1. AGRICULTURAL AND FARM SYSTEMS - CONCEPTS AND DEFINITIONS

'For an understanding, not only the elements but their interrelations as well are required.'
Ludwig von Bertalanffy (1973)

The first purpose of this introductory chapter is to develop a conceptual framework for the examination of the agro-economic structure of farm-level agricultural systems. The second purpose is to sketch the relationships among these farm-level systems, and between these on the one hand and higher-level systems on the other. These considerations form the basis for the presentation in later chapters of an analytical approach to farm management from a systems perspective applied in the context of Asian agriculture.

While somewhat original in the comprehensiveness of its farm systems' schema, the analytical framework and approach taken are not in conflict with the approaches to systems theory and (agricultural) systems analysis as presented by such authors as Ackoff (1973), Ackoff and Emery (1972), Boulding (1956), Checkland (1981), Dillon (1992), Dillon and Anderson (1990, pp. 164-174), FAO (1989 and 1990), Fresco and Westphal (1988), Friedrich (1992), Kast and Rosenzweig (1974), Norman (1980), Ruthenberg (1976 and 1980), Shaner, Philipp and Schmehl (1982), Spedding (1979) and von Bertalanffy (1973).

1.1 SYSTEM DEFINITION AND HIERARCHY

An *agricultural system* is an assemblage of components which are united by some form of interaction and interdependence and which operate within a prescribed boundary to achieve a specified agricultural objective on behalf of the beneficiaries of the system.

This definition is analogous to the general definition of any *artificial* (i.e., man-made) *system* of which all managed agricultural systems (including specifically the farm-level systems) form one sub-division as shown in Figure 1.1.

From a practical production, administration and management point of view, as shown in Figure 1.2, 'all agriculture' can be regarded as consisting of sets of systems at 16 Order Levels or levels of generality. As discussed in Section 1.3. these 16 Order Levels largely constitute a nested hierarchy. This book is concerned with the 12 lowest-order systems, those at farm level, i.e., systems of Order Levels 1 to 12 in Figure 1.2.

1.2 GENERAL SYSTEMS CLASSIFICATION

Discussion and analysis of systems can be of them as *actual systems* (e.g., of constituent physical processes in the case of natural physical systems) or as*representational systems.* Common representations or models of actual systems take such forms as written descriptions, physical models, mathematical models, flowcharts, tables of data and computer programs. In the following discussion, reference is to representational systems.

1.2.1 Natural, social and artificial systems

Systems can be classified into three broad families or divisions as either natural, social or artificial systems (Figure 1.1).

(a) Natural systems - those that exist in Nature - consist of all the materials (both physical and biological) and interrelated processes occurring to these materials which constitute the world and, *inter alia,* provide the physical basis for life. They exist independent of mankind. Our role in relation to natural systems is to try to understand them and, as need be, make use of them. We also (increasingly) attempt to duplicate them, in part or whole; but at this point they become, by definition, man-made or artificial systems. These fundamental natural systems remain unaffected by attempts at imitation. Those natural physical and biological systems (shown in their totality as the division of natural systems in Figure 1.1) which are relevant to agriculture will be self-apparent: rock weathering to form soil; plants sustained by such soil; animals sustained by such plants ... are

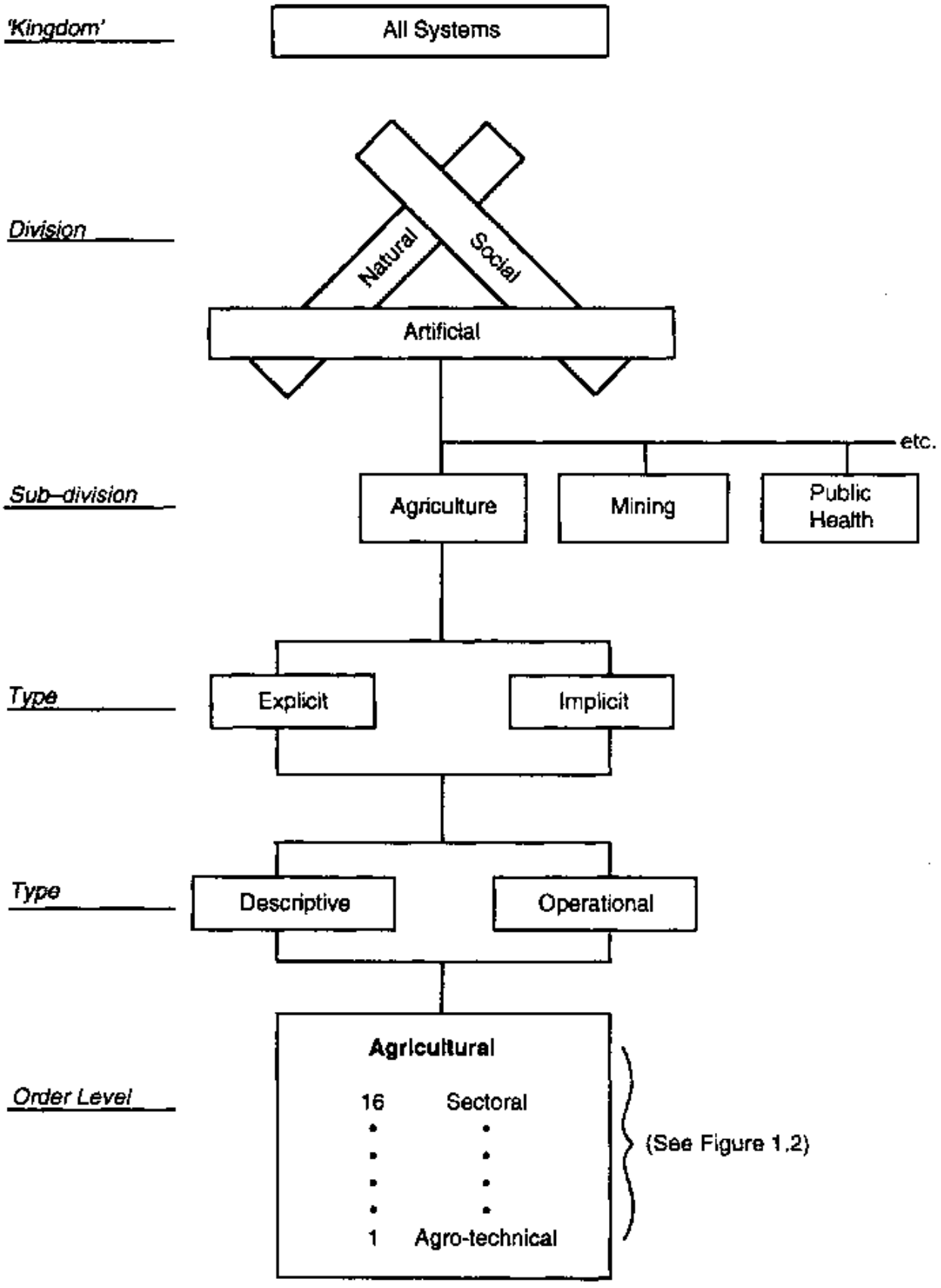
examples of the outward forms of agriculturally relevant natural systems in operation.

(b) Social systems are more difficult to define. Essentially they consist of the entities forming animate populations, the institutions or social mechanisms created by such entities, and the interrelationships among/between individuals, groups, communities, expressed directly or through the medium of institutions. Social systems involve relationships between animate populations (individuals, groups, communities), not between things. Concern here is with human social systems as they relate to or impinge upon farming, and the term social system is used broadly to include institutions and relationships of an economic, social, religious or political nature. There is a certain degree of ambiguity in defining social systems. As an example, the law of property is in its essence a social system. Insofar as it is viewed as consisting of concepts, principles and rules, it is a pure social system, independent of natural systems. But its existence also presupposes the existence of property, including natural physical things, some of which exist as systems. To this extent, as a social system the law of property is dependent on or subordinate to natural systems.

(c) Artificial systems do not exist in Nature. They are of human creation to serve human purposes. All artificial systems, including agricultural systems, are constructed from either or both of two kinds of elements: (a) elements taken from either or both of the other two higher-level orders of systems at division level, i.e., from natural and social systems, and (b) from elements which are constructed or proposed for specific use by each respective artificial system as the need for this arises.

The upper part of Figure 1.1 depicts the dependence relationship between natural and social systems on the one hand and between these and artificial systems on the other. The relevant relationships are: (i) natural systems are independent of systems of the other divisions; (ii) social systems could also be viewed as being independent, but generally a more legitimate view would be that they depend immediately or eventually on natural systems for the essentials of their material existence; and (iii) artificial systems are directly dependent on either or both natural and social systems, or indirectly on natural systems (through the dependence of social systems themselves on natural systems).

FIGURE 1.1 - Agriculture in relation to Other Systems



In Figure 1.1, agriculture is shown as comprising one of a very large number of actual or potential artificial systems at the sub-division level. Others are those relating to mining, transport, public health, education etc. What such systems at this sub-divisional level have in common is that each is artificial: each is based upon or draws elements from higher-level natural and social systems; and each also contains elements which are purposefully created by some human agency in order to meet its needs.

1.2.2 Further sub-classification of systems

As shown in Figure 1.1, systems within the three broad divisions or their multitudinous subdivisions can be further classified according to system 'type', a loose term but one which might be used to differentiate among agricultural systems according to a number of factors of which only two are shown in the sketch. As outlined below, first, the system might be either an explicit or implicit one; second, its purpose might be either descriptive or operational. Other 'type' designations could be added; e.g., operational systems could be further classified according to whether or not they are amenable to optimization.

• *Explicit systems* are those in which the constituent elements are more or less closely identified and defined, and the relationships among these elements are stated formally in quantitative, usually mathematical, terms. Agricultural scientists and economists who work with farmers are concerned mainly with explicit systems of Order Levels 1 to 10 as specified in Figure 1.2. But farmers themselves will seldom be concerned with explicit systems - only with systems of a simpler kind, or only with selected parts of such systems.

• *Implicit systems* are systems in which only the main or critical elements are acknowledged and only the major or immediately relevant interrelationships are considered. However, these elements and relationships are not formally recorded, analysed or evaluated. Farmers themselves deal primarily with implicit systems. In both traditional and more modem societies particular agricultural systems of Order Levels 1 to 10 are implied in what farmers do, or deliberately do not do. In more 'advanced' societies, farmers might formalize and work with a few explicit systems or parts of systems (farm record books, simple crop budgets, household expenditure accounts) but here also most agro-management systems will exist by implication.

The purpose in here distinguishing between explicit and implicit systems is to discourage the view that, because farmers (especially small traditional farmers) do not deal with explicit formal systems, these farmers are backward, ignorant, unsophisticated and generally inferior as resource managers. If anything, the facts generally point to a contrary conclusion. While bad farmers can be found

anywhere, any close study of small traditional farmers and farming villages in the developing world will, with patience, identify implicit systems at agro-technical, enterprise, farm, farm-household and village levels which are far more complex, sophisticated, sustainable and socially efficient than most agricultural systems found in developed countries.

- *Descriptive systems* are usually intended to facilitate an understanding of the organization, structure or operation of a productive process. This might be their sole purpose; e.g., a farmer might construct a simple input-output budget table in order to learn the structural configurations of some potential new crop. Depending on the results of this, he or she might then proceed to construct a more detailed budget (an operational system) to find how best to fit this new crop into his or her farm plan. At higher Order Levels an organogram describing the administrative structure of a ministry of agriculture or of an extension service might be constructed or the flowchart of a commodity from farm to consumer might be drawn - these also are descriptive systems.

- *Operational systems* are constructed (by an analyst or manager or research worker) as a basis for taking or recommending action aimed at improving the performance of the system. Such systems are often elaborate (as exemplified in Chapters 9 and 11). However, increased precision is not infrequently achieved at the cost of decreased practical usefulness. Thus farm managers themselves work primarily with simple operational systems, although the actual physical systems which these represent may be very complex.

As outlined by Dillon (1992), it is also sometimes useful to recognize that, like other systems, agricultural systems may be categorized as:

- *Purposeful* or *non-purposeful* depending on whether or not they can select goals and the means by which to achieve them.

- *Static* or *dynamic* depending on whether or not they change over time in response to internal or external influences.

- *Open* or *closed* depending on whether or not they interact with their environment.

- *Abstract* or *concrete* depending on whether or not they are conceptual or physical in nature.

- *Deterministic* or *stochastic* depending on whether or not their behaviour exhibits randomness over time, i.e., their future behaviour is uncertain.

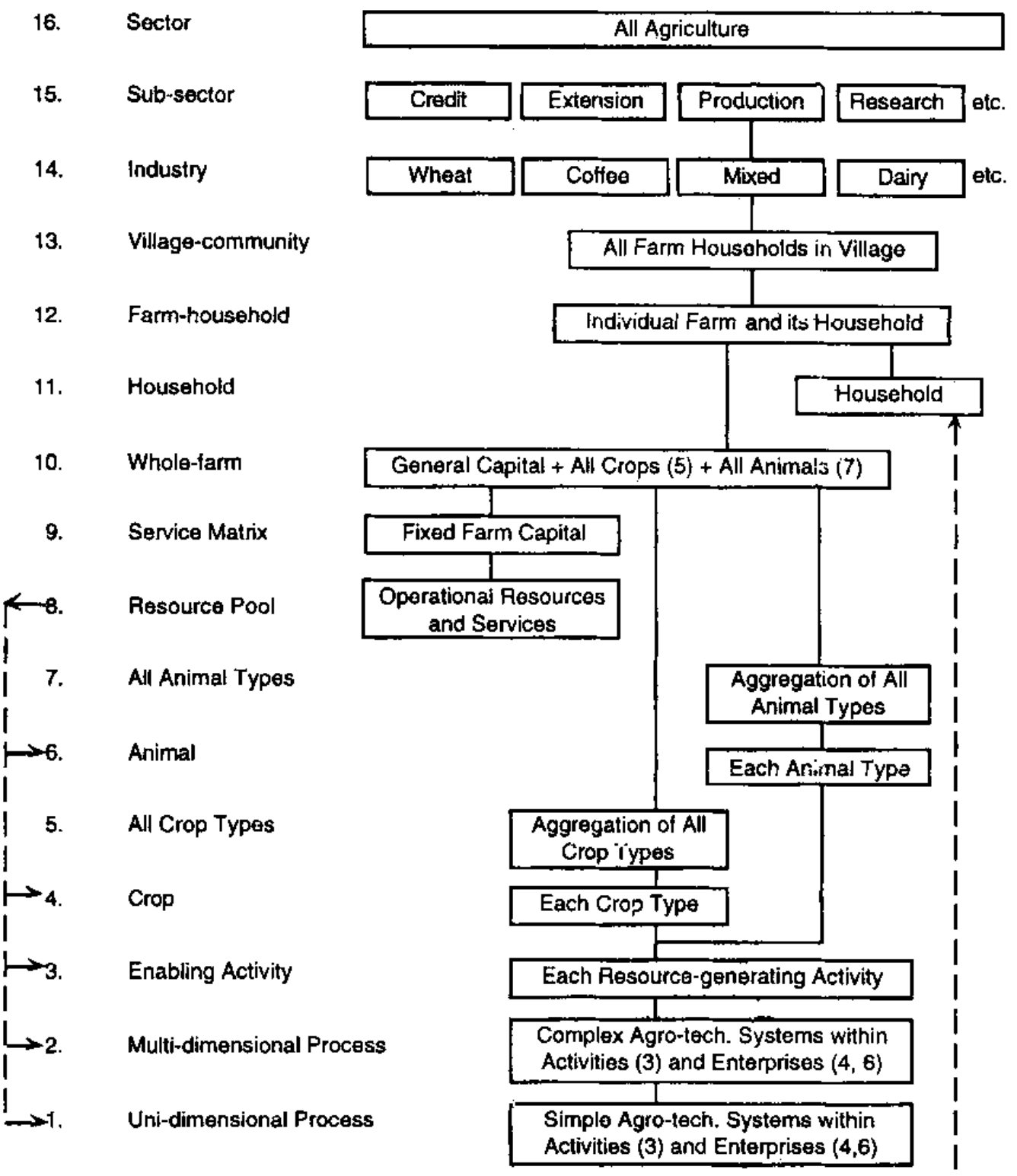
1.3 AGRICULTURAL SYSTEMS CLASSIFICATION AND ORDER HIERARCHY

Agricultural and particularly farming systems exhibit great diversity as shown by, e.g., Duckham and Masefield (1970), Grigg (1974), Kostrowicki (1974) and Ruthenberg (1980). They have been classified in various ways as reviewed by Fresco and Westphal (1988) who also present an ecologically-based classification and typology of farm systems. The hierarchical classification of farm systems presented here is distinctly different. It is specifically oriented (i) to a farm management and farm-household perspective and (ii) to use as a framework for analysis of what are proposed as the six basic types of farms found in Asia (and elsewhere in the developing world).

Figure 1.2 is an elaboration of the lower part of Figure 1.1 and relates specifically to agricultural systems. These are listed in largely hierarchical order encompassing 16 Order Levels. Alternatively, with a few minor exceptions, the Order Levels 1 to 16 could have been depicted, reflecting their nested character, as a set of concentric circles with Order Level 1 as the innermost and Order Level 16 as the outermost circle.

In Figure 1.2, the sectoral system, 'all agriculture', is specified as being of the highest order rank, i.e., Order Level 16. Any national or regional agricultural sector, however, consists of such subordinate sub-sectors or subsystems as agricultural credit, education, research, production, transport etc. Each of these constitutes and would be analysed, administered and managed as a system of Order Level 15. Each such (sub)system may then be further disaggregated into commodity-based industry systems of Order Level 14 such as for coconuts, rubber, wheat, coffee, fish etc. If that flow-path relating to production is being followed, as depicted in Figure 1.2, this would then lead to villages or other community units where such production occurs (systems of Order Level 13); these would in turn consist of and could be disaggregated into the individual farm-household systems of Order Level 12 which comprise such villages. Further lower Order Level systems relate to the agro-economic structure of individual farms and, in turn, their component crop and livestock enterprises and to the activities and individual agro-technical processes which underlie such enterprises.

FIGURE 1.2 - The Hierarchy of Agricultural Systems



OTHER SYSTEMS AFFECTING HOUSEHOLDS:

Type I: Material, Economic: Family income-earning activities off the farm; some are sufficiently complex to warrant their designation as systems. They affect the household or farm components (11, 10) or both.

Family Off-farm Earnings

Type II: Non-material, Social: These systems are external to but significantly affect the household in relation to its farming operations, abilities. Some examples are:

Malaria Control Program

General Education System

Social Security System

Systems of Order Levels 1 to 12 comprise the field of farm management (as discussed in Chapter 2). But systems of Order Level 1 and 2 are also, indeed primarily, the domain of the applied agricultural sciences. A further proviso is that the 'household' components of farm-household systems of Order Level 12 remain as yet not very well understood. This component is primarily the province of workers in such fields as household economics, rural sociology and social anthropology. While these various farm family-related fields are fairly well established, they have yet to be brought together in a comprehensive and cohesive way at farm-family level to provide verified models of how rural families in the developing world think about, plan and operate the 'farm' component of their farm-household systems (Clayton 1983, Chs 4 and 5).

Figure 1.2 depicts the direction of hierarchical status as proceeding downward from sector to industry to village to farm to crop etc. But whether this direction of subordination is valid will depend on circumstances and analytical purpose. Agricultural scientists would probably reverse the order-ranking shown for the systems on the grounds that, unless the basic agro-technical processes (Order Level 1 and 2 systems) are well developed, the production of individual crops will be inefficient, total farm production will be low and the agricultural sector itself will in consequence be an impoverished one. Similarly extension workers might be inclined to place household systems at the top of the systems hierarchy on the basis that good farming practices (Order Level 1 and 2 systems) will not be adopted unless the household systems are working well, nor consequently will the 'higher'-order systems at industry and sector level operate at their full potential.

1.3.1 Nature of farm-level systems

The nature of each farm-level system (i.e., Order Levels 1 to 12) of the hierarchy presented in Figure 1.2 may be specified from a management point of view as follows:

• *Order Level 1: Uni-dimensional process systems.* Systems of this lowest order are of an agro-technical nature. They involve an issue or problem which for purposes of analysis or management is abstracted from the context in which it naturally or normally occurs. One example is the application of a single fertilizer element, say nitrogen (*N*), to a crop and consequent plant response to *N* in terms of crop yield *Y.* As noted previously, systems of this order are primarily the domain of physical scientists, but those systems which have practical relevance for farmers thereby also have an economic dimension and so fall within the scope of farm economics. Such simple single-dimensional systems are later examined as processes (Chapter 5) and as input-output response relationships (Chapter 8).

• *Order Level 2: Multi-dimensional process systems.* Systems of this second order are also concerned with limited agro-technical relationships and again they are primarily the domain of physical scientists. They differ from Order Level 1 systems in that they take - or are defined to take - a wider and more realistic view of a subject or problem. To use the same example of fertilizer response: at Order Level 2 an agro-technical system might involve the response of plant growth or yield *Y* to not one but to several or a large number of input factors such as nitrogen, phosphorous, irrigation water, crop hygiene, soil tilth etc. These multi-dimensional systems also are later examined as processes (Chapter 5) and as response relationships (Chapter 8). Order Level 2 systems can be viewed as aggregations (often interactive) of constituent Order Level 1 systems.

• *Order Level 3: Enabling-activity systems.* Systems of this order are certain enabling activities which generate an intermediate product intended for use as an input/resource by enterprises which do produce a final product. An example is offered by a legume crop turned under to provide fertility for a following (final product-generating) paddy crop. There will often be alternative ways of obtaining this resource: e.g., stripping leaves off leguminous trees, keeping cattle for their manure, or buying a bag of fertilizer. These are all enabling, resource-generating activities but only some of them, the complex ones, warrant designation as systems. They are intended to supply resources to systems of Order Levels 4 and 6.

• *Order Level 4: Crop systems.* Systems of this order relate to the production of individual crops; but if these are primarily intended to produce inputs for other crops or livestock, they are regarded as systems of Order Level 3. On many small farms, crop and livestock enterprises produce both final products and resources (as discussed in the context of activities in Chapters 3, 4 and 9).

• *Order Level 5: All crop systems.* Systems of this order, known also as *cropping systems,* refer to the combined system of all the individual crops on a farm. On a farm with a single mono-crop, this Order Level 5 system will obviously be equivalent to an Order Level 3 system; but on small mixed farms there will usually be four, five, six or more different crops (of Order Levels 3 and 4) grown in some degree of combination and as many as 20 or more on the highly diversified forest-garden farms of South Asia.

• *Order Level 6: Animal systems.* These systems relate to single-species animal enterprises or activities - e.g., dairy cows, camels, fish, ducks. They are the animal equivalent of Order Level 4 (i.e., individual crop) systems.

• *Order Level 7: All animal systems.* These systems are the aggregation of all Order Level 6 (sub)systems on a farm. Known as *livestock systems*, they are the animal equivalent of Order Level 5 (i.e., all crop) systems.

• *Order Level 8: Resource pool.* This subsystem is a conceptual device for farm-system planning in which resources and fixed-capital services required by other subsystems are 'stored' in a 'resource pool' from which they are allocated to the other subsystems (of Order Levels 1, 2, 3, 4 and 6). The resource pool is central to operation of the whole farm-household system. It is discussed in Chapter 3.

• *Order Level 9: Farm service matrix.* A system of this Order Level consists of all the fixed capital resources of a farm which are pertinent to the operation of the farm as a whole but are not assigned to the exclusive use of any particular enterprise or activity: land, fences, barns, irrigation channels and work oxen are common examples. Some of these capital items are true (sub)systems, having interdependence among their component parts (as in an irrigation storage/delivery/distribution network, a grain drying facility, an integrated network of soil conservation structures etc.). Some are only things (e.g., fences, a plough, a barn). But, in its totality, such capital is managed and manipulated as a system for the purpose of providing general services which, while not specific to them, enable the functioning of lower Order Level systems of the farm. This service matrix is discussed in Chapter 5.

• *Order Level 10: Whole-farm systems.* Systems of this Order Level consist of all the lower Order Level (sub)systems which go to make up a farm. They consolidate in a single entity all the farm fixed capital, all the operating capital, all the final-product enterprises, all the activities and all the agro-technical processes which underlie such enterprises and activities. Structuring and managing systems of this Order Level are the main tasks or focus of farm management as carried out, on the one hand, by farmers and as investigated, on the other hand, by farm management economists in their professional capacity of providing advice to farm managers, development agencies and governments.

The terms farm *system* and *farming system* are often used interchangeably. Here the practice is to use farm system to refer to the structure of an individual farm, and farming system to refer to broadly similar farm types in specific geographical areas or recommendation domains, e.g., the wet paddy farming system of West Java or the grain-livestock fanning systems of Sind.

• *Order Level 11: Household systems.* On small farms the household itself is the most dynamic and complex of all farm-level systems, although it is a social system not an agricultural one. It dominates the agricultural systems which comprise the farm component. It has two functions: as *household* it provides

purpose and management to the farm component, and as major system *beneficiary* it receives and allocates system outputs to itself and other beneficiaries.

• *Order Level 12: Farm-household systems.* These consist of two components or (sub)systems of Order Levels 10 and 11, i.e., the whole-farm system and its associated household system, respectively. The term is a very useful if not mandatory one when used to refer to the small farms of Asia. It carries an insistence that the technical analysis discussed in following chapters will amount to nothing at all unless it is applied to achieving the real needs and aspirations of the household - which, as discussed in Chapter 6, might be quite a different thing from evaluating the performance of a farm system according to the subjective or preconceived ideas of agricultural technicians and economists (Chambers and Ghildyal 1985; Rhoades and Booth 1982). As the peak farm-level system, the farm-household system may be described in system terms as a goal-setting (i.e., purposeful) open stochastic dynamic system with a major aim of production from agricultural resources. These attributes are sufficient to make it also a complex system. The purposefulness of a farm-household system is ensured by its human and social involvement which enables the system to vary its goals and their means of achievement under a given environment. The openness of the farm-household system is obvious from its physical, economic and social interaction with its environment. The non-deterministic or stochastic nature of the farm-household system is guaranteed both by the free-choice capacity of its human (and, if present, animal) elements and by the stochastic nature of the environment with which it (and all its subsystems) interacts. Necessarily, a farm-household system is also dynamic by virtue of its purposefulness, openness and stochasticity which ensure that the system changes over time. Too, any farm-household system is a mixture of abstract and concrete elements or subsystems. The concrete elements are associated with the physical activities and processes that occur in the system. The abstract elements relate to the managerial and social aspects of the system.

1.3.2 Village-level farming systems

Not infrequently in parts of Asia, as also elsewhere in the developing world, the village may replace the farm-household in whole or part as the focal entity for agricultural production. Systems of Order Level 13, i.e., village or community systems, are thus often relevant to the performance of farming systems (Cederroth 1995; Walker and Ryan 1990).

• *Order Level 13: Village-community systems.* Village-level systems or community systems in some situations replace all or part of individual farm-household systems. Three situations are common. First, some production activity

in its entirety, including the operation of whole farms as production units, may be on a formal cooperative or group basis. Second, only part of an activity might be carried on by individual farmers while critical parts of it (such as land preparation, the supply of inputs, harvesting and/or marketing) are the responsibility of a formal farmers' club or cooperative. Third, and most difficult to analyse, is the situation found in many Indonesian villages where informal and temporary groups form to perform certain production tasks in common (such as land preparation, irrigation and/or harvesting) then disband and re-form to do different tasks on different crops, with membership continuously changing as individuals drop in and out of groups according to their interests, needs and mutual obligations. In a village there might be 10, 20 or 30 such 'cooperatives', though none might exist officially. Other examples are offered by the semi-nomadic livestock farmers of West Asia who sometimes operate as individual households and sometimes as members of a collective. In all these situations the boundaries of individual units are often so fluid and obscure that the focus for productive analysis has to be the group or village community. (Nevertheless, much externally sponsored farm-development planning remains locked into the mythology of agricultural individualism; perhaps that is why on the small farms of Asia it has borne so little and often poisonous fruit.)

Farm-level systems of Order Levels 1 to 12 are discussed more fully in the following chapters. Before proceeding, however, it will be useful to examine those constituent structural elements of a farm-household system which are relevant to its organization and management.

1.4 STRUCTURAL ELEMENTS OF THE FARM-HOUSEHOLD SYSTEM

The definition of an agricultural system given in Section 1.1 is a general one and applies broadly to systems of all the Order Levels. When applied specifically to a farm-household system of Order Level 12 it implies the system involves ten structural elements or components:

1. Boundaries
*2. Household 3. Operating plan
*4. Production-enabling resources: the resource pool
*5. Final product-generating enterprises
*6. Resource-generating activities
*7. Agro-technical processes
* 8. Whole-farm service matrix
9. Structural (interdependence) coefficients
10. Time dimension.

Those elements marked by an asterisk have been considered above as subsystems of the farm-household system (see Figure 1.2). The ten elements are briefly discussed below and, except for structural coefficients and the time dimension, their interrelationships as components of a farm-household system of Order Level 12 are sketched in the example of Figure 1.3 where they are denoted E1, E2 ... E8.

1. *Boundaries:* This first element, the boundaries of the farm-household system, set it apart from other systems and from the world at large. These boundaries are provided partly by the structural characteristics of the particular type of farm (Chapter 2), and partly by the purpose of analysis, i.e., to some extent they are subjective and relate to more than the simple physical boundary of the farm. Boundaries are discussed in Chapter 3.

2. *Household:* As previously noted, the household plays two roles: first, it provides purpose and management to its associated farm system and, second, it is the major beneficiary of its associated farm system. Its role as beneficiary is discussed in Chapter 3. In its first role it provides purpose, operating objectives and management to the farm component of the farm-household system according to its broad domestic and social goals. Obviously these goals vary widely with culture, tradition and the degree of commercialisation and external influences to which the household is exposed. However, one would probably be not too far wrong in offering a generalization that the primary economic goal on most small farms (Types 1, 2, 3 of Chapter 2) is security and the primary non-economic goal is social acceptance (Clayton 1983, Ch. 4). If this is correct, the primary objectives for the farm are, first, production of a low-risk sustainable subsistence for primary system beneficiaries; second, generation of a cash income to meet needs not directly met in the form of food and other farm-produced materials; and third, pursuit of both of these in ways which are not in conflict with local culture and tradition. Goals, objectives and planning criteria are discussed in Chapter 6.

3. *Operating plan:* The above objectives are pursued through preparation and execution of a farm operating plan. The core of this may be taken as selection of the best possible mix of agro-technical processes, activities, enterprises and fixed capital (systems of Order Levels 1, 2, 3, 4, 6 and 8). Formulation of operating plans is discussed in Chapter 9.

4. *Resource pool:* This element was noted above as a system of Order Level 8 central to the management of other subsystems within the farm system. It is discussed in Chapter 3.

5. *Final product-generating enterprises:* These were noted as systems of Order Levels 5 and 7 in the previous section and are discussed in Chapter 4 and Section 9.3.

6. *Resource-generating activities:* These also were previously discussed as systems of Order Level 3. They are intended to supplement or entirely supply the resource pool as discussed in Sections 4 4.1 and 9.3.1.

7. *Agro-technical processes:* These were defined above as systems of Order Levels 1 and 2. Processes may be of a biological or mechanical kind. They are a shorthand designation of all the potentially complex and interrelated physical and biological factors underlying production from crop or livestock species, only some of which may be economically relevant. They are discussed in Chapter 5.

8. *Whole-farm service matrix:* This was discussed previously as a system of Order Level 9. It is further examined in Chapter 5.

9. *System structural coefficients:* These coefficients identify and quantify linkage relationships (a) among the various parts or elements within each subsystem and (b) between subsystems. From the general system definition, an essential property of any system is that there be interrelatedness between its parts. In farm-household systems (and in subordinate subsystems of lesser Order Level, particularly Order Levels 4 and 6) such interrelatedness is specified by these coefficients. They are discussed in Chapter 5.

10. *Time dimension:* Unlike mechanical systems which stamp out buttons or TV sets, agricultural systems rest on biological processes which occur over considerable periods of time - from, e.g., a few days in the case of quick-response agricides to 70 or more years in the case of growth and decline of a coconut palm. Agricultural systems are thus inherently stochastic: being dependent on the passage of time, *ex ante,* their outcomes are uncertain. Moreover, because agriculture is also a set of economic activities, the old adage applies: time is money. Other things being equal, a system which yields its product or ties up resources over a short time is better than one which yields its output or occupies resources over a long time. Strictly speaking, time is not a system component; rather it is a dimension in which the system operates. The time dimension in relation to resource use is discussed in Section 3.3.4 and in relation to farm planning in Section 9.1. The evaluation of activities which occur over long time periods is examined in Chapters 10 and 11. The latter chapter also considers uncertainty as it occurs in farm planning and decision making. Also important from a time perspective are the sustainability and environmental compatibility of the farm system being used. If, over time, the farm system is not biologically and economically sustainable or causes resource degradation, as

discussed in Sections 6.2.7 and 8, this is to the disadvantage of both the farm household and society at large.

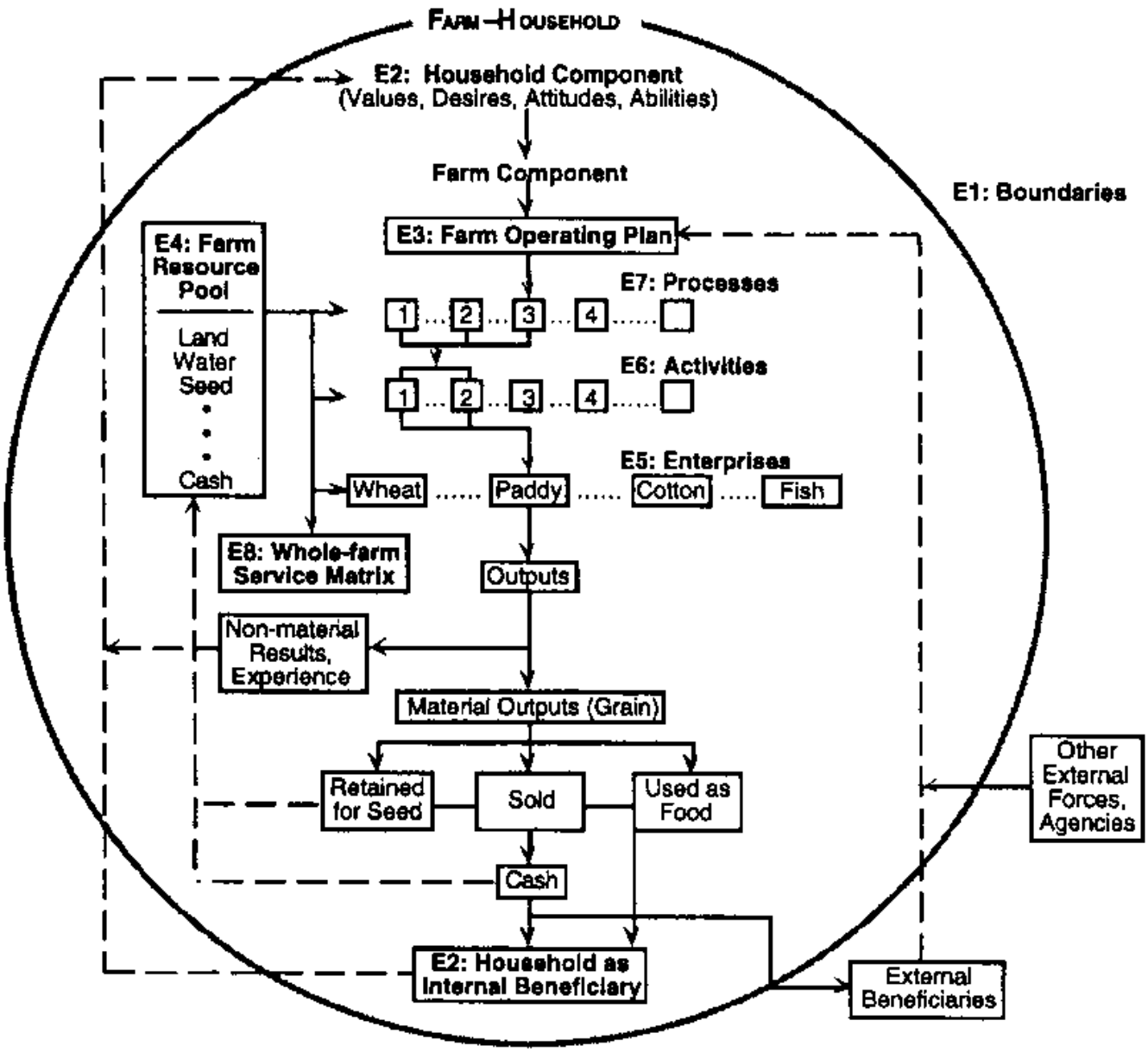
1.5 STRUCTURAL MODEL OF A FARM-HOUSEHOLD SYSTEM

Before examining the elements of a farm-household system in more detail in later chapters it is useful to consider where they lie in relation to each other in the structure of a small mixed farm as exemplified in Figure 1.3.

Element 1, system boundaries: Depending on the purpose of analysis, the farm-household system may be specified with different boundaries. In Figure 1.3, these are suggested by the shaded circle around the system which sets it apart from other neighbouring systems and from the larger community or environment in which it is imbedded.

Element 2, household: As noted at the top of Figure 1.3, the household provides objectives and management of the farm-household system and, at the bottom, it exists as the primary internal beneficiary of the system, while distributing some of the system output to external beneficiaries.

FIGURE 1.3 - Interrelationships of Elements in a Simple Farm-household System



Element 3, operating plan: As shown in Figure 1.3, this is determined largely by the household but it might also be influenced by the requirements of external individuals, agencies or other influences, some of whom might be (external) beneficiaries of the system as outlined below.

Element 4, resource pool: This element consists of resources which are initially present at the time of planning or commencing operation of the system - some pool or stock of land, water, seed, cash etc. which the other elements of the farm system may draw upon. Once the system begins operating, certain components of it (the resource-generating activities and by-products of the enterprises) will

replenish the pool. In the schematic sketch of Figure 1.3, the arrows from the farm resource pool indicate that items from the resource pool flow to processes as well as to activities and to enterprises (as well as possibly to maintenance of the whole-farm service matrix). Strictly speaking, resources should be shown as flowing directly only to processes, since this is the level (subsystems of Order Levels 1 and 2) at which they are actually used. But from a practical viewpoint and because most of the potential processes are actually ignored in planning the operation of a farm system, resources may also be viewed as flowing directly to activities and enterprises as indicated.

Element 5, final-product enterprises: Only four enterprises are shown in the system of Figure 1.3: wheat, paddy (rice), cotton and fish. Only the flow lines of inputs to and output from the paddy crop are shown.

Element 6, resource-generating activities: In the example of Figure 1.3, there are two of these supplying some resources to paddy (e.g., a prior fertility-generating legume crop and possibly a cattle activity providing oxpower).

Element 7, agro-technical processes: These underlie the activities and enterprises. Only three are indicated as relevant to paddy in Figure 1.3 but (as discussed in Chapter 5) there are a very large number of biological and mechanical processes actually present in any form of agricultural production.

Element 8, whole-farm service matrix: This was defined previously in relation to Figure 1.2 as a system of Order Level 9. It consists of fixed farm capital which provides a flow of services (not shown in Figure 1.3) to all other elements of the system, particularly to Elements 5, 6 and 7 but it is not specific to any one of them.

Element 9, structural coefficients: These are not depicted in Figure 1.3. They are discussed in Chapter 5.

Element 10, time: In the schematic example of Figure 1.3, the time dimension is not specified explicitly but the model would probably refer to a single operating phase with a duration equal to the life of the longest-term enterprise subsystem, here cotton with a term of six to seven months, or, if climatic seasons are constraining, to a full seasonal cycle of one year. If the system proves to be a 'good' system in terms of household objectives, it might be reactivated in successive phases and continue indefinitely; if a 'very good' system it might permit further farm intensification and development; if a 'bad' system it might be restructured (as discussed in Chapters 6 and 9); if a 'very bad' system it will, in the absence of restructuring, prove to be non-sustainable and eventually collapse.

Figure 1.3 is intended only as a schematic example to indicate the broad relationships which the elements of a farm-household and its associated whole-farm system bear to each other. Real small-farm systems are much more complex than Figure 1.3 suggests, particularly in their internal cycling of resources. The following chapters are essentially an elaboration of Figure 1.3 in terms of managerial considerations.

Outputs of the farm component of the farm-household system depicted in Figure 1.3 are, as an example, shown as flowing from the paddy enterprise. They do not comprise a separate element but are part of Element 5 (final-product enterprises). Outputs are allocated to the farm component and to system beneficiaries. Thus, to enable continuation of the system in subsequent phases (seasons or years), some paddy grain output is cycled back to the resource pool to replenish the seed stock. Similarly, to replenish the cash resource which was used up in this phase, some rice grain is sold. Whatever grain is left might also be sold to generate cash income or be used as food. These latter outputs will be distributed among system beneficiaries who might be internal to the system, i.e., the household, or external to it. External primary beneficiaries may consist of needy relatives and friends, landless neighbours, a landlord receiving cash or part of the crop as rent etc. External secondary beneficiaries, as discussed in Section 3.2, might also be present - usually the tax collector. External beneficiaries often also play another role: they can exercise a direct influence on how the system is planned, constructed and operated. This influence is indicated in Figure 1.3 by the broken line indicating feedback from external beneficiaries to Element 3, formulation of the farm plan. Returning to the paddy flow column of Figure 1.3, the system will also generate a second type of output apart from the material one of grain, namely *non-material output.* This consists of the knowledge and experience gained from operating the system over any phase. Farm-household systems are dynamic: the results of one operating phase flow back not only as products giving sustenance and cash income to the household but also as knowledge and experience to influence the formulation of plans for future phases.

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