of the modern agriculture has lost the balance needed for long-term sustainability (Kimbrell, 2002). With their excessive dependence on fossil fuels and external inputs, most industrialised agro-ecosystems are overusing and degrading the soil, water, genetic and cultural resources upon which agriculture has always relied. Modern agricultural practices and high input technologies can always mask the agricultural natural resource foundation. And as we borrow ever-increasing amounts of water and fossil fuel resources from future generation, the negative impacts in farms and farming communities will continue to become very evident.

In short, conversion to sustainable agro-ecosystems must become our goal. (Gliessman, 2001)

History of Agro-ecosystem Analysis

Agro-ecosystem analysis originated in late 1970s at the University of Chang Mai in Northern Thailand (Conway and Barbier, 1990). At that time, interest in Farming Systems

Research was increasingly motivated by the realization that production per unit area was not the only constraint faced by the farmers in their pursuit of improved livelihood. Agro-ecosystem analysis is a codification of the kinds of information that need to be gathered in order to generate technologies appropriate to different farming systems. It entails a broad and often visual systems analysis (Conway, 1985) used to understand opportunities and constraints in an agro-ecosystem.

Agricultural researchers found the formal interviews and surveys in agro-ecosystem analysis too slow for obtaining data from rural areas. More rapid methods were needed (McCracken *et al.*, 1988) and the series of techniques developed in response to this need came to be grouped under the umbrella term of Rapid Rural Appraisal (RRA). RRA adopts a systems frame work that owes much to agro-ecosystem analysis. RRA may be defined as a systematic, but semi structured activity carried out in the field by a multidisciplinary team and designed to acquire quickly, new information and new hypothesis about rural life. To this framework, RRA adds a specific philosophy on information gathering:

- The process is rapid but seeks information from several sources to improve its reliability;
- The process is iterative, allowing knowledge gaps to be filled successively;
- The process avoids formality; and learning takes place with community participation (McCracken *et al.*, 1988).

Indeed, much of the impetus behind the development of RRA techniques came from the desire to bring local knowledge to bear on analysis such as agro-ecosystem

analysis. A number of techniques have evolved in conjunction with this philosophy, including semi-structured interviews, reliance on key informants within the community and group interviews.

Agro-ecosystem analysis is a systematic workshop procedure based on systems analysis for determining research and development priorities in rural development. The agro-ecosystem analysis process sharpens farmers' skills in the areas of observation and decision-making and helps develop their power of critical thinking. The workshop uses information on the target area, which is collected and partially analysed before hand. Farmers, out of necessity, adopt a multidisciplinary holistic approach to their work and it seems logical that this should also apply to the design and implementation of agricultural research and development programmes for sustainable development of lesser endowed regions and poorer farmers having frugal resources. The attempts in this line have led to the development of Farming Systems Research (FSR) and Participatory Technology development (PTD) approaches. Both these approaches have proved of immense practical value, especially for resource poor small and marginal farmers. In FSR and PTD, the important considerations are the identification and quantification of resources (bio physical, economic, social and cultural) and problems using participatory approaches. Keeping this in view, the agro-ecosystem concept has been proposed for understanding farming system, needs, resources and problems faced by the farmers.

Agro-ecosystem

A system is an assemblage of elements in a boundary and within the boundary, the elements are strongly linked to each other.

The transformation of an ecosystem into an agro-ecosystem involves a number of significant changes. The system itself becomes more clearly defined, at least in terms of its biological and physio-chemical boundaries. These become sharper and less permeable, the linkages with other systems being limited and channelled. The system is also simplified by the elimination of much of the natural fauna and flora and by the loss of many natural physio-chemical processes. However, at the same time, the system is made more complex through human management and activity.

Concepts

The concepts of agro-ecosystem analysis are simple and basic, involving a minimal set of assumptions that are hopefully acceptable to all the disciplines involved in the programme. The central concept is that of the system and the related concepts of system hierarchy, system properties and the agro-ecosystem.

A system is defined as an assemblage of elements contained within a boundary such that the elements within the boundary have strong functional relationships with each other, but limited, weak or non-existent relationships with elements in other assemblages. The combined outcome of the strong functional relationships within the boundary is to produce a distinctive behaviour of the assemblage such that it tends to respond to stimuli as a whole, even if the stimulus is only applied to one part. The living world can be conceived of the natural living world i.e., organism-population-community-ecosystem-biome-biosphere, each with more or less defined boundaries and a distinctive system behaviour

Name of the system	*Example*
Physical System	Planet earth Solar system
Mechanical System	Car
Mechanical/living System	Plough – buffalo – man
Ecological System	Pond Forest Grassland
Agro-ecological System	Rice field Farm Village Watershed

Definition of an agro-ecosystem:

An agro-ecosystem (agricultural ecological system) is an ecological system partly modified by man to produce food, fibre or other agricultural products.

Features of an agro-ecosystem (eg. Rice field)

In the transformation of an ecological system to an agro-ecosystem, the following occurs:

1. Boundaries become sharper and stronger

In rice fields there are bunds around the field, which makes it a separate entity. And also there are limited outside linkages for irrigation in the rice field.

2. Reduction in natural and biological components

Natural and biological components get reduced when an area is converted into rice field confining it to rice plants, weeds, few pests and diseases and their enemies.

3. Ecological processes continue in terms of competition between rice and weeds, herbivory of rice by pests, predation of pests by natural enemies etc.

4. Ecological processes get modified by socio-economic process such as cultivation and harvesting of rice, subsidies in the form of fertiliser, control of water and pests, co-operation and competition between people in management etc.

Thus the combined ecological and socio-economic processes create and determine the agro-ecosystem.

An agro-ecosystem is an agricultural-socio-economic-ecological system.

Agro-ecosystem hierarchies

In the process of agricultural development, the system is modified for the purpose of food or fibre production, thus creating hybrid agro-ecosystem. They can also be arranged in a hierarchic scheme eg., Field – farm – village – watershed region. Agricultural ecology provides the bridge between the two hierarchies, linking the pure ecology of natural living systems with the multiplicity of disciplines that lie within the broad gamut of agriculture. Human ecology provides the bridge between both these hierarchies and the hierarchies of social system – family, kin, group, tribe etc.

Agro-ecosystems are typically arranged in a nested hierarchy. The systems higher in hierarchy tend to control those below. The behaviour of system higher up is not easily understood solely from study of systems lower down. Each level in hierarchy has to be studied in its own right.

CHAPTER II

AGRO - ECOSYSTEM PROPERTIES

The distinctive behaviour of agro-ecosystems can be described by four interconnected system properties –

(1) Productivity – is the net increase in value product per unit resource (land, labour, energy). It is commonly measured as annual yield or net income per hectare or man-hour or per unit of energy or investment.

(2) Stability – is the degree to which productivity remains constant in spite of normal, small-scale fluctuations in environmental variables, such as climate or in the economic conditions of the market. It is most conveniently measured by the reciprocal of the coefficient of variation in productivity.

(3) Sustainability – can be defined as the ability of the system to maintain its productivity or increase when subject to stress or perturbation. Here stress is defined as a regular, sometimes continuous, relatively small and predictable disturbance, for example the effect of growing soil salinity or indebtedness. Perturbation by contrast, is an irregular, infrequent, relatively large and unpredictable disturbance, such as is caused by a rare drought or flood or new pest, where prediction and measurement is difficult and can be done retrospectively. Lack of sustainability may be indicated by declining productivity or profitability but equally, as experience suggests, collapse may come suddenly and without warning.

(4) Equitability- is a measure of how evenly the productivity of the agro-ecosystem is distributed among its human

beneficiaries. The more equitable the system, the more evenly are the agricultural products, the food or the income or the resources shared among the population of the farm, village, region and nation.

These system properties give us an idea about the performance of an agro-ecosystem. Traditional agricultural systems such as shifting cultivation generally have low productivity and stability, but high sustainability and equitability. On the other hand, improved technologies during 1960's such as high yielding varieties, use of fertilisers etc., had high productivity with wide fluctuation (low stability, sustainability and equitability). The varieties introduced in recent past combine high productivity with high stability, but still have low sustainability. The ideal goal should be the system having high productivity and high stability in marginal areas. However, in both situations sustainability and equitability should be high.

CHAPTER III

METHODOLOGY OF AGRO-ECOSYSTEM ANALYSIS

The procedure of Agro-ecosystem analysis has evolved over the past two decades from one originally designed for the analysis of natural eco-systems. (Walker, *et al.* 1978). It rests on the concept described above and on the following four assumptions:

1. It is not necessary to know everything about an agro-ecosystem in order to produce a realistic and useful analysis.
2. Understanding the behaviour and important properties of an agro-ecosystem requires knowledge of only a few key functional relationships.
3. Producing significant improvements in the performance of an agro-ecosystem requires changes in only a few key management decisions.
4. Identification and understanding of these key relationships and decisions require that a limited number of appropriate key questions are defined and answered.

Agro-ecosystem analysis is a technique to analyse an agro-ecosystem for its four system properties namely productivity, stability, sustainability and equitability. As part of the Externally Aided Project on WGDP entitled "Socio-technical system analysis of tribal and settler farmers in the Western Ghat regions of Wayanad District in Kerala" which is funded by the Planning and Economic (E) Affairs Department, Govt. of Kerala and implemented in College of Agriculture, Vellayani, a one day interface cum consensus building workshop on Agro-ecosystem Analysis was organised at Regional Agricultural Research Station (RARS), Ambalavayal, Wayanad on 28th of January 2005. One of the main objectives of the project was to study the perception and practices of the four main dimensions

of agro-ecosystem. Agro-ecosystem analysis was conducted as a systematic workshop procedure based on systems analysis for determining research and development priorities in rural development.

The methodology adopted was that of workshop and consensus building. An orientation about agro-ecosystem was carried out initially to give an idea to the audience about the purpose of agro-ecosystem analysis. Then the whole participants were divided into groups taking into account the major crops of the district. The group was then supplied with a schedule and they were asked to generate data and discuss about their relevant crop with respect to the properties of agro-ecosystem namely productivity, stability, sustainability and equitability. Later a consensus building exercise was carried out so as to include all the suggestions from other group members also.

Research personnel from Kerala Agricultural University, RARS Ambalavayal, scientists from various institutions such as Coffee Board, Centre for Water Resource Development and Management, extension personnel from State Department of Agriculture, Soil Survey Department etc., and progressive farmers representing all the three blocks of Wayanad viz., Kalpetta,Sulthan Bathery and Mananthawady participated in the interface.

Project background

The project was carried out in Wayanad district, which falls under the Western Ghat regions of Kerala. This investigation is a pioneering attempt aimed at a comprehensive analysis of tribal and settler agriculture in Wayanad district. It is hoped that the results of the study would serve as useful guidelines for planned interventions in technology generation and its transfer at the field level.

This workshop uses information on the target area, which is collected and partially analysed before hand. To have a

thorough analysis of the agro-ecosystem and build consensus on the various aspects of the system, like productivity, stability, sustainability and equitability this workshop was conducted at Ambalavayal.

This technical bulletin covers the results of the agro-ecosystem analysis conducted by the scientists and experts with the active participation of selected farmers of Wayanad district.

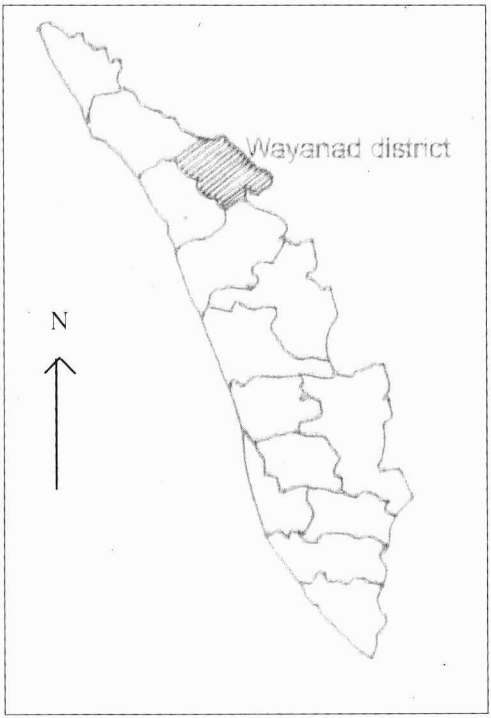


Fig: 1. Map showing Kerala State with the selected district

Locale:

Nestled among the mountains of the Western Ghat, lies Wayanad, one of the loveliest hill stations of Kerala. The last populous of Kerala's districts, Wayanad is relatively backward and development has not appreciably improved the lives of the

Wayanad district with the selected blocks

Fig 2. Green paradise – Wayanad

tribes who comprise a sizeable section of the population. This green paradise, located at a distance of about 76 km from the seashores of Kozhikode, lies at a height between 700 and 2100 m. above mean sea level, on the north-eastern part of the state. This district receives an average rainfall of about 2000 mm to 3000 mm per year and it is spread over a period of 9 to 10 months. Wayanad is blessed with a hot humid climate. The minimum temperature ranges from 14.5°C to 20.2°C and maximum temperature ranges from 25.1°C to 32.6°C respectively. Relative humidity is very high which goes even above 90 % during South West monsoon. Ideal climate coupled with conducive soil profile, rich in organic matters, make the district, the home of many aromatic crop plants.

Wayanad's climate and geography makes it ideal for the cultivation of coffee, tea, cardamom, pepper and rubber and also paddy. Indeed, it has a long history of agriculture. The name itself, Wayanad, is derived from the expression, '*Vayalnadu*', which means the land of paddy fields. Two tribes, who are among the inhabitants of this region from early times, and associated with earliest cultivation of rice in valley wetlands and rainfed millets in uplands, largely by shifting cultivation, are the 'Kurichiyas' and 'Kurumas'. The agro-ecological conditions of the area, which is vastly different from the plains, and virtual isolation of the area from plains due to lack of proper communication and other factors restraining early migration from the plains, the agrobiodiversity conserved and used by the native tribes, evolved several unique adaptive properties. Selection of these traits eventually evolved many landraces of rice and crops unique to the region. Later, which is more recent in historical time, huge migration from the plains and domination of these migrants in influencing the cropping pattern in the uplands led to the total decline of millets and rise of plantation crops. However, the land use pattern in lowlands changed very little, thus helping the retention of many of the unique indigenous landraces of rice. Between the two early cultivator tribes, 'Kurumas' lost out to the migrants and became landless

farm labour, while 'Kurichiyas' retained land ownership and associated agrobiodiversity with the historical continuum, at least in the case of rice. Thanks to these indigenous people and their penchant for conservation and innovative agriculture that, landraces have sustained a place in the midst of improved varieties. Wayanad has a rich repository of rice genetic variability, not only suited to hill agriculture, but also distinct in many other ways.

The in-migration into Wayanad district was initially induced by the establishment of commercial plantations by the Britishers, during the twenties and thirties of the present study. The extensive tea and coffee estates in Wayanad faced the problem of shortage of labour, as tribals were the only source of labour at that time. Migrants could find ready employment and had easy access to un-occupied virgin land. This encouraged not only in bringing vast areas of fallow land under cultivation, but also in encroachment and occupation of forest lands and tribal lands. One significant development, which stemmed from large-scale migration and settlement, was establishment of numerous commercial plantations in the district apart from conversion of extensive areas of forests for raising commercial crops. Large-scale migration and settlement had commenced in Wayanad district with the launching of the Wayanad colonisation scheme in 1948. Thus, Wayanad District also experienced a new move of immigration of the settlers in the sixties and seventies and now the district has one of the largest populations of settlers in the State. (Mohandas, 1992)

Many of the farmers realize that time had led to the erosion of several local landraces. Local farmers recognize the existence of about 24 landraces, although a recent survey by M.S. Swaminathan Research Foundation (MSSRF) could locate only 14 of them. Immigrants also do cultivate some of these landraces and they are also well aware of the specific advantages of these in the local agriculture. Some of the landraces more common now in Wayanad are *Chennellu*,

Chomala, *Gandhakasala*, *Jeerakasala*, *Njavara*, *Kaima*, *Karuthan*, *Thondi* and *Veliyan*. Among these *Njavara*, *Gandhakasala* and *Jeerakasala* have unique medicinal and culinary properties.

Wayanad also occupies primary position in terms of area and production of coffee in Kerala. More than 80 % of the total coffee produced in Wayanad is exported to various countries. '*Wayanadan Robusta*' coffee growers are small holders who depend chiefly on coffee cultivation for their livelihood. Organic cultivation, value addition and proper marketing strategies are the major steps to increase the export potential of coffee from Wayanad. Quality assurance through standard drying yards, pulping units, storage facilities and quality control labs are the immediate measures to attract foreign orders. Branding of Wayanadan coffee is also positive step in this venture. The Coffee Board has accorded an exclusive brand "Tiger" for Wayanadan Robusta coffee, which will boost the export potential of premium Wayanadan Robusta. Special emphasis is needed to be given in maintaining quality system in the area of production, processing including post harvest technology and post harvest handling.

The general information about Wayanad presented in Table 1 and 2 gives an idea about the area and production of the major crops in the district.

Table 1: Wayanad at a glance

BARE FACTS	
District	*Wayanad*
Area (in sq.km.)	2,131
Population	7,86,627
Male	3,93,397
Female	3,93,230
Sex ratio: Females/1000	966

District	*Wayanad*
Density of Population	369
Per Capita Income (in Rs)	34,123
Literacy rate	General – 85.25% Scheduled Caste- 75.271 % Scheduled Tribe- 50.63%
Coastal line (in km.) Water bodied area (in ha.)	Nil 936
Forest area (in ha.)	78,787
Assembly Constituencies	1. Kalpetta 2. North Wayanad 3. Sulthan Bathery

Source: Panchayat Level Statistics, Wayanad District, 2001

Table 2: Area and production of major crops in Wayanad District

Crops	*Area under cultivation (ha.)*	*Production (in tonnes)*
Rice	10175 (Winter) 2168 (Summer)	23549 (Winter) 4872 (Summer)
Pepper	42287	12173
Ginger	4392	21257 (Cured)
Cardamom	4106	329 (Processed)
Cashew	1346	876 (Raw cashew nuts)
Tapioca	1964	102609
Coconut	11098	47 million nuts
Arecanut	8689	4192
Tea	6492	7334
Coffee	67429	54650
Rubber	6636	6230
Banana	11819	80162

(Source: Farm Guide, 2006)

Pepper Production System

Coffee Production System

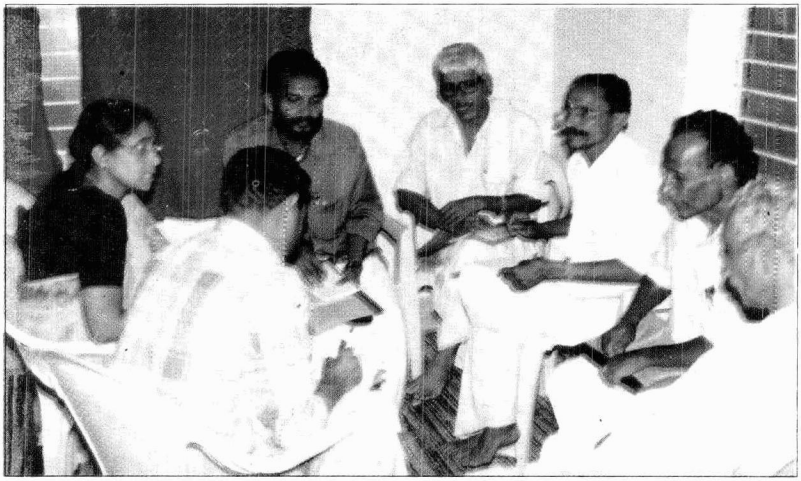
Paddy Production System

Banana Production System

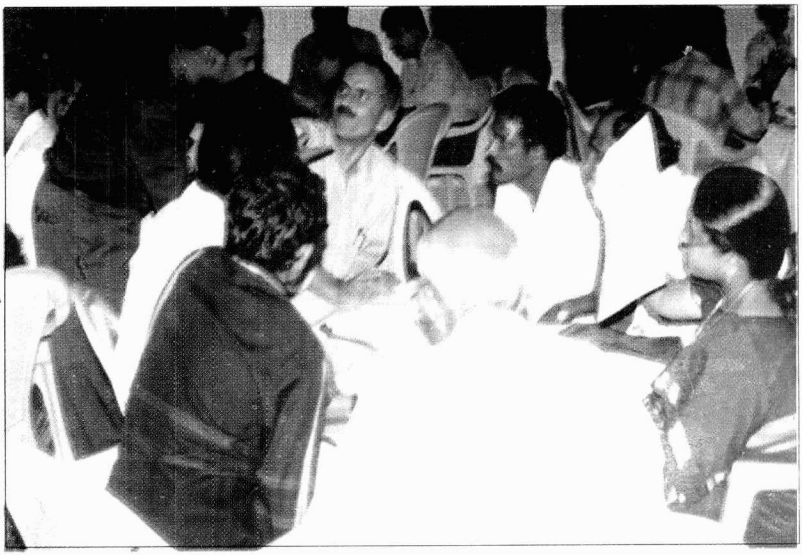
Ginger Production System

Inauguration of the Agro-ecosystem Interface

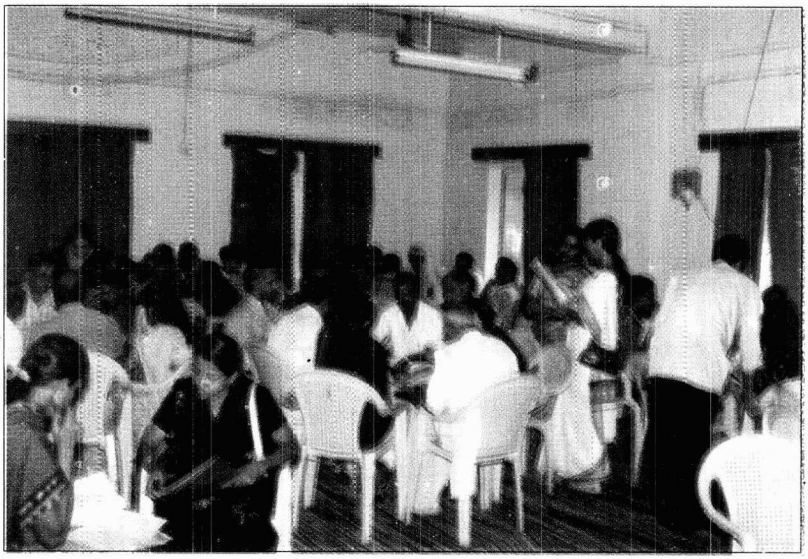
Various groups of Agro-ecosystem analysis at work



Groups at work



Consensus of building



CHAPTER IV
ANALYSIS OF SYSTEM PROPERTIES

The behaviour of any agro-ecosystem can be described by the four system properties mentioned earlier in the text. These properties are easy to define, but not equally easy to measure. The properties although primarily neutral descriptions of system behaviour, may also be used as indicators of performance. It then becomes possible to view agricultural development as a progression of changes in the relative values of these properties.

(1) Productivity

Productivity is the net increase in value product per unit of resource like land, labour, energy. It is commonly measured as annual yield or net income per hectare or man hour or per unit of energy investment.

In case of land it can be measured in terms of output per unit of land or calorie output/unit of land, whereas productivity of labour can be measured in terms of output in kg or value of the output per man hour.

Productivity of capital is measured as returns in rupees per unit of capital invested whereas productivity of technology can be measured in terms of kg output unit of technology.

For each level of hierarchy of agro-ecosystems i.e., plant, crop, field, farm, village or region, productivity can be measured in terms of output.

Table 3 : Yield of crops in the area as perceived by farmers and potential yield as perceived by experts

Crop	Panchayat (Farmers)	Block (Farmers)	District (Farmers)	Potential (Experts)
Paddy	3650 kg/ha	3500 kg/ha	2412 kg/ha	5000 kg/ha
Ginger	7800 kg/ha	6000 kg/ha	4395 kg/ha	30000 kg/ha
Banana	24000 kg/ha	15000 kg/ha	6799 kg/ha	25000 kg/ha
Coffee	950 kg/ha	1500 kg/ha	787 kg/ha	1000 kg/ha
Pepper	560 kg/ha	400 kg/ha	295 kg/ha	325 kg/na

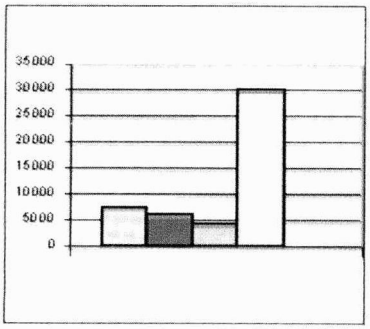
As seen from the Table 3 and Fig 3 productivity was measured on the basis of output per unit of land area at three hierarchical levels namely panchayat, block and district.

Also, the productivity of the different production systems were assessed as low, medium or high against the potential at each level and the results are presented in Table 4.

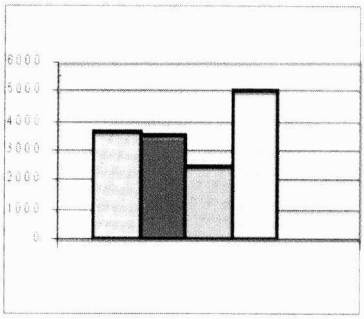
Table 4: Comparison of productivity of major crops – Panchayat, Block and District wise

	Panchayat	Block	District
Paddy Production System	Low	Low	Low
Ginger Production System	High	Medium	Low
Coffee Production System	Medium	High	Medium
Pepper Production System	Low	Low	Low

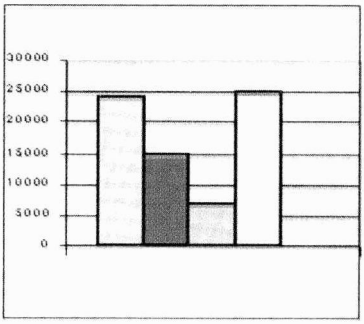
Analysing the results, it could be seen from Table 3 that the yield of the crops like paddy and ginger is comparable at panchayat and block levels. But the levels at panchayat, block and district when compared with realisable yields are very low. The reasons attributed were mainly adverse weather conditions, decline of soil fertility due to excessive use of pesticides and



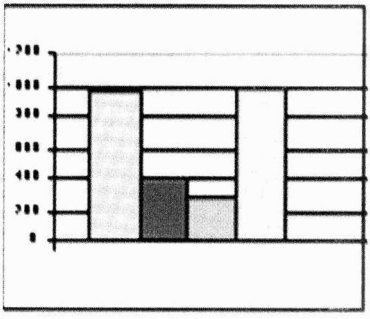
Ginger



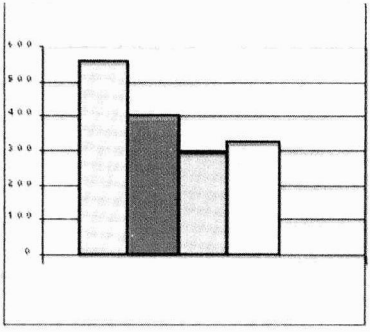
Paddy



Banana



Coffee



Pepper

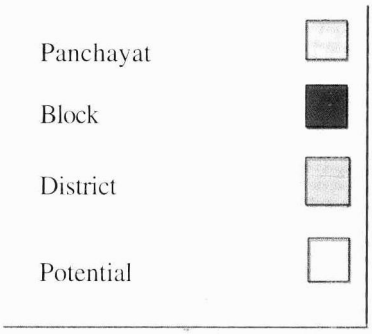


Fig. 3. Yield of crops in the area as perceived by farmers and potential yield as perceived by experts

chemical fertilizers, diseases and pests, lack of availability of bio fertilisers and new technologies and insufficient price for the produce in markets.

(2) Stability

Stability means the consistency of productivity in response to small disturbances caused by the normal fluctuations of the surrounding environment which includes physical, biological, social and economic factors. These fluctuations may be in the form of change in rainfall pattern, temperature, market demand and so on.

Stability can be measured as coefficient of variation of productivity. In this study, it was measured using time series of productivity measurements and establishing a trend line.

The behaviour may be high, equal or low with respect to similarly measured stabilities at panchayat, block and district levels. It may increase, decrease or remain the same over time.

Table 5: Trend in productivity of major crops over 50 years

Crops	Year					
	1950	1960	1970	1980	1990	2000
Paddy	2500 kg/ha	2500 kg/ha	1250 kg/ha	1250 kg/ha	1250 kg/ha	2400 kg/ha
Cassava	7500 kg/ha	8000 kg/ha	8000 kg/ha	8000 kg/ha	7500 kg/ha	6000 kg/ha
Banana	—					6500 kg/ha
Coffee	625 kg/ha	750 kg/ha	1315 kg/ha	800 kg/ha	800 kg/ha	78 kg/ha
Pepper	—	3000 kg/ha	2000 kg/ha	2500 kg/ha	4500 kg/ha	2500 kg/ha

Table 5 and Fig. 4, showing the trend in productivity from 1950 to 2000 give a clear idea about productivity of the important crops over years. The productivity of paddy has shown an increase in 1970's but after that has shown a decrease. But by the year 2000 it has once again shown an increase coming upto 2400 kg/ha. Ginger has shown an increasing trend in the earlier years and remained stable during 1960s and 1970s. After which it has declined very sharply.

Extensive banana cultivation was introduced in Wayanad during 2000 only and so a trend analysis could not be done.

Productivity of coffee has shown an increase in the earlier years, but after 1980's it has declined. The reasons attributed were negligence on the part of farmers as a result of low returns due to price fall, unstable weather conditions, poor disease management, soil fertility deterioration due to irrational use of fertilisers etc. Poor price for the produce was another reason reported for the unstable trend line as shown in the table. Some suggestions were also put forth.

The planting should be done in such a way that sufficient sunlight must be allowed into the plantations. Pruning of coffee plants/trees should be carried out three times a year. Conservation of soil moisture through contour bunding and providing water channels to direct rainwater to the plantations may be practiced. Organic farming should be practiced in place of chemical fertilisers for conserving soil fertility. During summer months, facilities should be made to irrigate the crop (sprinkler irrigation).

The cultivation of pepper also had similar problems. The reason for low stability of production in pepper was the incidence of diseases especially quick wilt and slow wilt. Also farmers are reluctant to spend on improved farming practices. The traditional reservoirs of organic manures have been depleted resulting in the decline in soil fertility, and the consequent low productivity of almost all crops.

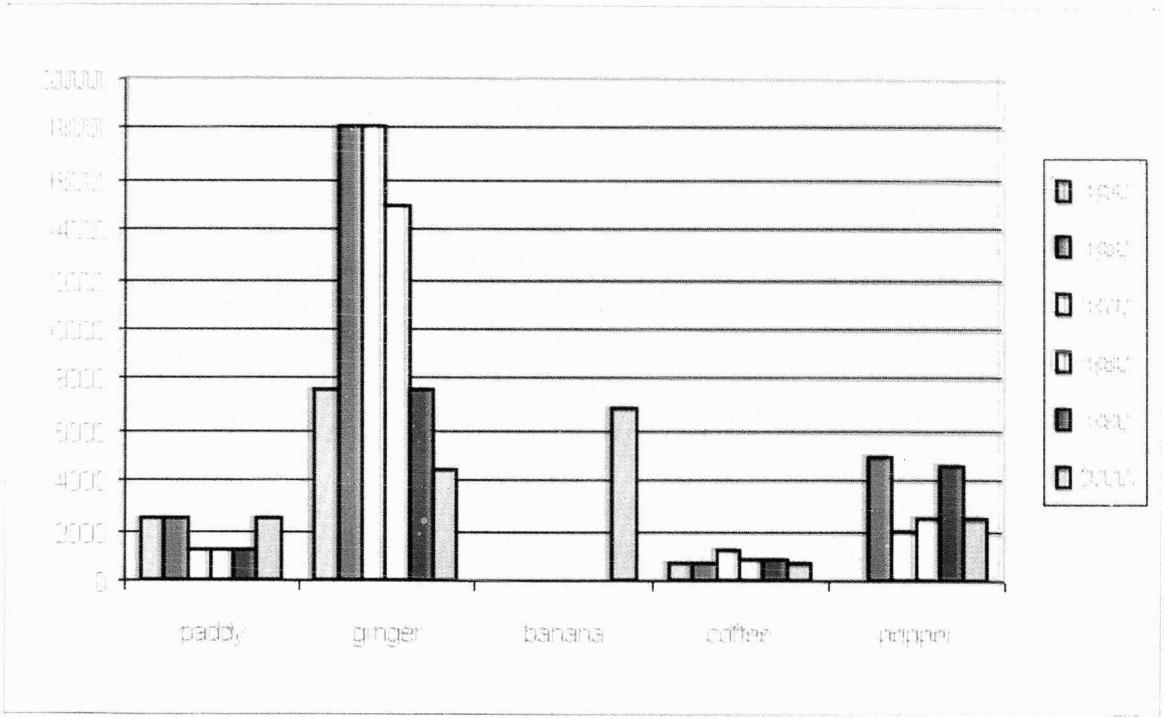


Fig. 4. Trend in productivity of major crops over 50 years

In the case of paddy, the weather conditions in the recent years have affected the crop yield adversely. In earlier years, two crops of paddy were taken but now it has been reduced to one crop a year. This is mainly due to scarcity of water and decline in use of pesticides over the years.

In case of ginger the decline in soil fertility was one of the main reasons attributed to low yield. Floods due to heavy rains and poor soil and nutrient management were also there. The other reasons are reduction in market prices and the higher status was conferred on newly introduced crops like vanilla, annata etc. Scarcity of quality planting materials is yet another reason. As in the case of pepper, if certification and international standards are established in ginger, the farmers can be expected to get more profit from marketing of ginger.

(3) Sustainability

Sustainability is defined as the ability of the ecosystems to maintain productivity in spite of major disturbances in the environment such as stress or perturbation.

Stress is defined as regular, sometimes continuous relatively small and predictable disturbance. For eg., the effect of growing soil salinity. Perturbation, by contrast is an irregular, infrequent relatively large and unpredictable disturbance such as which is caused by a rare drought or flood, new pest and its prediction. Measurement is difficult and can be done only retrospectively.

It is very difficult to measure sustainability quantitatively and the behaviour over the years gives us the indication of sustainability.

The behaviour of sustainability is dependent on the productivity. Following the disturbances, productivity may remain unaffected, fall in return to previous level or settle to new lower level or collapse and disappear.

Agro-ecosystems are subjected to human intervention, which affect sustainability. Application of fertilisers yields a high-level of productivity despite frequent harvesting. But fertiliser application has to be repeated every time. On the other hand, a single input of nitrogen fixing perennial legume provides a more sustainable system.

Similarly pesticides sustain productivity in the face of pest attacks. But they have to be repeated whereas an input of a biological control agent eg., a population of predators that feeds on the pests, would create a more sustainable system.

Sometimes, pesticide inputs dramatically lower the sustainability. Repeated pesticide applications may result in the evolution of resistance by the pests, thus causing pest attack resulting in the productivity to collapse. Application of pesticides may cause destruction of soil microbes, which in turn affect productive capacity of soil.

Table 6: Ability of the ecosystem to sustain productivity of soil

Crops	Sustainability level
Paddy	Low
Ginger	Medium
Banana	—-
Coffee	Medium
Pepper	Low

Table 6 reveals the ability of the various crops to sustain productivity. The productivity of paddy and pepper has declined over the years. The reasons accounted were the increased use of chemicals, which have resulted in the depletion of soil

fertility. The cultivation of the same crops continuously on the same piece of land is another reason for decrease in soil fertility.

The productivity of ginger and coffee was also slightly affected over the years. But this can be surely increased by the use of organic farming. According to the farmers, indigenous knowledge also should be incorporated into the existing systems for sustaining productivity.

(4) Equitability

Equitability is the evenness of distribution of the production of the agro-ecosystem among the human beneficiaries. The more equitable the system, the more evenly are the agricultural products, the food or the income or the resources shared among the population of the farm, village, region and nation.

This can be measured in terms of total yield or net income for the agro-ecosystem under consideration eg., the farm, the village, the region, the nation

It can also be graphically measured by representing on a histogram.

If Y axis represent number of people and X axis, the classes of income (or product), then area under histogram is total population of the agro-ecosystem

The behaviour may be high with everyone obtaining a similar share in terms of production or low with some receiving considerably more than others. It may increase, decrease or remain the same over time.

Here the equitability among the settler (small, marginal and large) and tribal (small, marginal and large) farmers were discussed among the participants.

Table 7: Comparison of productivity of major crops among large, small and marginal of settler and tribal farmers

Crops	Settler farmers			Tribal farmers		
	Large	Small	Marginal	Large	Small	Marginal
Paddy	Medium	Medium	Medium	Medium	Medium	Medium
Ginger	High	Low	Low	High	Low	Low
Banana	High	Low	Low	High	Low	Low
Coffee	High	Medium	Medium	High	Medium	Medium
Pepper	High	Low	Medium	Low	Low	Medium

It can be seen from Table 7 that in the case of paddy, ginger, banana and coffee there was not much difference between settler and tribal farmers. Whereas the productivity of pepper among large-scale farmers is high as compared to marginal and small-scale settler farmers. Productivity of pepper among marginal farmers is more than that of small farmers. This means marginal farmers have medium productivity for pepper followed by small and large farmers with low productivity.

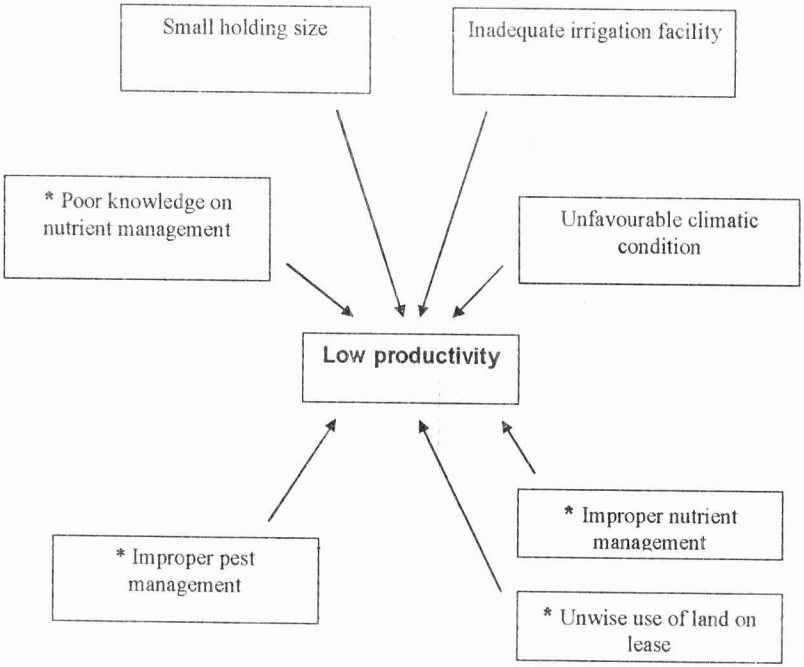
The suggestions put forth by the participants in the work-shop were to make facilities to avail loans, formation of SHGs, ensure good price for their produce, integrated nutrient management and value addition in products to get more returns from agriculture.

CHAPTER V

PROBLEM DIAGNOSIS AND PRIORITISATION

Problem diagnosis was done using information generated from the consensus building and workshop conducted. The root cause for low productivity, stability, sustainability and equitability were analysed for various crops and the results are presented in the following pages. The illustrations (Figs. 5 to 9) reveal the causes for low productivity and priority of problems for intervention.

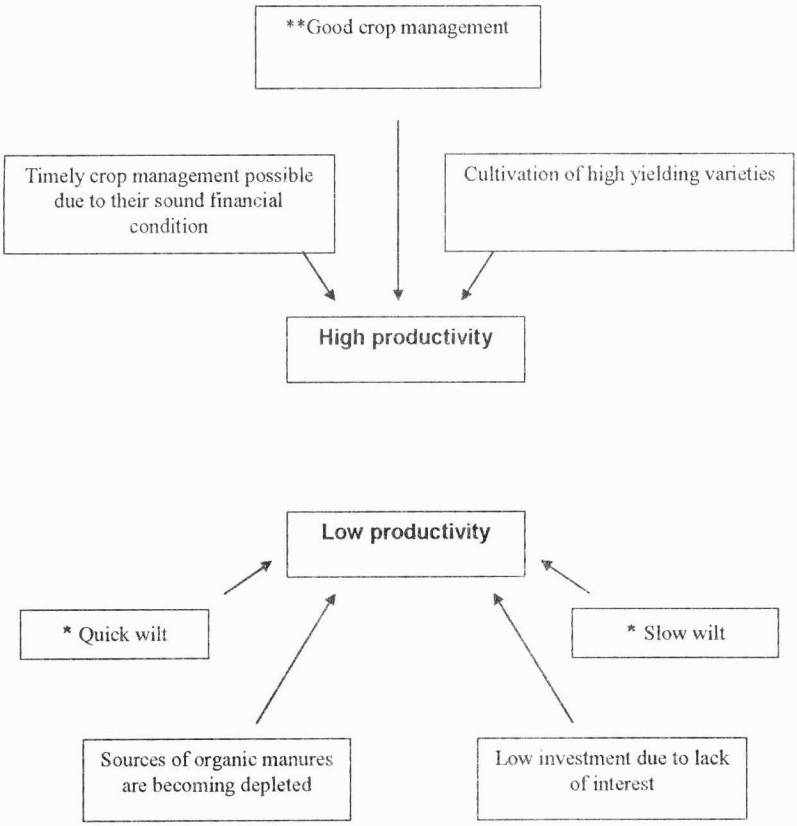
Problem - Cause Relationship for low productivity of Paddy



* Extension intervention should be taken up.

Fig. 5

Problem - Cause Relationship for high productivity of Pepper

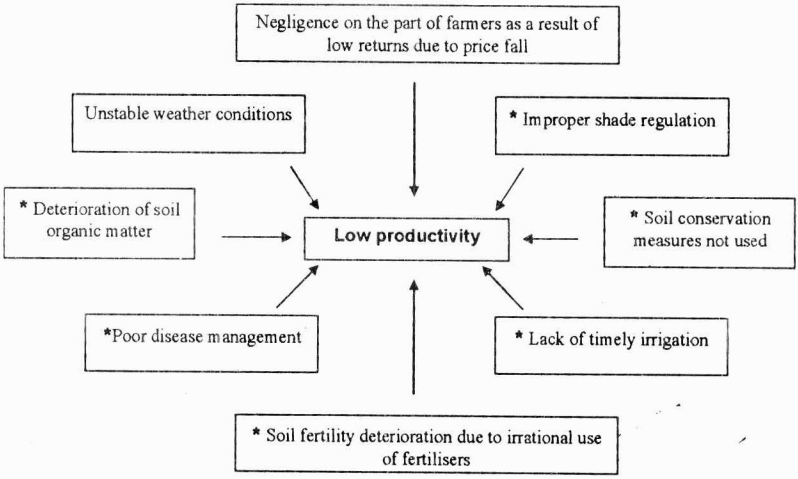


* Extension Intervention should be taken up

** Good crop management: Pest, Disease, and Nutrient Management

Fig. 6

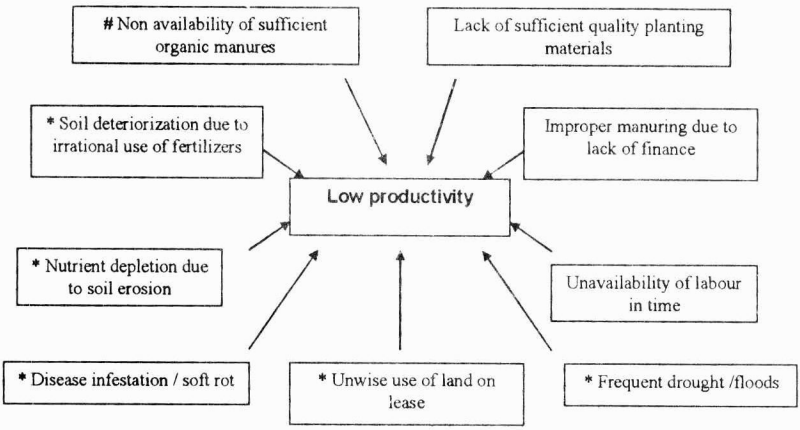
Problem - Cause Relationship for low productivity of Coffee



* Extension intervention should be taken up

Fig. 7

Problem - Cause Relationship for low productivity of Ginger

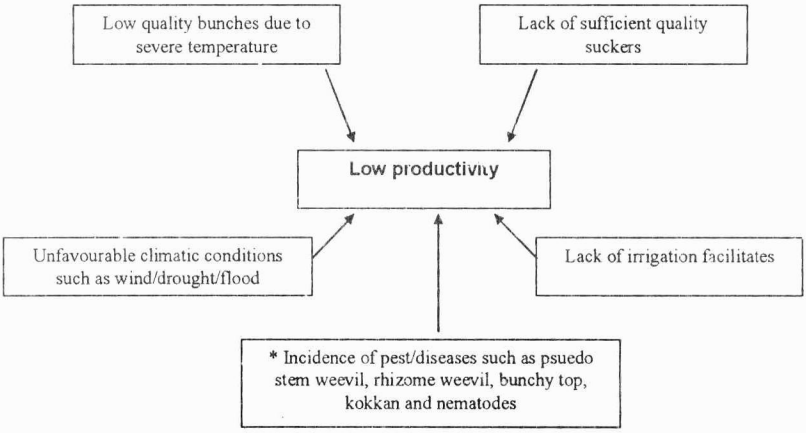


* Extension intervention should be taken up

(Reasons) : Deforestation, Reduction in cattle population, Lack of organic recycling, Increase in cultivated area

Fig. 8

Problem - Cause Relationship for low productivity of Banana



* Extension intervention should be taken up

Fig. 9

CHAPTER VI
FUTURE PERSPECTIVES

Problems in agriculture create the pressure for the change, which will bring about a sustainable agriculture. Designing and managing sustainable agro-ecosystems as an approach is in its formative stages. It builds initially upon the fields of ecology and agricultural science and emerges as the science of agro-ecology. This combination can play an important role in understanding the transition to sustainable agriculture. But sustainable agriculture is more. It takes on a cultural perspective as the concept expands to include humans and their impact on agricultural environment. Agricultural systems are a result of the co-evolution that occurs between culture and environment and a sustainable agriculture values the human as well as the ecological components.

In the broader context of sustainability, we must study the environmental background of the agro-ecosystem as well as the complex processes involved in the maintenance of long-term productivity. Then we must examine the interactions among the many organisms of the agro-ecosystem, beginning with interactions at the individual species level and culminating at the ecosystem level as one, understanding the dynamics of the entire system.

It should also integrate the multiple aspects of the social, economic and political systems within which agro-ecosystems function, making them even more complex systems. In short, by properly selecting and understanding the upstream inputs into agriculture, it can be ensured that what we send downstream will promote a sustainable future.

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