AGRICULTURE COMPARÉ/COMPARATIVE AGRICULTURE PV4

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CHAPTER ONE

1.0 Introduction: Comparative Agriculture is based on agronomy's methods and results, but equally involves the social sciences such as history, agrarian geography, as well as rural economics. Three levels of analysis are employed: the plot or herd level where practices are observed; the production unit level, within which the different cropping and herding systems are integrated with one another; and the regional or country level to which the application of the concept of the agrarian system pertains. By using these three different levels of analysis, Comparative Agriculture allows as much for switching scales as for a comparative approach aiming to make sense out of agricultural transformations around the world.

The characteristics of specific geographical areas define the ways of living of people in the modern world. To understand the issues concerning food and agriculture that directly affect people's lives, the unique features of each region, which have been formed over a long period of time, needs to be identified.

Primary production of plant and animal commodities is among the most variable and complicated of all human endeavors, and it is hardly surprising that we cannot yet claim full comprehension of the patterns and processes of agricultural differentiation. Inquiry still tends to resolve around such fundamental questions as:

1) How essentially dissimilar are the diverse agricultural landscapes of the earth?
2) Do dissimilar agricultural landscapes reflect generic forms of agriculture?
3) What kinds of criteria best serve to isolate generic differences in agriculture?
4) Where, how, and under what conditions did various kinds of agriculture originate and develop?
5) What changes are taking place in the nature and practice of world agriculture?

In essence these questions are directed to the central but unresolved issues of how many specific kinds of agriculture exist (or have existed), and how the observed facts of variable agricultural practice can be most effectively and realistically organized to distinguish them

1.2 CONCEPTS AND DEFINITIONS

The **term system** in this course refers to a recognizable assemblage of agricultural procedures and activities that can be distinguished as a functionally integrated pattern characterized by genetic and generic cohesion of elements, traits, technologies, procedures, and activities. Individual systems differ in the innovative development and employment of dissimilar sociocultural, technological, and operational methods brought to bear on the production and disposition of assemblages of plant and animal commodities.

In plural usage, **agricultural systems** refer to an orderly and loosely evolutionary, hierarchical grouping of kinds of agricultural practices distinguished on the basis of a small number of universal, hence primary, genetic/generic criteria. The grouping forms an open-ended structuring that includes both the earliest procedures of the initial agricultural system (once plant and animal domestication had been achieved), and the most recent procedures now undergoing formulation into different and more complexly organized patterns.

Activity system is a combination of income generating activities at the household level. These activities can relate to farming (cropping, livestock rearing) or not (collection of Common Pool Resources (CPR), wage labour, self-employed or salaried agricultural occupation). It is perceived to be a system because the different income generating activities are inter-dependent and managed through a labour management strategy established at the family level.

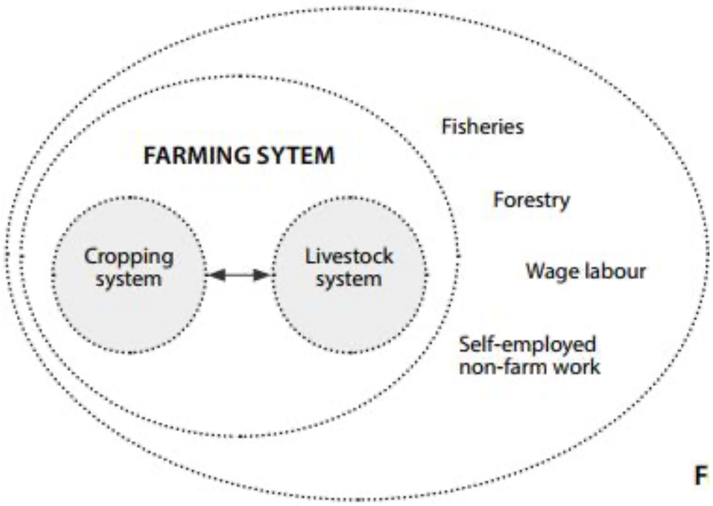


Figure 1. Representation of an activity system

Agrarian system is a theoretical expression of a historically constituted and geographically localized type of agriculture, composed of a cultivated ecosystem and a specific social production system comprising people, social relations and institutions.

Agro-ecological zone (AEZ) refers to a division of territory that has similar characteristics defined in terms of climate, landform, soils and land cover, and that has a specific range of potentials and constraints for land use (FAO 1996). An agroecological zone is the constitutive element of the agrarian system. It is not limited to agricultural land uses, and can also consist of forest, wetlands, grazing area, and so on, or a combination of several land uses (e.g agro- forestry and agro-fishing). An agro-ecological zoning refers to the process of delineating the agro-ecological zones.

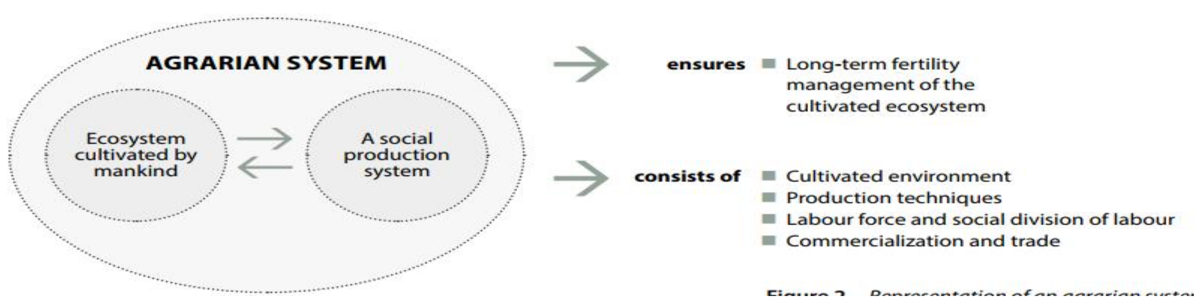


Figure 2. Representation of an agrarian system

Common pool resources (CPR) activities relate to the collection and use of natural resources that are part of a resource base shared by a group of people, whether this resource is managed collectively by this group of people, by the State or is under any other forms of management.

Cropping system includes the crops planted, crop sequences, and all of the techniques applied to them following a specific organization and under given soil and climate conditions.

Family farming is an organized agricultural, forestry, fisheries, pastoral and aquaculture production which is managed and operated by a family and is predominantly reliant on family labour. The family and the farm are linked, co-evolve and combine economic, environmental, reproductive, social and cultural functions.

Farming system is conceptualized as an organized combination of production factors and activities geared towards agricultural production (both cropping and livestock) directed to self subsistence and to sale. An examination of a farming system includes the study of relations existing between different elements of the system, notably the organization and distribution of family labour between the different production activities as well as relations between the different cropping and livestock systems.

Farming systems typology is a classification of farming systems based on differences in farm size (land area, size of herds, level of mechanization, and so on) and on the technical characteristics of the current cropping and livestock rearing systems. The farming systems typology is based on the differentiation processes between families in response to recent history.

Livestock rearing system integrates aspects relating to the herd structure (genetic characteristics, population pyramid, sex ratio, and so on), its feeding and the corresponding forage calendar, as well as herd management (movement, reproduction and care among other issues). Aquaculture (fish raising activities) is considered and conceived as a livestock rearing system.

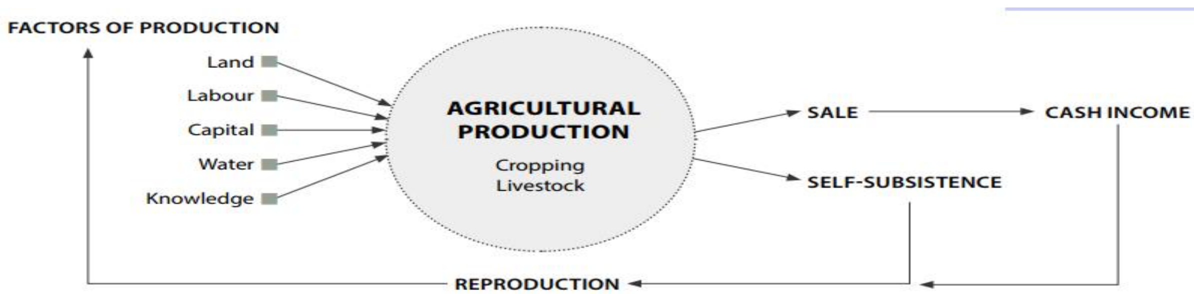


Figure 3. Representation of a farming system

Non-farm activities are conducted by any members of the family outside of the farming sector or sector related to the collection and processing of common pool resources (timber and non-timber forest products and capture fisheries). They include different types of employment: self-

employment (own entrepreneur, taxi driver, and handicrafts and so on); salaried jobs (implying that the job is registered); or wage-labour.
Non-farm activities might or might not include migration.

Off-farm activities include agricultural wage labour activities.

The realization of prime importance of staple food production for achieving food security for future generations has brought the concept of “Sustainable Agriculture” to the forefront and began to take shape in the following three points.

1. **The inter-relatedness of all the farming systems including the farmer and the family.**
2. **The importance of many biological balances in the system.**
3. **The need to maximize desired biological relationships in the system and minimize the use of materials and practices that disrupt these relations.**

Sustainability of agricultural systems has become a global concern today and many definitions to Sustainable Agriculture have become available.

A broad and commonly accepted definition of sustainable Agriculture is as follows: Sustainable Agriculture refers to an agricultural production and distribution system that:

- Achieves the integration of natural biological cycles.
- Protects and renews soil fertility and the natural resource base.
- Reduces the use of non-renewable resources and purchased (external or off-farm) production input.
- Optimizes the management and use of on- farm inputs.
- Provides on adequate and dependable farm income
- Promotes opportunity in family farming and farm communities, and
- Minimizes adverse impacts on health, safety, wildlife, water quality and the environment

CHAPTER TWO

2.1 HISTORY OF AGRICULTURE

Agriculture is the most comprehensive word used to denote the many ways in which crop plants and domestic animals sustain the global human population by providing food and other products. The English word agriculture derives from the Latin ***ager*** (field) and ***colo*** (cultivate) signifying, when combined, the Latin ***agricultura***: field or land tillage. But the word has come to subsume a very wide spectrum of activities that are integral to agriculture and have their own descriptive terms, such as cultivation, domestication, horticulture, arboriculture, and vegeculture, as well as forms of livestock management such as mixed crop-livestock farming, pastoralism, and transhumance.

Also, agriculture is frequently qualified by words such as incipient, proto, shifting, extensive, and intensive, the precise meaning of which is not self-evident. Many different attributes are used too to define particular forms of agriculture, such as soil type, frequency of cultivation, and principal crops or animals. The term agriculture is occasionally restricted to crop cultivation excluding the raising of domestic animals, although it usually implies both activities. The Oxford English Dictionary (1971) defines agriculture very broadly as "***The science and art of cultivating the soil, including the allied pursuits of gathering in the crops and rearing live stock; tillage, husbandry, farming (in the widest sense).***"

The history of agriculture records the **domestication of plants and animals and the development and dissemination of techniques for raising them productively**. Agriculture began independently in different parts of the globe, and included a diverse range of taxa. At least **eleven** separate regions of the Old and New World were involved as independent centers of origin. Wild grains were collected and eaten from at least 20,000 BC. From around 9500 BC, the eight **Neolithic founder crops – emmer wheat, einkorn wheat, hulled barley, peas, lentils, bitter vetch, chick peas, and flax –** were cultivated in the Levant. Rye may have been cultivated earlier but this remains controversial. Rice was domesticated in China by 6200 BC with earliest known cultivation from 5700 BC, followed by mung, soy and azuki beans. Pigs were domesticated in Mesopotamia around 11,000 BC, followed by sheep between 11,000 BC and 9000 BC. Cattle were domesticated from the wild aurochs in the areas of modern Turkey and Pakistan around 8500 BC. Sugarcane and some root vegetables were domesticated in New Guinea around 7000 BC. Sorghum was domesticated in the Sahel region of Africa by 5000 BC. In the Andes of South America, the potato was domesticated between 8000 BC and 5000 BC, along with beans, coca, llamas, alpacas, and guinea pigs. Bananas were cultivated and hybridized in the same period in Papua New Guinea. In Mesoamerica, wild teosinte was domesticated to maize by 4000 BC. Cotton was domesticated in Peru by 3600 BC. Camels were domesticated late, perhaps around 3000 BC.

The Bronze Age, from c. 3300 BC, witnessed the intensification of agriculture in civilizations such as Mesopotamian Sumer, ancient Egypt, the Indus Valley Civilisation of South Asia, ancient China, and ancient Greece. During the Iron Age and era of classical antiquity, the expansion of ancient Rome, both the Republic and then the Empire, throughout the ancient Mediterranean and Western Europe built upon existing systems of agriculture while also establishing the manorial system that became a bedrock of medieval agriculture.

In the Middle Ages, both in the Islamic world and in Europe, agriculture was transformed with improved techniques and the diffusion of crop plants, including the introduction of sugar, rice, cotton and fruit trees such as the orange to Europe by way of Al-Andalus. After the voyages of Christopher Columbus in 1492, the Columbian exchange brought New World crops such as maize, potatoes, sweet potatoes, and manioc to Europe, and Old World crops such as wheat, barley, rice, and turnips, and livestock including horses, cattle, sheep, and goats to the Americas.

Irrigation, crop rotation, and fertilizers were introduced soon after the Neolithic Revolution and developed much further in the past 200 years, starting with the British Agricultural Revolution. Since 1900, agriculture in the developed nations, and to a lesser extent in the developing world, has seen large rises in productivity as human labour has been replaced by mechanization, and assisted by synthetic fertilizers, pesticides, and selective breeding. The Haber-Bosch process allowed the synthesis of ammonium nitrate fertilizer on an industrial scale, greatly increasing crop yields. Modern agriculture has raised social, political, and environmental issues including water pollution, biofuels, genetically modified organisms, tariffs and farm subsidies. In response, organic farming developed in the twentieth century as an alternative to the use of synthetic pesticides.

Adverse effects of modern high- input agriculture

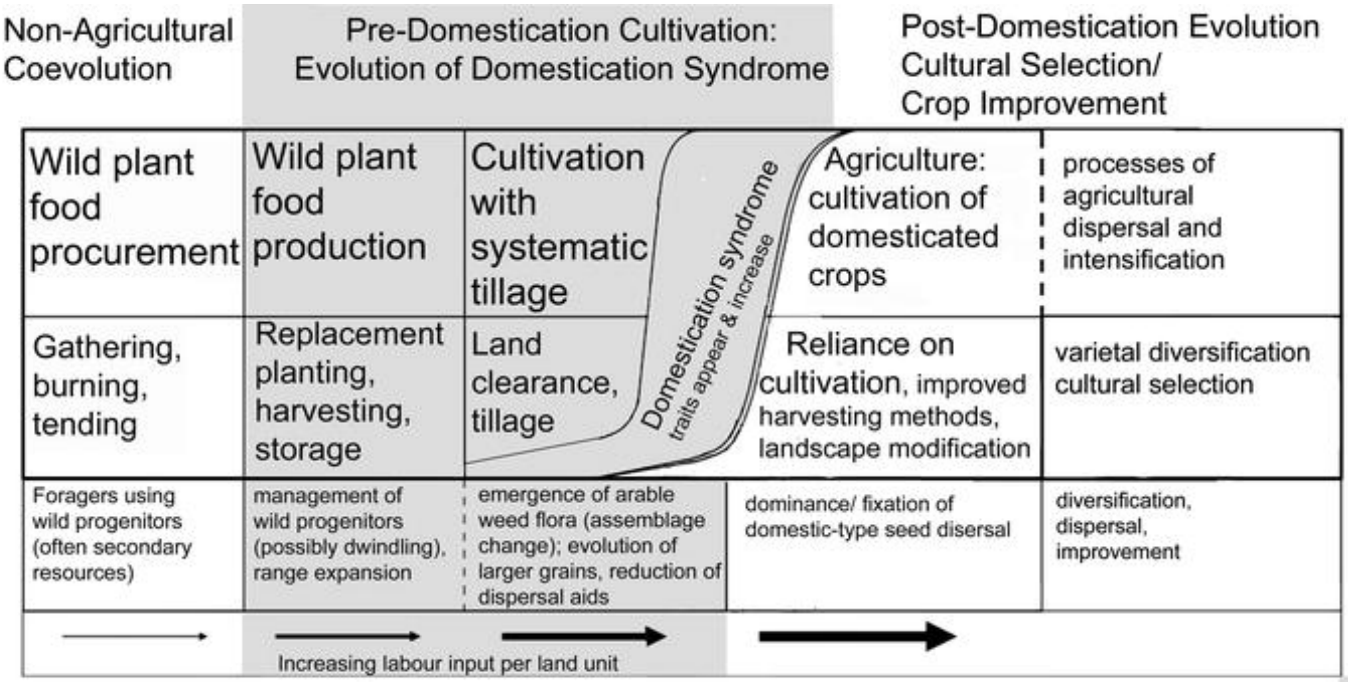
- Overuse of natural resources, causing depletion of groundwater, and loss of forests, wild habitats, and of their capacity to absorb water, causing waterlogging and increased salinity:
- Contamination of the atmosphere by ammonia, nitrous oxide, methane and the products of burning, which play a role in ozone depletion, global warming and atmospheric pollution:
- Contamination of food and fodder by residues of pesticides, nitrates and antibiotics.
- Contamination of water by pesticides, nitrates, soil and livestock water, causing harm to wildlife, disruption of ecosystems and possible health problems in drinking water;
- Buildup of resistance to pesticides in pests and diseases including herbicide resistance in weeds

- Damage of farm and natural resources by pesticides, causing harm to farm workers and public, disruption of ecosystems and harm to wildlife.
- Erosion of genetic diversity – the tendency in agriculture to standardize and specialize by focusing on modern varieties, causing the displacement of traditional varieties and breeds:
- New health hazards for workers in the agrochemical and food processing industries

Added to the above adverse effects the increasing human as well as cattle population, is imposing intense pressure on available natural resources. Accordingly, a challenge has emerged that required a new vision, holistic approaches for ecosystem management and renewed partnership between science and society.

In the published literature on early agriculture, there is a tendency for the word agriculture and many of its subsidiary terms to be used vaguely without precise definition, and sometimes their connotations overlap, for example, proto/incipient and shifting/extensive. There is need to clarify much agricultural terminology to avoid confusion, particularly because the multidisciplinary nature of research on the subject leads to many concepts being used that derive from disparate disciplines; principally archaeology, anthropology, biogeography, genetics, linguistics, and taxonomy. In this course, we cannot review comprehensively all the typological terms currently used in discussions of the origins and early development of agriculture. Instead we focus on the two most fundamental processes that led to agriculture, **cultivation and domestication (of plants and animals)**, and then comment on some of the terms used to denote particular categories of agricultural production

This approach, leading from consideration of cultivation through domestication to agriculture (Fig. 1), proposes that agriculture is **a form of land use and economy** that resulted from the combination of cultivation (a bundle of human actions focused on preparing soil and planting, tending, and harvesting plants) and domestication (a bundle of genetic and morphological changes that have increased the ability of plants to adapt to cultivation). Cultivation and domestication are related as cause and effect, a change in human strategy with consequences in genetic adaptations of another organism, which increased the interdependencies of both.



Agriculture: Definition and Overview, Fig. 1

An evolutionary model from foraging to agriculture, in which the transitions to cultivation, domestication.

Assignment: Elaborate on the history of agriculture highlighting, green revolution, organic agriculture and GMOs.

Cultivation

Cultivation is an activity through which humans become directly involved in the management of the lives and life cycles of certain plants. In abstract terms, this can be considered a change from a largely extractive approach to subsistence (collecting) towards a highly regulative one, with seasonal scheduling of labor for delayed returns and storable product. In practice, cultivation involves manipulation of soil, water, and other components of the plant environment. At its most basic, it involves sowing of seeds on soil which has been cleared of other vegetation. In low-intensity systems, this may come about through burning of vegetation (slash and burn) or by taking advantage of fresh deposits of silt by river floods (e.g., *décrue* agriculture). It usually involves preparation of the soil by tillage. Tillage methods and tools vary from simple handheld devices (digging sticks, spades, hoes) to team-employed tools, such as the Andean "foot-plough," to animal-powered ards and true ploughs. Other important variables include the addition of nutrients to the soil by such means as manuring, multiple cropping with nitrogen-fixing species (usually legumes of the family Fabaceae), or using crop rotations with legumes or fallow periods. This represents an important component of cultivation, i.e., scheduling the seasons of sowing and harvesting and interannual patterns in crop rotation and fallowing.

Domestication

Domestication is most clearly defined as a biological phenomenon, that is, by traits in crops that result from adaptation to cultivation and by which they differ from close wild relatives. Several recurrent "domestication syndromes" can be recognized as sets of characters that define domesticated crops and characterize domestication as a form of convergent evolution under cultivation. The domestication syndrome differs for different kinds of crop plants, according primarily to how they are reproduced, by seed or by cuttings, and what plant organ is the target of selection (grain, fruit, tuber).

The best defined domestication syndrome is that for grain crops, including cereals, pulses, and oilseeds. While all of these traits are the product of cycles of harvesting and sowing from such harvests, the actual selection pressures seem to come from two different aspects of cultivation. First are some traits selected for by harvesting and the crops' growing reliance on humans for seed dispersal. Second are traits that relate to soil conditions, as tilled fields are essentially early successional communities on empty soil, which is generally loose and allows deeper burial of seeds. Although there are six essential syndrome traits in seed crops, only the first four have some chance of archaeobotanical preservation in some species.

i. The elimination of natural seed dispersal, such as through non-shattering rachis in cereals and non-dehiscent pod in pulses and oilseeds. This is often regarded as the single most important domestication trait as it makes a species dependent upon the farmer for survival.
ii. Reduction in aids to wild seed dispersal. Plants often have a range of structures that aid seed dispersal, including hairs, barbs, awns, and even the general shape of the spikelet in grasses. Thus domesticated wheat spikelets are less hairy, have shorter or no awns, and

are plump, whereas in the wild they are heavily haired, barbed, and aerodynamic in shape.

iii. Synchronous tillering and ripening, sometimes including a shift from perennial to annual. Planting at one time and harvesting at one time will favor plants that grow in synchronization.

iv. More compact growth habit with apical dominance, such as a reduction in side branching and denser spikes or seed heads. In some species, such as in several pulses, this involved a shift from a climbing habit to self-standing. Harvesting methods, like those that select for non-shattering types, can also favor plants with single and compact parts to be harvested.

v. Loss of germination inhibition. In the wild, many seeds will only germinate after certain conditions have passed – conditions of day length and temperature – or after the seed coat is physically damaged. In wild legumes, for example, this may mean that 90 % of seeds will fail to germinate.

CHAPTER THREE

3.1 Types of agriculture

3.1.1 Organic farming

Organic farming, also known as ecological farming or biological farming, is an agricultural system that uses fertilizers of organic origin such as compost manure, green manure, and bone meal and places emphasis on techniques such as crop rotation and companion planting. Organic farming is a new agricultural production system **involves locally and naturally available organic materials or agro-inputs to meet out the production system without endangering our precious natural resources**. In organic farming, the nutritional demands of crop are met out mainly through on farm organic wastes, biofertilizer, green manure crop and vermicompost. The excess use of chemical fertilizers has deleterious effect leading **to decline in the productivity of crops resulting in non-availability of micronutrients,** which has become a serious threat to the environment. Organic agriculture is an important step of production methods and are supportive of environment. Organic manure works as inducer in nature and generally determined in terms of physical, chemical and biological properties of soil and crop growth. The advantages of organic manure are many and varied.

Modern organic farming was developed as a response to the environmental harm caused by the use of chemical pesticides and synthetic fertilizers in conventional agriculture, and it has numerous ecological benefits. Compared with conventional agriculture, organic farming uses fewer pesticides, reduces soil erosion, decreases nitrate leaching into groundwater and surface water, and recycles animal wastes back into the farm. These benefits are counterbalanced by higher food costs for consumers and generally lower yields. Indeed, yields of organic crops have been found to be about 25 percent lower overall than conventionally grown crops, although this can vary considerably depending upon the type of crop. The challenge for future organic agriculture will be to maintain its environmental benefits, increase yields, and reduce prices while meeting the challenges of climate change and an increasing world population.

Regulation in organic farming

Organic agriculture is defined formally by governments. Farmers must be certified for their produce and products to be labeled "organic," and there are specific organic standards for crops, animals, and wild-crafted products and for the processing of agricultural products. Organic standards in the European Union (EU) and the United States, for example, prohibit the use of synthetic pesticides, fertilizers, ionizing radiation, sewage sludge, and genetically engineered plants or products. In the EU, organic certification and inspection is carried out by approved organic control bodies according to EU standards.

Organic matter forms an important part of soil environment. Therefore, nutrients can be supplied to the soil as well as to the crop too through various organic manures and microbial bioinoculants.

Composting is a natural way of recycling of solid waste. They supply balanced nutrients to plant roots and stimulate growth by increasing organic matter content of the soil. Different organic sources like **vermicompost** and **green compost** are rich in nutrient content which are the better sources for sustainable production by enhancing the crop yield and growth.

vermicompost is one of the best sources of nutrients improves the physical and chemical properties of crops. Due to absence of toxic enzymes, it is also eco-friendly and has beneficial effect on the biochemical activities of the soil. It also increases the quality, fertility, mineral content of the soil structure and at the same time enhances soil aeration, texture and tilt thereby reducing soil compaction. It also build up water retention capacity of soil because of its high organic matter content and promotes root growth and nutrient absorption. **Green manure** is one of the significant sources of nutrient supply for organic crops. They improve the physical properties of soil by supplying plant nutrients and promote the biological properties of the soil. Use and management of crop residues and green manures are becoming an increasingly important aspect of environmentally sound sustainable agriculture.

Green manuring is a cheap and effective way of improving soil fertility and can be a boon to poor/marginal farmers who cannot afford to use chemical fertilizers due to its high cost.

Bioinoculants or microbial inoculum enhance the process of composting and enrich nutrient content to the soil. Biofertilizers combined with organic manure influences the plant growth by **enhancing root biomass, total root surface facilitates higher absorption of nutrients and increase in yield by reducing consumption of natural sources of energy**.

Summary

Organic 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. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved.

Fig. 4. Overview of organic farming practices

3.1.2 Conservation agriculture

Conservation Agriculture is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment" (FAO 2008). Conservation Agriculture (CA) is defined as a sustainable agriculture production system comprising a set of farming practices adapted to the requirements of crops and local conditions of each region, whose farming and soil management techniques protect the soil from erosion and degradation, improve its quality and biodiversity, and contribute to the preservation of the natural resources, water and air, while optimizing yields.

Agronomic practices included in CA are based on three core principles, which must be fulfilled concomitantly:

- Minimum soil disturbance.
- Maintenance of permanent soil covers.
- Cropping system diversity, crop rotations.

The first key principle in CA is practicing minimum mechanical soil disturbance which is essential to maintaining minerals within the soil, stopping erosion, and preventing water loss from occurring within the soil. The second key principle in CA is much like the first principle in dealing with protecting the soil. The principle of managing the top soil to create a permanent organic soil cover can allow for growth of organisms within the soil structure. This growth will break down the mulch that is left on the soil surface. The breaking down of this mulch will produce a high organic matter level which will act as a fertilizer for the soil surface. The third and final principle that is exercised by the FAO is the practice of crop rotation with more than two crop species. This process will not allow pests such as insects and weeds to be set into a rotation with specific crops. Rotational crops will act as a natural insecticide and herbicide against specific crops.

Some concepts related to CA include:

I. **No tillage**: No tillage (NT) is a CA agronomic practice for annual crops, and is defined as a way to farm without disturbing the soil through tillage. NT must leave at least 30% of area covered by plant residues right after crop establishment, and crops are sown using a machinery which is able to place seeds through plant residues from previous crops. The agronomic practice that best characterizes CA for annual crops is NT, which has the highest degree of soil conservation in annual crops, since the mechanical tillage of the ground is completely suppressed.

II. **Groundcovers**: Groundcovers (GC) is the most widely used CA agronomic practice for perennial crops, whereby the soil surface between rows of trees remains protected against erosion. With this technique, at least 30% of the soil not covered by the canopy is protected either by sown cover crops, spontaneous vegetation or inert covers, such as pruning residues or tree leaves. For the establishment of sown cover crops and the spread of inert covers, farmers must use methods in coherence with CA principle of minimum soil disturbance.

Fig 5. Conservation agriculture

3.1.3 Precision agriculture

Precision Farming is a new technology that allows farmers to look at their fields more site specifically than before and apply inputs in a manner more specific than a blanket application. Precision agriculture (PA) is a farming management concept based on observing, measuring and responding to inter- and intra-field variability in crops. PA is also sometimes referred to as **precision farming, satellite agriculture**, as-needed farming and **site-specific crop management** (SSCM). This technology saves money while holding or enhancing yield output of the field. Environmental pollution is also be reduced using this method. Precision agriculture uses ICT to cover the three aspects of production namely for data collection of information input through options as Global Positioning System (GPS) satellite data, grid soil sampling, yield monitoring, remote sensing, etc; for data analysis or processing through Geographic Information System

(GIS) and decision technologies as process models, artificial intelligence systems, and expert systems; and for application of information by farmers.

Precision agriculture is a principle of management of agricultural plots which aims to optimize yields and investments, by seeking to better take into account environmental variabilities and conditions between different plots as well as at intra-plot scales.

Benefits of PA.

After data is collected, predictive analytics software uses the collected data to provide farmers with guidance about crop rotation, optimal planting times, harvesting times and soil management.

Agricultural control centers can integrate sensor data and imaging input with other data to provide farmers with the ability to identify fields that require treatment and determine the optimum amount of water, fertilizers and pesticides to apply.

This helps the farmer avoid wasting resources and prevent run-off, ensuring that the soil has just the right number of additives for optimum health while also reducing costs and controlling the farm's environmental impact.

3.1.4 Sustainable agriculture

Sustainable Agriculture refers to the ability of a farm to produce food indefinitely, without causing severe or irreversible damage to ecosystem health. Sustainable agriculture is farming in sustainable ways meeting society's present food and textile needs, without compromising the ability for current or future generations to meet their needs. It can be based on an understanding of ecosystem services.

Two key issues are biophysical (the long-term effects of various practices on soil properties and processes essential for crop productivity) and socio-economic (the long-term ability of farmers to obtain inputs and manage resources such as labor). SA integrates three main goals: environmental stewardship, farm profitability, and prosperous farming communities.

Others (Browse for more information)

Urban agriculture/peri-urban agriculture

Industrial agriculture

Slash and burn agriculture

Conventional agriculture

Specialized Types of Livestock Management and Crop Production

Mixed Crop-Livestock Farming

One of the most significant variables in the historical differentiation of agricultural systems is whether domestic livestock were fully integrated with the processes of crop cultivation as beasts of burden and agents of soil fertilization as well as producers of food. Such systems of "mixed farming" or "agropastoralism" developed early in only a few regions. They did so most comprehensively in Southwest Asia (and later in Europe) where domesticated herd animals – cattle, sheep, goats, and pigs – were raised in close conjunction with wheat, barley, and other cereal and pulse crops as producers of meat, milk, hides, hair, wool, and dung and as traction animals used for ploughing, load-bearing, and other purposes.

In other regions of early agriculture where domestic herd animals were present, they were not fully integrated with crop cultivation as providers of food, fertilizer, and traction. Thus, in northern tropical Africa, cattle, camels, sheep, and goats, and in the Andean region of South America camelids (llama and alpaca), were not fully incorporated into indigenous systems of cereal, pulse, and root-crop cultivation.

Pastoralism

The full incorporation of domestic herd animals into systems of mixed farming requires permanent facilities such as barns, sheds, stalls, fenced fields, and other enclosures for confining the animals and controlling their movements. This contrasts with pastoral systems that are characterized by more mobile methods of management. The term pastoralism derives from the Latin *pastor*, meaning a herdsman or shepherd, and it applies to mobile systems in which the herd animals, principally sheep, goats, cattle, horses, donkeys, camels, llamas, alpacas, and reindeer, are raised to provide food and other products and as pack and riding animals. The essence of pastoralism is that people move with their animals. The spatial and temporal scales of their movements range from short daily movements of flocks and herds to and from pastures near their owners' settlements (diurnal grazing) to longer seasonal movements by part of the local community with their animals to higher and/or more distant pastures (transhumance), to the most fully mobile system in which families migrate from pasture to pasture with their herds throughout the year and from year to year (nomadic pastoralism). Nomadic pastoralists own and largely depend on their animals, although they have historically obtained some of their food and other supplies by trading with or raiding settled agricultural communities. In fact, all nomadic pastoralists depend to some degree on crop products for their food and often also for supplementary fodder for their animals.

Horticulture

Horticulture has two contrasted connotations in the literature on traditional agricultural systems and the origins of agriculture. The first relates directly to the origin of the word from the Latin *hortus*, meaning garden (juxtaposed to *ager*, field), and in this literal sense it refers to the cultivation of plots of land adjacent or quite close to the houses of the cultivators. Such gardens are normally smaller than fields, which are usually located farther from their associated settlements. A greater variety of plants, especially perennial shrubs and trees, tend to be cultivated in gardens than in fields, which are commonly devoted to one or only a few types of crop. Also, whereas most fields are cultivated in seasonal cycles, gardens are usually tended continuously, especially in the tropics where long growing periods favor year-round production.

Arboriculture

The term arboriculture, from *arbor* the Latin for tree, is used to specify agricultural systems focused exclusively or largely on the cultivation of trees and shrubs for the production of fruits and seeds and, in some species, also for ancillary products such as wood for construction and leaves for thatch, fiber, etc. The term, which is sometimes equated with agroforestry (see above), refers mainly to the specialized cultivation of fruit- and nut-bearing trees and shrubs in single- or mixed-species orchards and plantations. It can refer also to plantations of trees for timber production, although this process is more usually described as forestry.

Arboriculture differs from horticulture in that the plants are grown in less floristically diverse communities on larger landholdings.

Vegeculture

The word vegeculture is used to describe agricultural systems that produce mainly root and tuber crops with underground storage organs consisting of starch-rich roots, root and stem tubers, corms, and rhizomes. The crops are reproduced asexually by planting pieces of a parent plant such as parts of tubers, stem cuttings, or sprouts, rather than being grown from seed.

Agriculture as Landscapes of Food Production

The beginnings of food production represent a strategic shift in human behavior, towards the manipulation of the soil environment and through an influence on the composition of plant populations grown in that soil, via preferential seeding and tending of one or a few species. While cultivation may involve a range of practices, and these will tend to select for morphological domestication, at least in seed crops, we can define agriculture in relation to the scale of cultivation, its prominence in local landscapes and in contributing a major component of human diet. In this sense, *agriculture* is the form of land use that represents a *change in the landscape*, as people regularly cultivate, raise, and focus more attention on domestic plants and/or animals. Agriculture creates fields for larger-scale production of crops and livestock. While small-scale cultivation may involve a few plants, agriculture involves the creation of substantial fields of sown vegetation on such a scale that it should, in principle, be recognizable in regional palaeovegetation datasets, recoverable from palaeosols, and a prominent part of the inferred source of archaeological plant remains. How one distinguishes agriculture from small-scale cultivation varies according to the parameters of particular geographical and cultural contexts.

Irrigation systems are one notable and widespread way in which distinctive landscapes of agriculture have been created. Control of water can be focused either on its removal (drainage) or by adding water to otherwise locally dry areas to allow cultivation where rainfall is insufficient to enhance productivity. In riverine agriculture, such as that associated with ancient Mesopotamia and Egypt, this took the form of canals and basins that helped to conserve floodwater and distribute it more evenly and widely. In some mountain environments, such as the Andes, canal systems, often closely associated with cultivated terraces, were also developed to bring steep slopes into agricultural production.

CHAPTER FOUR

3.1 PRINCIPLES OF FARMING SYSTEMS ANALYSES

3.1.1 INTRODUCTORY CONCEPTS

According to Dixon *et al.* (2001) and Köbrich *et al.* (2003), a **farming system** is defined as a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate. However, there is a wide diversity of farming systems among a group of farms, not only on a large-scale in terms of geographic space but also within restricted rural areas or more oriented types of these systems

Survey sampling is the selection of a subset of units from a finite population, from which information may be obtained such as information on crop production, livestock inventories, and other economic, environmental and social measures. Estimators based on the sample design convert the sample data to the universe being measured.

The method applied in selecting a sample of units to measure items of interest is relevant to the survey's inference capabilities. Before the sample selection procedure can be performed, several choices pertaining to methodology and definitions require knowledge of certain basic concepts. These are:

• **Population or target population**

A population, or target-population, is the finite set of all elementary units [sampling units] about which information is sought. Depending on the survey's goals, the elementary units, or simply the elements of a population, may assume different forms. Three typical elements are: holdings or farms, holders or farmers, and households or dwellings. In addition to the nature of its elements, defining a population requires identification of a place and a point in time. The set of all holders of a province in 2021, and the set of all households of a region in a given year are examples of populations.

• **Subpopulation**

Multi-purpose aspects of agricultural surveys may require estimates for subpopulations of interest. These are specific subsets of elementary units for which inferences are required. For example, if maize production is an item of interest, then inferences for the subpopulation of holdings with maize production from irrigated lands may be necessary.

• **Variables of interest**

The variables of interest are characteristics that relate to each item of interest and are measured for each element of the population. If maize is an item of interest, then the area, yield, and production of maize are examples of variables of interest that would be measured for each farmer of a population. If income is an item of interest, then income from crops and livestock are examples of variables of interest that would also be measured from each farmer or household.

• **Parameters**

Parameters are numerical characteristics relating to each item of interest that are aggregated over the population's elements. Usually, they are summaries of the values of the variables of interest, taken over all the population elements. The average crop yields, the total area cultivated for a specific crop, or the percentage of farms using a certain type of transportation are all examples of parameters of interest for a survey.

The concepts of variables of interest and parameters of interest are related. A variable of interest is a specific data item to be collected for each population element. For example, if a census is carried out, the aggregated values of the variables of interest for the whole population are parameters.

• **Sampling unit**

Sampling units can be an element or a set of elements from the target population, identified through the frame. The sample unit is the basic frame unit component that can be directly selected by a randomization process, leading to the sample selection. If multiple stages of sampling are necessary, a sample unit will be associated to each sample stage. Sampling units defined for the first stage are the PSUs; sampling units of the second stage are called SSUs, and so forth.

• **Observation unit**

While sampling units are randomly selected frame component units, observation units are the units on which the measurement procedure is applied. Sometimes, sampling and observation units are the same. In area sampling, for example, sampling units can be segments of land, while observation units can be: i) the segment of land if objective measurements are to be taken.

• **Reporting unit**

Reporting units can be defined as the units that report the required data concerning population elements. If such data come from direct measurements, the reporting and observation units are the same. However, they commonly differ from each other when, for example, a farmer is asked for a subjective estimate of his production on a certain type of crop. In this case, the farmer is the reporting unit that provides information about the farm (observation unit).

Probability Sample Vs Non-Probability Sample

There are two main methods of sampling: **Probability sampling and non-probability sampling**. In probability sampling, respondents are randomly selected to take part in a survey or other mode of research. For a sample to qualify as a probability sample, each person in a population must have an equal chance of being selected for a study, and the researcher must know the probability that an individual will be selected. Probability sampling is the most common form of sampling.

Non-probability sampling is when a sample is created through a non-random process. This could include a researcher sending a survey link to their friends or stopping people on the street. This type of sampling would also include any targeted research that intentionally samples from specific lists. Non-probability samples are often used during the exploratory stage of a research project, and in qualitative research, which is more subjective than quantitative research, but are also used for research with specific target populations in mind, such as farmers that grow maize.

Generally speaking, non-probability sampling can be a more cost-effective and faster approach than probability sampling, but this depends on a number of variables including the target population being studied. Certain types of non-probability sampling can also introduce bias into the sample and results. For general population studies intended to represent the entire population of a country or state, probability sampling is usually the preferred method.

Types Of Probability Sampling

There are several sampling methods that fall under probability sampling. In each method, those who are within the sample frame have some chance of being selected to participate in a study. Four of the common types of probability sampling are:

Simple Random Sample: The most basic form of probability sampling, in a simple random sample each member of a population is assigned an identifier such as a number, and those selected to be within the sample are picked at random.

Stratified Random Sample: A stratified random sample is a step up from complexity from a simple random sample. In this method, the population is divided into sub-groups, such as male and female, and within those sub-groups a simple random sample is performed. This enables a random sample that is representative of a larger population and its specific makeup, such as a country's population.

Cluster Sample: In cluster sampling, a population is divided into clusters which are unique, yet represent a diverse group – for example, villages are often used as clusters. From the list of clusters, a select number are randomly selected to take part in a study.

Systematic Sample: Using a systematic sample, participants are selected to be part of a sample using a fixed interval. For example, if using an interval of 5, the sample may consist of the fifth, 10th, 15th, and 20th, and so forth person on a list.

SAMPLE SIZE

Sample size is a frequently-used term in statistics and research, and one that inevitably comes up whenever you're surveying a large population of respondents. It relates to the way research is conducted on large populations.

When you survey a large population of respondents, you're interested in the entire group, but it's not realistically possible to get answers or results from absolutely everyone. So you take a random sample of individuals which represents the population as a whole.

The size of the sample is very important for getting accurate, statistically significant results and running your study successfully.

- If your sample is too small, you may include a disproportionate number of individuals which are outliers and anomalies. These skew the results and you don't get a fair picture of the whole population.
- If the sample is too big, the whole study becomes complex, expensive and time- consuming to run, and although the results are more accurate, the benefits don't outweigh the costs.

To choose the correct sample size, you need to consider a few different factors that affect your research, and gain a basic understanding of the statistics involved. You'll then be able to use a sample size formula to bring everything together and sample confidently, knowing that there is a high probability that your survey is statistically accurate.

The steps that follow are suitable for finding a sample size for continuous data – i.e. data that is counted numerically. It doesn't apply to categorical data – i.e. put into categories like green, blue, male, female etc.

Stage 1: Consider your sample size variables

Before you can calculate a sample size, you need to determine a few things about the target population and the level of accuracy you need:

I. **Population size**

How many people are you talking about in total? To find this out, you need to be clear about who does and doesn't fit into your group. For example, if you want to know about home gardens, you'll include everyone who has at some point owned a home garden. (You may include or exclude those who owned a home garden in the past, depending on your research goals.) Don't worry if you're unable to calculate the exact number. It's common to have an unknown number or an estimated range.

II. **Margin of error (confidence interval)**

The question is how much error you'll allow. The margin of error (confidence interval), is expressed in terms of mean numbers. You can set how much difference you'll allow between the mean number of your sample and the mean number of your population. It's expressed like this: "68% of participants said yes to Proposition Z, with a margin of error of +/- 5%."

III. **Confidence level**

This is a separate step to the similarly-named confidence interval in step 2. It deals with how confident you want to be that the actual mean falls within your margin of error. The most common confidence intervals are 90% confident, 95% confident, and 99% confident.

IV. **Standard deviation**

This step asks you to estimate how much the responses you receive will vary from each other and from the mean number. A low standard deviation means that all the values will be clustered around the mean number, whereas a high standard deviation means they are spread out across a much wider range with very small and very large outlying figures. Since you haven't yet run your survey, a safe choice is a standard deviation of .5 which will help make sure your sample size is large enough.

Stage 2: Calculate sample size

Now that you've got answers for steps 1 – 4, you're ready to calculate the sample size you need.

V. **Find your Z-score**

Next, you need to turn your confidence level into a Z-score. Here are the Z-scores for the most common confidence levels:

- 90% – Z Score = 1.645

- 95% – Z Score = 1.96
- 99% – Z Score = 2.576

VI. Use the sample size formula

Here's a worked example, assuming you chose a 95% confidence level, 0.5 standard deviation, and a margin of error (confidence interval) of +/- 5%.

$$\text{Necessary Sample Size} = \frac{(\text{Z-score})2 \times \text{StdDev} \times (1\text{-StdDev})}{(\text{margin of error})2}$$

((1.96)2 x 0.5(0.5)) / (.05)2

(3.8416 x .25) / .0025

.9604 / .0025

384.16

385 respondents are needed

If the sample size is too big to manage, you can adjust the results by either

- decreasing your confidence level
- increasing your margin of error

This will increase the chance for error in your sampling, but it can greatly decrease the number of responses you need.

In case the population size is known, use:

$$\frac{\dfrac{z^2 \times p(1-p)}{e^2}}{1+\left(\dfrac{z^2 \times p(1-p)}{e^2 N}\right)}$$

Parameters:

- Population size= N
- Margin of Error = e
- Z-Score= z

- p= Standard Deviation

Types Of Non-Probability Sample

In non-probability sampling, those who participate in a research study are selected not by random, but due to some factor that gives them the chance of participating in a study that others in the population do not have. Types of non-probability sample include:

Convenience Sample: As its name implies, this method uses people who are convenient to access to complete a study. This could include friends, people walking down a street, or those enrolled in a university course. Convenience sampling is quick and easy, but will not yield results that can be applied to a broader population.

Snowball Sample: A snowball sample works by recruiting some sample members who in turn recruit people they know to join a sample. This method works well for reaching very specific populations who are likely to know others who meet the selection criteria.

Quota Sample: In quota sampling, a population is divided into subgroups by characteristics such as age or location and targets are set for the number of respondents needed from each subgroup. The main difference between quota sampling and stratified random sampling is that a random sampling technique is not used in quota sampling; For example, a researcher could conduct a convenience sample with specific quotas to ensure an equal number of males and females are included, but this technique would still not give every member of the population a chance of being selected and thus would not be a probability sample.

Purposive or Judgmental Sample: Using a purposive or judgmental sampling technique, the sample selection is left up to the researcher and their knowledge of who will fit the study criteria. For example, a purposive sample may include only PhD candidates in a specific subject matter. When studying specific characteristics this selection method may be used, however as the researcher can influence those who are selected to take part in the study, bias may be introduced.

Designing A Questionnaire

In a survey, the researcher uses a questionnaire to gather information from the respondents to answer the research questions. A questionnaire is a very convenient way of collecting information from a large number of people within a period of time. Hence, the design of the questionnaire is of utmost importance to ensure accurate data is collected so that the results are interpretable and generalisable. A bad questionnaire renders the results uninterpretable, or worse, may lead to erroneous conclusions.

A survey can come in many forms: postal survey, telephone interviews, face-to-face interviews and internet surveys. Each type of survey requires a slightly different design. A self-administered questionnaire (e.g. postal survey) should have very clear instructions and questions, follow a logical order and avoid complex filtering. The respondents are more likely to answer truthfully without prompting from an interviewer. On the other hand, in an interviewer-administered questionnaire (e.g. face-to-face interview or telephone interview), the questions can be more complex as they can be clarified by the interviewers. However, the presence of an interviewer may "pressurize" the respondents to give "appropriate" rather than truthful answers.

WHAT IS A GOOD QUESTIONNAIRE?

A good questionnaire should be valid, reliable, clear, interesting and succinct.

Valid: A valid questionnaire should ask what it intends to ask, i.e. the questions should be phrased in such a way that the respondent understands the objective of the question. To achieve this, the questionnaire should be reviewed by the "content expert" during the pilot test (e.g. if the target respondent is a potato farmer, then a potato farmer should comment whether he understands the questionnaire). Any uncertainties and queries should be clarified till the question is clearly understood.

Reliable

A reliable questionnaire should yield the same answer if the same question is posed to the respondent repeatedly in a short span of time. This can be achieved by performing a "test-retest", i.e. administer the same questionnaire to the respondent a second time and check for consistency of the answer. Any discrepancy in the answers could be due to lack of clarity of the questions and this should be reviewed and rephrased.

Interesting

An interesting questionnaire is more likely to be completed by the respondent and hence yields a better response rate. This requires the researcher to put some thoughts into asking questions that are relevant to the respondent and in a logical sequence.

Succinct

A succinct questionnaire asks questions that aim to answer only the research objectives. Any questions beyond the scope of the research should be excluded.

HOW TO DESIGN A GOOD QUESTIONNAIRE?

Developing a conceptual framework

The first step of designing of a good questionnaire is to construct a conceptual framework. The researcher needs to be very clear about his research questions and what "dependent" and "independent" factors he intends to investigate. The importance of this framework is to ensure the research covers all relevant variables and any irrelevant variables can be excluded. This will answer the commonly asked questions: "Did I miss any important questions in the questionnaire?", "Should I include/exclude this particular question?"

Asking the "right" questions

Now that you have developed the conceptual framework and you know exactly what questions you want to ask, it is time for you to design the questions in such a way that it is valid and reliable. The researchers have to brainstorm and come up with the preliminary questions.

Close- vs open-ended questions

These questions can be in the form of "close-ended" or "open-ended" questions. **"Close- ended"** questions provide options to the respondents and require them to choose one or more items from the list. **"Open-ended"** questions allow the respondent to express their opinions freely and they are not restricted by the options. The former is preferred if the range of answers are well known and the options are limited; the latter is preferred if the answer options are multiple and unknown. The answers to the open-ended questions require re- grouping before analysis.

Closed-ended questions

Did you experience higher temperatures in the past 2 years? _Yes _No

Open-ended questions

What is/are the methods you use to provide nutrients to your crops? (You can list down more than one method.

Filtering

Think of the last time you noticed fungal attack. Did you apply a fungicide? _Yes _No
If No, please go to Question 14.

Sensitive questions

It is common for people to chemical inputs. Do you apply chemical inputs to your crops? _Yes _No

Likert scale

We should always use chemical inputs to improve our yields. (Please circle the answer)

!- Strongly disagree 2- Disagee 3- Neutral 4- Agree 5- Strongly agree

"Double-barreled" questions

Did you notice soil degradation and reduced biodiversity with increasing use of chemicals and monocropping? _Yes _No

Should be:

Did you notice soil degradation with increasing use of chemicals? Yes _No

Did you notice reduced biodiversity with increasing monocropping? Yes _No

Ambiguous Questions

How often do you apply organic fertilizers? !- Not at all 2- Not very often 3- Sometimes 4- Quite often 5- Very often

Change to:

How many times did you apply organic fertilizer in the past 1 year? ---- times in the past 1 year

Options/choices

Design the questionnaire with analysis in mind

When designing a questionnaire, it is crucial to pre-empt what kind of method will be used to analyse the data collected. Take for example, age. If the objective of asking the age is to find out the mean age of the participants, then an exact age should be captured (e.g. "What is your age? (at your last birthday): _______ years).

Format

The final "touch-up" of the questionnaire is important because the "look" of the questionnaire may decide whether the respondent is going to fill it up. This is especially relevant for postal surveys. The **title should be highlighted** and it should reflect the main objective of the research. If possible, divide the questionnaire into sections according to the content (e.g. boxes with bold headings) and it should flow smoothly from one section to another with appropriate filtering. If your respondents involve older persons, bigger font size should be used. Finally, a cover letter stating the objective of your study, your affiliations, and, if appropriate, ensuring confidentiality and how you are going to use the information you have collected.

Pilot test

Pilot test is a crucial step in the design of questionnaire before data collection begins. It will help to detect flaws in the questionnaire in terms of content, grammar and format. First, ask your colleagues to comment on the questionnaire. This will pick up any mistakes in terms of content, grammar and format. This should be followed by asking the potential respondents to answer the questionnaire and provide their feedback.