SYNERGISTIC COOPERATION IN THE FOOD SYSTEM[1]

by

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Abstract

Meeting basic food needs involves using photosynthesis to harvest solar energy over extensive areas. This work-intensive process can consume the majority of human productive capacity - leaving only small amounts of this capacity to provide other features to which most societies aspire. There are systems of technology which can make food production more efficient in terms of human productive inputs. Because these technologies have high requirements for capital, energy and information they must be "grown" in place. This growing process is made more efficient by synergistic cooperation among many farm input, on-farm and post-farm sectors. Much of this growth and efficiency increase can be financed by having stable and rewarding prices for farm and food products. However, the information developments essential to this growth (food system research and extension) require special attention to their financing and organization.

Basic Food Needs

Despite the fact that we live in the midst of a very advanced technology, each calorie of the energy in the food which keeps each of us going comes only from solar radiation - processed by photosynthesis. The solar radiation is of low and intermittent intensity and distributed over the Earth's surface. The photosynthesis process can convert, in practical terms, a maximum of about 1 percent of solar radiation into food energy in a form that humans can digest, though a more typical value is 0.1 percent.

Human-organized agriculture has traditionally been able to produce 1000 kg of dry carbohydrate-based food per hectare per year (enough for six persons) (Chancellor and Goss, 1976). In order to manage that agricultural hectare farmers have had to manage:

10,000 tonnes of water,
2,500 tonnes of soil and
10 to 100 tonnes of green crop.

As a result, the human inputs involved in food production have required traditionally about 70 percent of the work capacity of the human population. In more favorable agricultural conditions this

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percentage may have been lower, while in less favorable conditions this work requirement may have constituted 90 to 95 percent of the work capacity of the population.

Efficiency in Food Production

Over the centuries there have been some advances in agricultural technology, such as the harnessing of draft animals for agricultural work. During the last one hundred years some economies have seen the development and deployment of food-system-related technologies that have reduced the proportion of human productive capacity necessary to secure food, to levels of approximately 15 percent (Table 1) (U.S. Bureau of the Census, 1997). As part of these technological changes the proportion of human productive capacity devoted to on-farm work has been reduced to about 2 percent (U.S. Bureau of the Census, 1997). At the same time these technologies have permitted the food consumed to include more of the high-resource-requirement animal products and convenience foods.

Table 1

Percentage of personal consumption expenditures for food and beverages used at home *

Country	Percentage
Bangladesh	62.6
France	17.2
Greece	33.9
Japan	17.8
Mexico	33.2
Philippines	54.6
United States	8.8**

* Data from U.S. Bureau of the Census, 1997
** Only 69 percent of U.S. personal consumption expenditures for food etc. were for at-home use.

Although the above-mentioned changes may seem striking, what has been even more significant has been the redeployment of human productive capacity - formerly engaged in food production - into other fields of endeavor, many of which have contributed to the richness of society and civilization - fields such as health, art, education, housing, clothing, transportation/communication, recreation, natural disaster impact minimization, etc. (Table 2)(United Nations, 1997). Furthermore, it has been found that when human productive capacity has been redeployed from the on-farm sector to other producing sectors, this capacity has assumed a more economically productive role than it had served in the on-farm sector (Denison, 1974).

Table 2

Percentages of Private Consumption Expenditures in Various Categories in 1993 (values adjusted for inflation)*

Category	France	Greece	Japan	Mexico	Phil.	Sweden	U.S.
Food, Bev. and Tobacco	18.7	35.4	17.7	37.4	59.9	21.6	11.2
Clothing, Footwear	5.7	5.9	5.5	8.1	3.8	5.7	6.4
Rent, Fuel, Power	18.7	17.9	21.0	13.7	4.1	30.3	17.9
Furniture	7.5	6.8	5.4	11.6	12.8	5.5	6.7
Medical	12.4	3.4	10.0	3.5	----	3.1	14.9
Transport, Communicat.	16.0	15.7	11.6	9.9	5.0	16.3	15.7
Recreation, Education	8.4	6.0	12.9	5.5	----	9.4	11.7
Misc.	12.9	8.7	14.4	11.1	14.2	7.5	16.1

* Data from United Nations, 1997.

How High-Efficiency Food Supply Systems Work

If one were to try to find what permitted and what caused such economic changes and what process pathways did these changes follow, one is faced with an undecipherable mass of time-dependent interactions and features, the antecedents of which have long since disappeared. If one were to identify and extract specific features of a total economy, probably no one of these features would be physically or economically viable in a setting other than the economy from which they were extracted. However, there are some generalizations that may be drawn relative to such changed economies:

1. Without the release of human capacity from the food production sector, few of these other changes could have taken place to the extent that has been seen.

2. The creation, preservation and accumulation of facilities, tools and know-how have been dependent on institutions which permit, encourage and secure such activities.

3. Such changed economies can be characterized by high flux rates of energy, information and economic value (Chancellor, 1969). Whether such economies can exist without non-renewable energy resources is an unanswered question, despite the fact that these flows of non-renewable energy resources are much less than the flow of "renewable" and highly structured energy that we have from the sun (Chancellor and Goss, 1976).

4. These economies have undergone the process of "structural transformation" (Johnston and Kilby, 1975) in which each production unit specializes in the efficient production of a limited number of products using special-purpose tools, materials and knowledge. These products are then shared among all consumers at prices reflecting the efficiency of their production. In such a transformed state every productive element is dependent on the reliable and efficient functioning of many other elements of the economy. Thus the potential for elemental failure, and even total system collapse, is very high. At the same time the potential for rapid regrowth and for development of collapse-avoidance mechanisms is also very high.

It may be seen that the process by which these economies have "grown" into their present state is that of a dynamic form of structural transformation, in which every person or group is looking around for ways to make their own activities more effective and efficient. What these persons find in their "looking around" depends on what there is to be seen, and once they make changes in their productive activities, these changes affect "what there is to be seen" by other productive persons. If one were to examine the economic impact that each productive person or group makes each year, the average result would be only a very small annual improvement. However, because every product is the result of so many productive stages, the overall annual improvement is significant (Alston et al., 1994).

The Quantitative Aspects of Synergism

To illustrate this system for the food-production sector (now representing 15 percent of the human productivity in some societies and 95 percent in others) the following equation is presented:

$$\frac{\text{Land}}{\text{Crop}} \times \frac{\text{Crop}}{\text{Food}} \times \frac{\text{Human resource inputs}}{\text{Land}} = \frac{\text{Human resource inputs}}{\text{Food}}$$

In this example the food production sector is represented by three subsectors, while in reality there are many subsectors (farmers raising seed, selling to farmers raising feed grains, selling to farmers raising young livestock, selling to farmers raising market-weight livestock, for example). The first subsector in the above equation (those trying to reduce the amount of Land per unit Crop) consists of farmers, being supplied by producers of seed, fertilizer and pesticides, providers of irrigation, drainage, soil testing and pest detection services, all being served by research on plants, soils, agronomy, farm management, etc. and by extension activities to connect these research findings to users who can benefit from them.

The second subsector in the equation (those trying to reduce the amount of Crop needed to get a given amount of Food) consists of food processors, crop handling and storage providers, livestock raisers, etc. who are supplied by processing equipment manufacturers, farm and industrial builders, livestock feed manufacturers, etc., all being served by research on food technology, post-harvest practices, livestock breeding and production, nutrition, food safety, etc., and by the related extension activities.

The third subsector in the equation (those trying to reduce the amount of Human resource inputs per unit Land farmed) consists of farmers and farm managers served by suppliers of farm machinery, equipment, computers, management services, fuels, etc., all served by research on farm machinery, equipment and facilities, on farm management and on energy and information resources for farmers, and by the related extension activities.

The reason for presenting the above equation is to show that any advance made in one subsector increases the impact and importance of any advance made previously or subsequently in either of the other two subsectors. The equation also shows that each of us in the food production system can benefit from appreciating, understanding and contributing to the other subsectors as well as the subsector in which each of us as an individual may be working. This means that persons who engage in all-out economic or allocation conflicts between crop production activities vs. farm mechanization (for example) are persons who do not understand the complete picture. It is also implied by the equation that if persons in one or two of the above-mentioned subsectors think that activities in the remaining subsector are not important, that they are really jeopardizing the effectiveness of their own work.

Constructing High-Efficiency Food Supply Systems

Reducing the proportion of human productive capacity necessary to provide food for everyone in a given society is an enabling element in the "structural transformation" of that society. On the surface this tends to support the "strategic notion" (Tomich et al., 1995) of the advisability of a cheap food policy for a national economy. Very few governments are in a position to subsidize food costs for very long. Thus, it is of interest to see if agriculture can be made more efficient by encouraging structural transformation of subsistence agriculture (Johnston and Kilby, 1975). One knowledgeable economist isolated five essential elements for subsistence agriculture to undergo structural transformation (Mosher, 1966) These are:

1. Production incentives for farmers
2. Markets for farm products
3. Local availability of supplies and equipment
4. Transportation
5. Constantly changing technology

It can be seen that all of these five essentials require economic resources to be placed at key points in the economic system - not necessarily on farms. The principal objective is to get these resources to be generated primarily within the agricultural system. The main mechanism for achieving such an objective is to maintain sufficiently high prices for agricultural products. These prices themselves can provide production incentives for farmers, encourage the development of markets for farm products and give farmers the economic resources to encourage suppliers of farm equipment and supplies to do an effective job of marketing their products.

Once farm productivity begins to increase the surpluses of agricultural products will result in lower prices to consumers and economic encouragement of livestock production and of food processing industries. Lower prices to consumers makes it possible for industries to expand without incurring undue labor costs.

Not mentioned above are "transportation" and "constantly changing technology". The infrastructure developments associated with transportation (and similarly with irrigation and drainage) are of a nature most suitable to regional or national development (Mosher, 1969). The resources needed for such investment can only be linked to expectations of heightened economic activity associated in part with increased and more efficient agricultural production over a longer time span (Fig. 1) than is associated with plans made by individual farmers or business managers. A constantly changing technology and the extension programs to link it to producers are subject to a sizable degree of uncertainty in their establishment and execution - particularly with regard to agriculture. This aspect discourages private firms from undertaking such activities - at least until a system for more certain economic return becomes clear. Such clarity is frequently associated with situations in which the outcome of each research activity is fairly certain to be of economic value. Thus, commercial firms, when they do engage in agricultural research, usually conduct applied research - as contrasted with exploratory research (Alston et al., 1994).

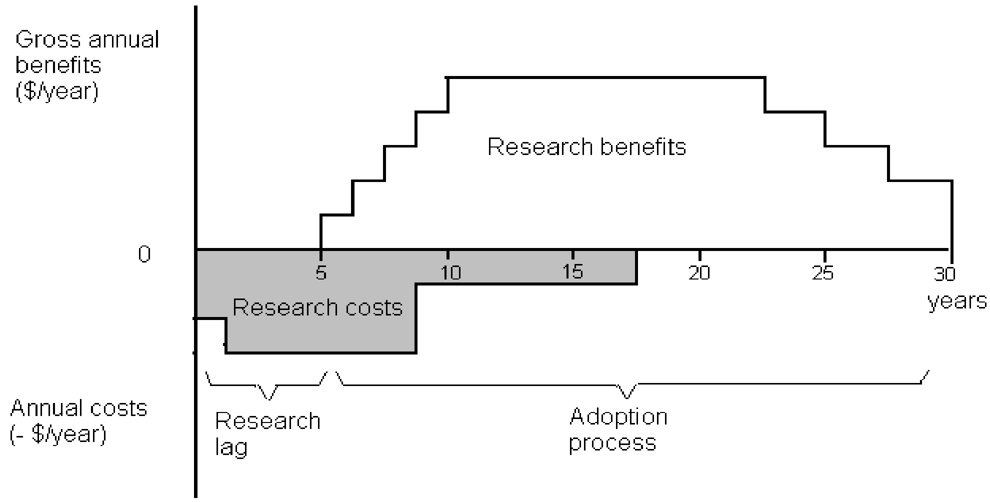

Figure 1. Benefits and costs over time for an agricultural research program, (Alston et al., 1994).

Conclusion

Only upon understanding (a) the key role of food system efficiency in the development of society, and (b) the synergism among all fields of food system research and practice, is it possible to justify and manage investments of resources in food system research and extension. Only when everyone, in general, holds these understandings is it possible for a society to tolerate the uncertainties as well as the time delays between investment and benefit, and to bear the burden of everyone having to always be "looking around" for ways to make their own activities more effective and efficient.

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