CHAPTER 4

THE INFORMATION SYSTEM

Earlier chapters discuss the scope and problems of food and agricultural decision making and the essential role of information. Indeed, information is defined as having meaning and economic value only when it is used in decision making. This utilitarian perspective is important for understanding and solving the problems of national statistical programmes in developed and developing countries alike. Therefore, with this manual, FAO is recommending an approach to statistical development which places statistical programmes and their design within the larger context of information systems.

This chapter defines and applies the systems approach to the design of information systems. The systems approach is a formalized problem-solving process, where a problem is defined as a situation in which a decision must be made among a set of feasible alternatives in order to achieve some objective. Section 4.1 discusses a distinctive feature of the approach, i.e., its systems view of the world, where the portion of the world relevant to a particular problem is looked at as a system. These concepts are applied in Section 4.2 in describing an information system as a process. Section 4.3, then, gives a broad overview of the systems approach and applies it to the problem of designing information systems, while Section 4.4 addresses organizational considerations.

4.1 The Systems View: General Concepts

This section discusses the meanings of "system" and related concepts, including the important system characteristics of feedback and stability, and their usefulness for decision making.

4.1.1. System Definition

A SYSTEM is a collection of objects or processes, called COMPONENTS, which interact to perform a given function or functions. The interactions, which are the linkages connecting the components, take place through the paths or mechanisms of material, energy, and information flow among the components. The STRUCTURE of a system is uniquely defined by the system's components and linkages, a change in either of which signifies a change in the system. The ENVIRONMENT of the system includes all aspects of the world not explicitly part of the system, and the system's BOUNDARY divides the system from its environment. The system interacts with its environment through flows, across its boundary, of material, energy, and information, called INPUTS and OUTPUTS. Figure 4.1 shows the relationships among these concepts for a generalized system of three components, four linkages, two inputs and two outputs.

The portion of the world comprising the domain of food and agriculture is described in Chapter 2 as a system (Figure 2.1). For simplicity in illustrating the concepts, let's consider a small part of that system as a system relevant to decision makers concerned with agricultural supply and demand. Thus, Figure 4.2 represents some components important to the agricultural sector of one region of a country, i.e., agricultural production, rural households, urban households and food markets. The key interactions linking these components are also indicated in the figure. The system as we have defined it does not have components for other regions within its boundary; therefore, other regions are considered part of the system's environment. Thus, for example, our system definition does not specify whether imports from the "environment" come from foreign trade or other regions of the country.

There are two observations to make here. First, a system, like beauty, is in the eye of the beholder. That is, we select the components and linkages according to what is relevant to our purposes for considering the agricultural sector (or any system) in the first place. This selection also partly depends, of course, on who "we" are: the farmer, the extension agent, the government planner, the input supplier and the food processor will all see the same agricultural system differently. Likewise, the selection of relevant interactions between system and environment (i.e., inputs and outputs) depends on who is doing the selecting and for what reason.

The system can also be defined at different levels of organization, again depending on our objectives. Thus, what we might consider to be a system in one context could be but one component of a broader system for other purposes. Conversely, a system component could also be viewed as a system with components of its own. For example, the regional agricultural sector might be just one component of a regional or national socio-economy. Other components of this broader system could represent household demographics, health, education or non-agricultural production. For other purposes, the decision maker might need to view the agricultural production component as a system in its own right, including components of crop production, livestock production and resource allocation, with appropriate interactions among them.

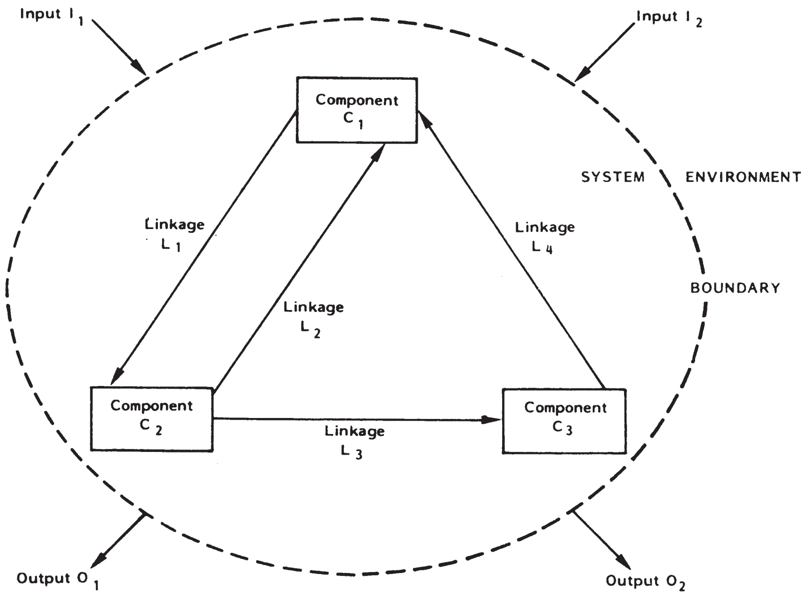


Figure 4.1 - System concepts

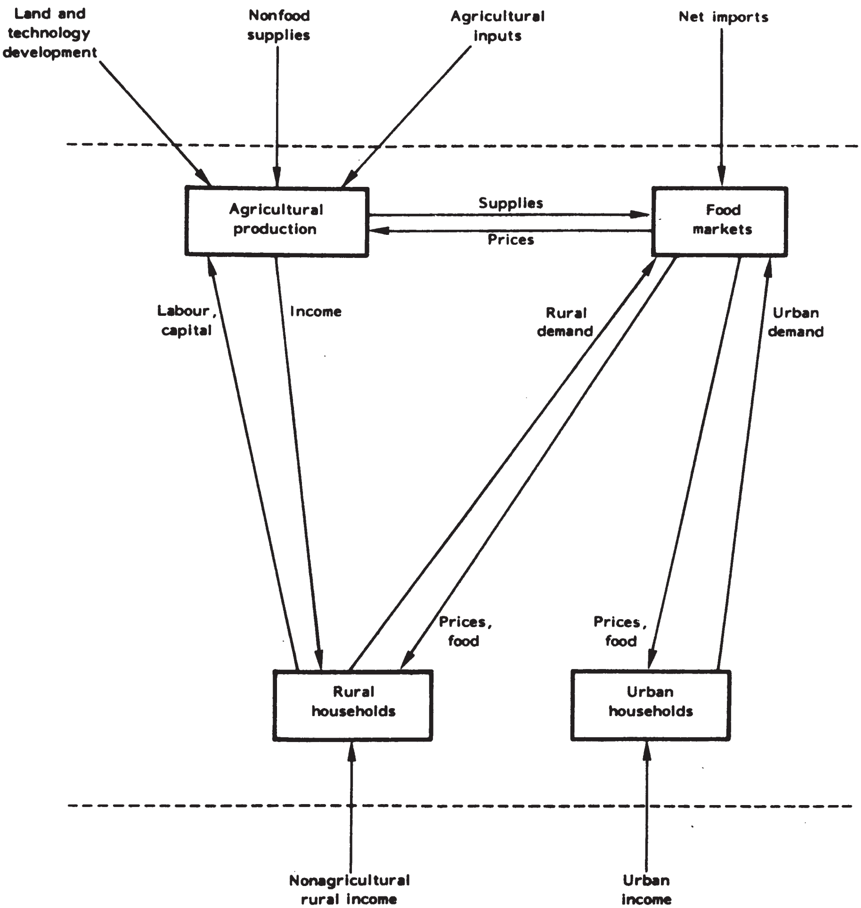


Figure 4.2 - An agricultural supply-demand system

The second observation is that systems and system components can be physical or abstract and refer to objects or processes -- again, depending on what suits our purposes. In agricultural production, for example, biomass growth (if that level of detail is needed) is a physical process, marketing is an abstract process, and the agricultural sector itself is an abstract object. A livestock housing component could be viewed as a physical object, if the physical characteristics of temperature, insulating properties, space, etc., are of interest, such as in a chicken coop design problem. It could also be considered a physical process, if we are concerned only with its function of providing shelter, warmth, and space. Section 4.2 of this chapter describes an information system as an abstract process, while Section 4.4 views it as an organization, i.e., an abstract object.

4.1.2 Feedback and Stability

The FEEDBACK LOOP is a linkage of a system component with itself, generally through a sequence of linkages with other components. It is a special, and very important, kind of linkage. The sequences $L_1 - L_3 - L_4$ and $L_1 - L_2$ in Figure 4.1 are feedback loops through which component C influences its own behaviour. In the agricultural system the agricultural production and food market components have an impact on one another. For example, agricultural production, if it increases faster than demand, will make prices fall, which, in turn, will reduce production in later periods.

This food example illustrates a very important feature of feedback loops. In particular, the supply-price interaction is not simultaneous; i.e., a change in price will not simultaneously affect supply. It is true of feedback interactions in general that they occur with time lags, i.e., feedback processes are time consuming and their impacts are distributed over time. Thus, feedback loops are at the core of what gives systems their dynamic behaviour (Forrester 1968), i.e., how the condition of a system at one point in time depends on its past history and influences its future. The importance for decision making of considering the dynamics of systems is discussed in Section 3.1.4 in terms of the need for multitemporal and intertemporal information.

While definition of the relevant system, including placement of the system boundary, is somewhat arbitrary, guided only by what is needed to consider the problem at hand, there is a general rule related to the feedback concept which reduces the arbitrariness and makes the ultimate system definition more useful. It is that the system should not have a feedback relationship with its environment;

i.e., those parts of the world which both affect the system and are affected by the system should be included within its boundary as part of the system. In the agricultural sector case, for example, if the problem involves the efficient allocation of rural resources and if the regional economy has a non-agricultural production activity which competes with agriculture for capital and labour and also produces inputs for agricultural production (a feedback loop), then non-agricultural production should be included as a system component and not left in the environment.

The are two basic kinds of feedback loops: positive and negative. It is important for decision makers to understand and appreciate them because of their implications for the stability of the system of interest and its ability to achieve behavioural goals. A couple of illustrations will serve to explain them.

Suppose Figure 4.3 represents our relevant system of interest and that a land reclamation project results, over time, in greater agricultural production. This begins a sequence of reactions: increased agricultural employment, increased rural income, increased investment in agriculture, <u>further</u> increases in agricultural production, and so on. The plus signs (+) next to each arrowhead mean that a change in one component causes a change in the next one in the <u>same</u> direction -- all increases in this case. Since the loop is reinforcing, i.e., since a change in agricultural production eventually leads to a further change in itself in the same direction, this is a POSITIVE FEEDBACK loop, as indicated by the (+) in the center of the loop.

It is clear that this is an example of an exponential growth process, and, hence, positive feedbacks are often called growth-inducing loops. Population growth is a common example, where births make more people which make more births and so on. If the growth were considered undesirable, such as in an escalation of conflict, we might call it a "vicious-circle" loop.

The loop does not have to reinforce increases, or growth, for it to be positive. The key is that the sequence of changes be in the same direction, whether they are increases or decreases, leading to growth or collapse. For example, suppose, instead of new land being developed, urban growth results in cropland losses. The resulting reduction in agricultural production reduces employment, which reduces income, which reduces investment, which <u>further</u> reduces production, and so on. All the impacts are in the same direction, so the loop is still positive, although, unless other steps are taken, it leads to accelerating collapse. One of these other steps might be a land development program to compensate for the losses to urbanization.

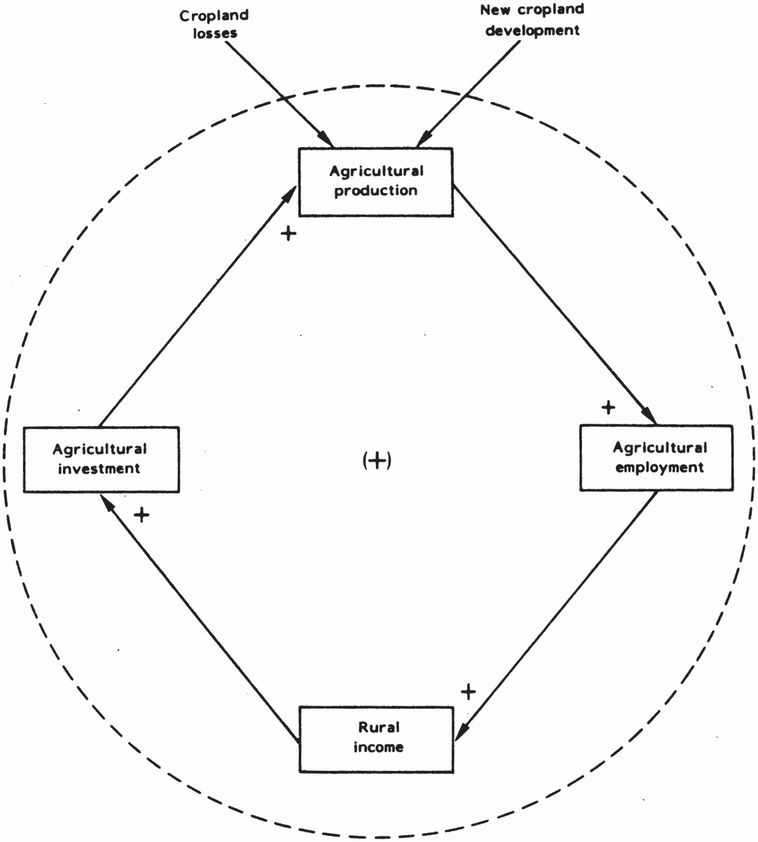


Figure 4.3 - A positive feedback loop in rural development

If the loop closes by counteracting or offsetting, rather than reinforcing, the initial change, it is a NEGATIVE FEEDBACK loop -- frequently called goal-seeking or self-equilibrating or self-correcting. A common example is a thermostat controlling the temperature in a home or a chicken coop: if the temperature is low, the heater comes on, raising the temperature until the heater shuts off, thus allowing the temperature to fall until the heater comes on again, and so on -- constantly correcting the temperature in search of the goal set at the thermostat.

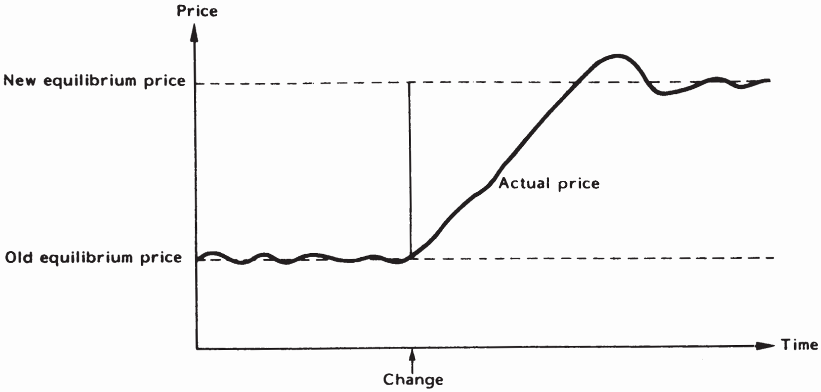
Loosely speaking, a system is STABLE if its response to an external shock or influence stays within reasonable bounds and eventually diminishes and damps out. In the price-demand-supply example of Figure 4.2, suppose supply is lowered, e.g., through some catastrophic loss of land, causing an increase in the equilibrium price (Figure 4.4). If the demand and supply adjust to bring the actual price up to the new equilibrium, perhaps with some oscillations, the system is stable. If, on the other hand, the price leaves the old equilibrium, continues to fluctuate wildly, and never stays close to the new equilibrium level, the system is unstable. The only way an unstable system can be managed, short of modifying the system structure to make it stable, is for outside influences to force it to behave in the desired way.

As suggested by this example, the stability of a system is associated with negative feedback. The growth of a system, as we have seen, is associated with positive feedback -- and so, unfortunately, is instability. A socio-economic system contains innumerable feedback loops, both positive and negative, and the net effect on any given component of the system, unemployment, for example, depends on the relative strengths of the various loops it is in. This is what makes the management of such a system so difficult: inducing growth through the stimulation of positive loops while maintaining stability by working with the negative loops.

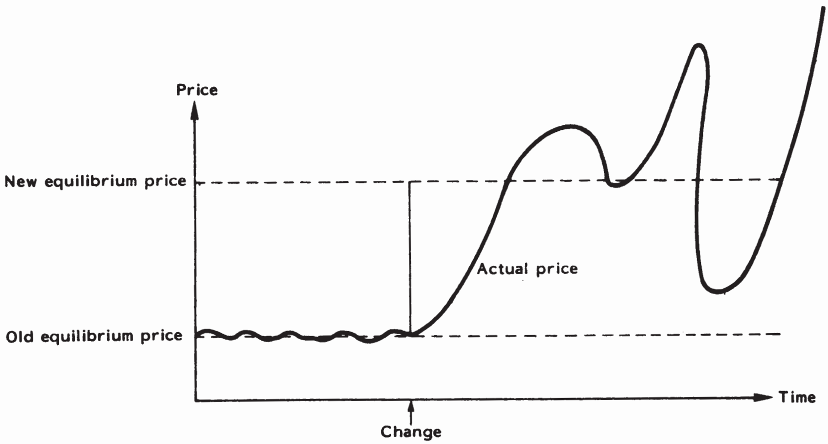
The next section uses these concepts to identify the food and agricultural information system as a process.

4.2 A Systems View of the Information Process

An information system is defined as a dynamic process whose function is the provision of information to support decision making in a specific subject area by a specific set of decision makers. It can also be described as an organization, with its associated structure, statistical and analytical programmes, personnel, budgets and support



(a) Stable



(b) Unstable

Figure 4.4 - Stability of a price-demand-supply system

services. This section focuses on the process description, and points out the importance of feedback in preventing the information system from becoming obsolete. Organizational considerations are addressed in Section 4.4.

4.2.1 Component Processes

The system has five principal components, each of which is also a process (shown as rectangular boxes in Figure 4.5): (a) conceptualization, (b) operational definition of concepts, (c) observation and measurement, (d) interpretation and analysis, and (e) decision making and implementation. These processes interact and take place continuously, as indicated in the figure by the solid double-headed arrows. The target world, which lies outside the information system, includes those parts of the real world relevant to the specific subject area encompassed by the information system -- food and agriculture in this case.

By definition, empirical awareness and knowledge of the target world can only come through the process of observation and measurement -- one of the components of the system. However, it is virtually impossible to know or comprehend every detail of the real world in all its complexity, or even of only the target subset of the real world. Therefore, all empirical perceptions of the world must, of necessity, pass through an observational filter which essentially defines and delimits what is observed and how it is observed. Thus, the adequacy and accuracy of observations and measurements are constrained, in the first instance, by the adequacy and accuracy of the filter.

The filter is the product of two other component processes of the information system: conceptualization and the operational definition of concepts. Conceptualization is the primitive, often subconscious, way people formulate notions of the real world. The resulting concepts tend to be vague and ill-defined. To gather information useful for decision making -- in particular, to design and carry out statistical activities and conduct meaningful analyses -- the vague concepts must be operationally defined. For example, what precisely is a farm, a holding, a parcel? How are they to be measured and in what units? The primitive concepts together with their operational definition, then, become the conceptual framework which is the observational filter.

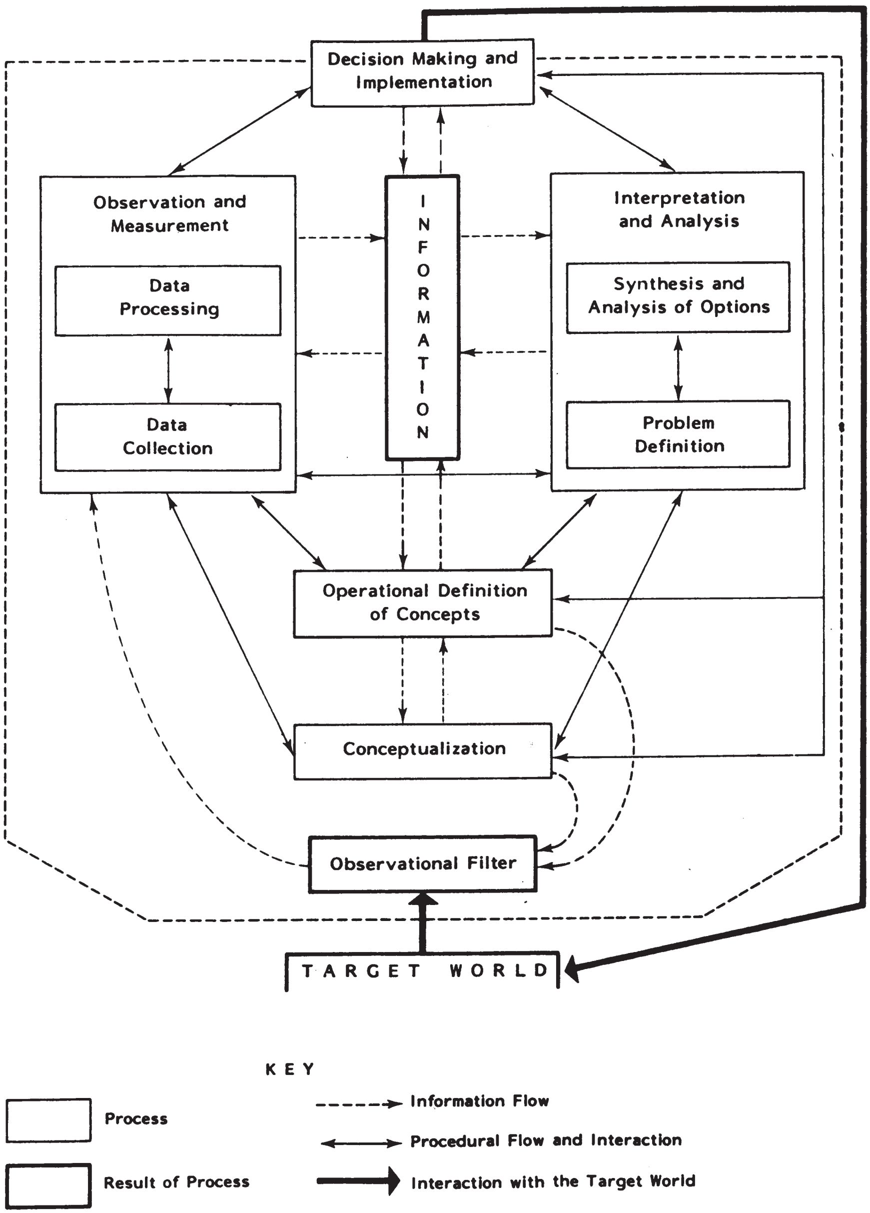


Figure 4.5 - A dynamic information system