Policy and Research Issues in Irrigation Management for Crop Diversification with Special Reference to Sri Lanka

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INTRODUCTION

IRRIGATION MANAGEMENT FOR diversified cropping, or crop diversification of rice-based agriculture in general, is an important research and policy issue which has been attracting a lot of attention in Sri Lanka as well as elsewhere in tropical Asia. The rapidly growing body of literature in the field best testifies to this increasing attention in recent years (IIMI 1987; Schuh and Barghouti 1987; World Bank 1988; Bhuiyan 1989; Miranda 1989; Valera 1989; IIMI 1990a). A basic factor, among others, behind such a rather abrupt proliferation of research in this field is the fact that the rice sector of many countries in this part of the world has come to a turning point; the introduction and diffusion of new rice seed-fertilizer technology coupled with the expansion of irrigated rice land in the last two decades or so has helped a number of countries in the region to either approach or attain self-sufficiency in rice, with a consequence of a long-term declining trend in the world rice price. The farmers in rice-based irrigation system need to diversify their income sources, while the demand for agricultural products diversifies from the major staple to various non-staple items as the economy grows. A logical deduction is that diversification of rice-based agriculture in general and crop diversification of rice-based irrigation systems in particular, and research thereof, are a necessity.

It is well-recognized that the nature of this issue of irrigation management for crop diversification in rice-based systems is so multifaceted that multidisciplinary approaches, embracing engineering, agronomy, soil science, economics, management, and other social as well as natural sciences, are necessary in its research. In fact, research in this field, as any other farming-system research, has usually been carried out in this multidisciplinary mode. Generally speaking, however, this multifaceted nature of the issue, coupled with its very location specific nature, often leaves research in this field at loose ends, e.g., partiality in analyses with certain ad hoc assumptions in facets that are not in main focus, difficulty in

deriving general conclusions/principles that could be applicable under different settings, research-based recommendations that are rarely followed by farmers in actual farming, aiid the like. In other words, the multifaceted nature inherently makes the issue/subject of crop diversification elusive, which means that, whenever certain research in this field is undertaken, it is always important to keep in mind the entire structure of the issue in its full spectrum while identifying clearly the specific problems to be addressed in the research.

The purpose of this paper is to reexamine briefly, mainly based on recent literature in the field in general, and experiences in Sri Lanka in particular, the structure of crop diversification of rice-based irrigation systems as an object of research and policy in order to facilitate understanding of the configuration and weak (often missing) links in this multifaceted research/policy topic. The primary intention of doing such a "thought exercise" is to help refine research subjects to be studied under this research network. It is further hoped that the exercise would be useful in promoting successful crop diversification in the irrigation systems in Asia where few countries, including the fast-developing east Asian countries, have been fully successful so far in attaining it on a sustainable basis.

BACKGROUND AND DIMENSIONS OF THE ISSUE

If crop diversification, or, more generally, agricultural diversification is defined as the process of broadening and maintaining the sources of incomes of rural households, as defined in a World Bank report (World Bank 1988; Schuh and Barghouti 1987), it is not a new issue. The origin of the issue could be traced back at least lo the eighteenth-century Agricultural Revolution in England, if not to the early civilizations in Mesopotamia and the Nile Delta.

Structural Transformation and Agricultural Diversification

As an economy starts growing from a static, traditional agriculture-based society to a dynamic, industrial one, the traditional agriculture, which is characterized by producing a limited list of traditional staple food crops, is bound to be diversified, in order to meet the increasing demand for lion-traditional food commodities. This process begins with increases in the productivity of traditional agriculture due to technological advances. Accompanying this is a relative decline in the importance of the agricultural sector as a whole in the total economy, which process is called "structural transformation." In this broadest framework or dimension, agricultural diversification and structural transformation are two sides of a coin; as an economy develops, rural households are forced to maintain and increase their incomes through diversifying their farming while transferring some of their resources, especially labor, to other income generating activities in the nonfarm sectors.

At the dawn of the industrial revolution, British crop agriculture experienced a major transformation in which the old cropping pattern was replaced by the Norfolk crop rotation with such new strategic fodder crops as clover and turnip. In nineteenth-century Denmark,

Danish agriculture successfully transformed itself through diversification from the old grain-based pattern to the one based on a new crop-livestock combination. In the early twentieth century, Japanese rice fanners succeeded in introducing sericulture production into the rice production cycle with a result of significantly diversifying their income sources. All these early examples of agricultural diversification occurred in response to changes in productand factor markets within a broader framework of structural transformation (Hayami 1989).

Of course, we do not always have lo go so far in dealing with the contemporary issue of crop diversification in Asia, which emerged in sharp profile in the 1980s because of the historic low level of world rice (and wheat, to a lesser extent) prices in the early 1980s, which in turn was partly a result of the successes in "Green Revolution" technology in Asian developing countries. In pursuing crop diversification, governments in these countries (which have promoted self-sufficiency programs in staple foods). donor agencies (such as the World Bank and ADB, which have invested in crop specific agricultural projects), and practitioners of international agricultural research institutes (who have been mostly crop specific), arc concerned mainly about low levels of world prices and the surplus situation in production of staple food crops, resulting in low incomes for the fanners producing these crops, and low rates of returns on the investments that have been made thus far inagriculture. particularly in irrigation infrastructure.

In such a context, agricultural crop diversification tends to be considered as a problem within the agricultural sector, or even within the smaller sector of "irrigated agriculture." In the case of this research network on crop diversification, the focus is naturally confined to the "irrigated agriculture" sector. The issue can be dealtwith at each level, from the fanners' field level to the macro-economic level. However, it should always be recognized that, since crop diversification in Asia is inevitably a part of the structural transforination process of the economies, policies for diversification at each level must be consistent with each other and with the broadest framework of structural transforination.

The process of structural transformation is nothing but the process of economic development that requires efficient resource allocation. One immediate implication of this understanding is, therefore. that policies for agricultural diversification at the macro-economic level and at any lower level should be such that efficient resource allocations among the sectors of the. economy as well as within the agricultural sector and between its subsectors are facilitated.

Rural Poverty and Diversification

On the other hand, the process of structural transformation is nothing but the process of adjustment in which the agricultural sector adjusts itself to new economic conditions that arc created by economic development. This adjustment is not cost free, but rather entails painful costs to the agriculture sector. Most distinct among them would be increases in income inequity in the society, which is an inevitable consequence of the development, the intrinsic nature of which is unbalanced growth among the sectors. There has been a growing concern among governments and donor agencies about this problem, and, as a consequence, existing policies for agricultural diversification at any level very often aim at alleviating poverty or improving the income distribution in rural areas.

Difficulties arise if the relationship between these two basic problems, efficiency and equity, is not one-to-one, and unfortunately this is often indeed the case. At least in the short run, the potential solutions to these problem do not necessarily correspond. The best example to illustrate this difficulty can he found in pricing policy, which is always central to any policy framework for agricultural diversification at any level. Price support for a certain crop is obviously the easiest and most effective way to maintain or improve the income level of the farmers who grow the crop, and therefore it is always a strong temptation for policymakers to resort to this measure. It is also obvious, however, that, by keeping the price of a crop higher than the equilibrium level in the market, the resources that otherwise leave for other sectors remain in thr crop sector, thus impinging against the efficient resource allocation and thereby structural transforination. Although huge budgetary costs that are to he borne by the governments if price support is extended beyond a staple crop lo othrr subsidiary crops virtually negate this option in diversification policy, economists arr. usually not in Savor of price support mainly on account of efficiency consideration in the long run (Timmer 1986).

Conventional wisdom among economists as to this trade-off between efficiency and equity is that economic development based on efficient resource allocation in the long run solves the income distribution problem; this is the U-Curve Hypothesis found by Kuznrts (Kuznets 1955) and further evidenced empirically by others (e.g., Ahluwalia 1976). Taking this wisdom as granted, a practical solution to this trade-off is to introduce explicit timr dimensions into the argument; when changes are so abrupt and adjustment costs are so high that the welfare of the losing party is intolerably endangered, adopt some kind of price-stabilizing measures in the short run, while not losing the sight for efficiency in the long run. This argument directly implies that thr issue of agricultural diversification involves different time dimensions; diversification policies intended to mitigate adjustment difficultirs in the short run must not override the efficiency perspective in structural adjustments in thr long run.

Diversification and Changing Role of Irrigated Agriculture

The recognition that the problem of rural poverty could he solved only through the development of the entire economy reminds us of thr role of the agriculture srctor in economic development. As explained in development economics textbooks, an important role of agriculture at an early stage of economic development is to supply resources, financial as well as human, to the rest of the economy. In developing countries in Asia, rxcrpt in traditional rice exporting countries, this role has been mainly playrd by the plantation sector (Thorbecke and Svejnar 1987, for the Sri Lankan case), and the irrigation sector has been absorbing from the other sectors resources mainly in the form of irrigation investments. This direction has been right; it was imperative for the development of a country to establish a productive domestic food production sector. Many countries which neglected their food sector in the past paid a high price in terms of lost development.

However, now that the irrigated land base has been well-established in many of these countries with near or full ricr. self-sufficiency, the role of the irrigation srctor should hr changed from a resource takrr to a resource contributor to the rest of the economy. Thr shift

from the traditional "construction" phase to the "management" phase, which has been going on in the irrigation sector in Asia (Aluwihare and Kikuchi 1990), releases a bulk of resources from the sector. Crop diversification in the sector with import-substituting and/or export promoting nonrice crops will further strengthen this role of the irrigation sector to the economic developrnent of the economy as a whole.

Crop diversification in the irrigation sector thus considered, therefore, precludes any policy which envisages a continuous net inflow of resources to the irrigation sector on a secular basis. The introduction of price support measures at a significant scale for nonrice crops is one such policy which naturally ends up absorbing, not supplying, resources from the rest of the economy in an unproductive manner. It should always he clear that, when considered in the broader context, crop diversification is more a means or process to attain economic development, rather than an objective by itself.

Diversification as an Endless Process

A more crucial implication of the whole argument above is that agricultural/crop diversification is a process of dynamic adjustment rather than a static target of establishing certain cropping patterns. The elusiveness as a policy issue largely stems from this characteristic of crop diversification. How it makes diversification policy difficult to deal with is apparent if compared to the policy for rice sell-sufficiency which offers a very clear-cut stationary target. In diversification policy, there cannot be such a target, or, if any, it is at best a "moving" target. Since racb country has heterogeueous agricultural regions, it is not possible, nor feasible, to set up a certain cropping pattern for the country as a whole. Certain cropping patterns may be established specific to a certaiii region or area of a country, but they keep changing according to changes in the outside world. In certain agricultural regions/areas, the best opportunity for diversification inay exist in switching a part of the rural labor force from the nonfarm sectors while an increase in the size of operation is being required in the farm sector.

Given such a distinct nature of the issue, the only definite policy target that can he established, cutting across the full range of the issue, would he to build flexibility into agriculture in general, and the traditional staple crop production system in particular, by which the never-ending adjustment process is made smoother. This should he the strategic target for whatever policy related to agricultural/crop diversification: price and income policy, investment policy, land and labor policy, market and credit policy, research and extension policy. and so on. A good example of the need to build in the flexibility is found in the irrigation systems in Asia which are constructed and operated solely for growing rice. An attempt to make such rigid systems amenable to diversified crop production, which is the major research theme of this research network, is nothing hut an effort to bring about flexibility in irrigated agriculture.

Horizontal and Vertical Diversification

Finally, in this section, a short remark should be made on geometric dimensions of the issue; horizontal and vertical diversification. Agricultural/crop diversificatioii intended in the preseut Asian context is primarily horizontal diversification; diversification through the introduction of nonrice crops in replacement of, or in addition to, rice.

It should be noted that at the national level, horizontal diversification can he attained through regional "specialization." Because of possible regional comparative advantages resulting from soil-climatic couditions and other location-specific factors, and of the economies of scale, this could he an efficient route to national level diversification. In fact, this method has been the major one adopted by developed countries, such as the U.S.A. and Japan, in their diversification processes. Among the developing countries in Asia, Thailand is the country that is most often mentioned as successful in diversifying agriculture. Although crop diversification in the rice-based farming system has been in progress in some regions of Thailand (Plusquellec and Wickham 1985), the major stream of agricultural diversification has been through "specialization" away from rice (World Bank 1988). There is a serious implication for attempts to diversify crops in rice-based farming systems while keeping rice as a major crop; such attempts are handicapped in terms of exploiting efficiency to the extent that comparative advantage and scale economies of such a system diverge from those in "specialized" systems.

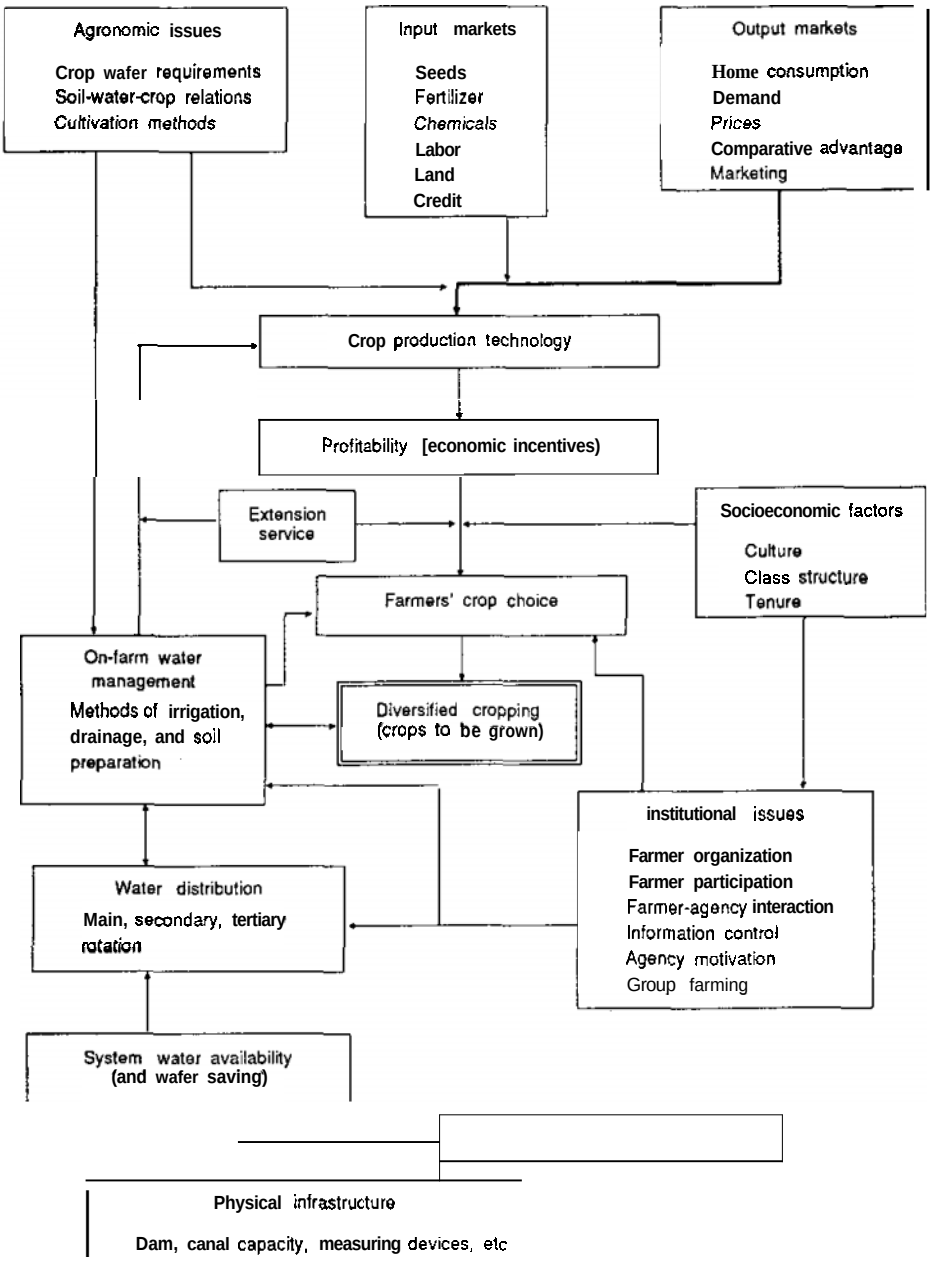
Vertical diversification refers to a process in which value-added of certain crops is increased through processing the crops iuto otber commodities, e.g., rice to rice cake, soybean to soybean curd, mango to mango juice, etc. Since the potential of diversification in this direction in increasing the income-earning opportunities of rural population is no doubt large, any policy towards agricultural diversification should take this potential into account. Here too, however, the economy of scale through specialization would work critically in many fronts; marketing, processing plants, quality control of raw materials, etc. We have to recognize that diversificatioii in rice-based farming system may have disadvantages in this respect too.

RESEARCH FACETS AND THEIR LINKS: DIVERSIFICATION IN RICE-BASED SYSTEMS

The issue of crop diversification is multifaceted, and so, any general discussion on this issue includes some kind of enumeration of the facets involved. For instance, the World Bank report referred to in the previous section, categorizes the facets into agronomic, technical, and economic factors (World Bank 1988), while Moya and Miranda (1989), dealing specifically with crop diversificatioii in rice-based irrigation systems, organize their discussions into technical, economic, and social and institutional issues.

A similar attempt to show research facets involved in the issue of crop diversification in rice-based irrigation systems. and links between them, is presented in Figure 1. Here, thr issue is divided into fourgroups of sub-issues: a) engineering; b) agronomic; c) institutional;

Figure 1. Engineering agronomic, institutional and economic issues related to crop diversification.



and d) economic. The engineering components are shown in the southwest corner of Figure 1 in several boxes. Similarly, the economic components are shown from the northeast corner (output and input markets) to the center (farmers' crop choice).

Facets

Engineering facers. The engineering issues can be classified into a few components of different dimensions: structural capacity of irrigation schemes at different levels from the main system down to the fanners' field, and water management at respective levels.

Since nonrice crops generally require water in ways that are different from rice, the structural capacity of irrigation systems which were designed and constructed solely for growing rice may not he adequate for irrigating nonrice crops. Continuous delivery of water at low tlow rates in the main part of the systems is typical for rice irrigation, whereas many nonrice crops require intermittent water supply with high flow rates. The capacity of a conveyance system for rice may not be adequate. The intermittent water supply may require more controlled water release, which may, in turn, necessitate better measurement devices at various levels of the systems. Some argue that substantial costs will be entailed in converting rice-based system into multiple-cropping systems (World Bank 1986, 1988 Bhuiyan 1989).The issue of how to make rice-based irrigation system flexible to accommodate nonrice crops in relation lo their physical capacity comes under the heading of "physical infrastructure" in Figure 1.

Recent research carried out by IIMI and others suggests that rice-based irrigation systems indeed have the flexibility to make it reasonably possible to grow nonrice crops in the dry season (Miranda 1989; Bhuiyan 1989). If this is taken forgranted, then comes the question of how to manage the systems towards nonrice crop cultivation which generally requires furrow irrigatioii as opposed to basin irrigatioii for rice cultivation. The management issues associated with the shift from rice to nonrice crops may be dealt with according to different levels in the systems, from the main system down to the farmers' fields.

At the main system level, water availability in a system for a certain season is determined by the physical structure of the system, and hy rainfall and other associated factors; given the water availability, water release and distrihutioit plans at the main, secondary, and tertiary levels are made, and, at the on-farm level, proper methods of irrigation and drainage for nonrice crops are determined. The issues at each level, needless to say, are closely related to each other. For instance, the availability of water and the type of rotation needed for intermittent irrigatioii depend on the type of crop to be grown.

Considered along this line, oil-farin water management seems to be an issue which has been relatively better researched as compared to main system management for diversified cropping. It is often said, for instance, that diversified cropping could save the water in the system which can be utilized to expand the planted area in the same season or in the following seasons. If this were the case, crop diversification would be instrumental in enhancing the efficient use of scarce water (Moya and Miraiida 1989). Little evidence, however, has been accumulated to demonstrate this impact.

Agronomic *facets.* Issues such as crop water requirements and soil-water-plant relations come under this facet. Rice is the plant that is best grown with wet puddled soil and/or with

ponded water, while nonrice crops fit lighter soil textures, and can withstand neither waterlogging nor prolonged water stress. Cultivation of nonrice crops on lowland soils has inherent disadvantages relative to lowland rice. On the research side, agronomy of lowland rice cultivation has been one of the best-researched fields, and that of nonrice crops under upland conditions also has a long research history. Reflecting the disadvantages, agronomy of upland crops to be grown in lowland paddies has been a relatively neglected field of research, though efforts have been made in recent years in this field (FAO 1984,1986).

Institutional facets. Nonrice crops, if grown in rice-based irrigation systems, generally require more deliberate delivery, distribution, and management of water than rice does. Diversified cropping is more demanding in terms of system operation and management. The management practices adopted in rice cultivation, typically top-down planning and implementation, are in most cases not congruent with diversified cropping (Stone 1987). The deep-rooted rice monoculture pattern in these systems has brought about among the managers of the systems an ingrained mentality of low-intcnsity, safety-first type of management (Moya and Miranda 1989). All issues related to making irrigation system management flexible and accountable to farmers' needs fall under this facet.

Examples of the issues in this facet, among others, are: the role of farmers' organizations and their participation in system management; fanner-agency interaction and interface; information channels and control; agency motivation; and so on. It should he noted that many issues in this facet are not specific to crop diversification. Most of them are issues that are applicable to the systems where rice is the sole crop lo be grown. Diversified crops only make the issues more acute than otherwise.

Economic facets. The issues in this facet revolve around the profitability of nonrice crops which are supposed to replace, or be added to, rice in rice-based systems. When reviewing the literature on crop diversification in general, not necessarily limited to that of rice-based systems and even excluding that written by economists, it is rather difficult to find a paper which has no mention of market and marketing problems, profitability of nonrice crops relative to rice, the needs of credit provisions, and other related economic issues.

These economic issues can be arranged according to the flow of the issues as shown in Figure 1. First, the markets, both for outputs and inputs, determine the prices. Second, these prices together with production technology available lo the farmers determine the profitability of crops. And, third, the farmers choose crops to be grown depending on the profitability.

Some qualifications are necessary along this line. First, the issue of "marketing" is an important part of "market issues." The market is the mechanism through which price signals are transmitted. There are cases where the market is either not working well or even nonexistent. For instance, it is an often heard problem in the crop diversification business that crops grown by farmers cannot find buyers, or that some inputs for nonrice crops, such as seeds and fertilizers, are not available to farmers in time. These are typical marketing problems in which high "transaction costs" due to imperfect markets are involved; the "real" prices to the farmers are lower for outputs and higher for the inputs than the "nominal" prices by the transaction costs.

The second qualification is that the tenn "profitability" here is a loosely defined one; it does not necessarily imply that the farmer is a "profit" maximizer. He may be so, or he may he an "income" maximizer. What he maximizes may depend on the basis on which he operates his farm. This leads to the third qualification that farmers' decision on crop choice may be restricted not only by economic consideration of their own but also by other factors such as their status in the farming community. The fourth qualification, also related to this, is on distributive impacts of diversified cropping, which are determined by crops to be grown, prices in output and input markets, production technology, and the ownership of the inputs used in the production process. Crop selections made by individual farmers imply certain income distribution consequences to the farming community. Their selections could diverge from the ones which give the highest income increase to, and the best income distribution in, the community.

Links

Apparent and obvious links exist among the facets. It could be said that crop diversification in rirc-based irrigation systems is a research issue which should be studied in its entirety to observe how these facets are closely related lo each other, rather than study each facet independently.

For example, the issues of "on-farm water management," classified as a part of the "engineering" facet in Figure 1, largely overlap those. of the "agronomic" facet. Without knowledge on soil-water-plant relations for a certain nonrice crop or a sequence of crops, irrigation and drainage methods to he adopted on farmers' fields cannot be determined. Similarly, given specific characteristics of an irrigation system, such as soil, water availability, and possible water dclivrry plan, the best cultivation methods for nonrice crops must he sought. Water management at the farm level and agronomic potentials together determine the level of "crop production technology," or production functions in economic terms, available to the farmers. Water availability at the farm level may affect even more directly "farmers' crop choice," as pointed out by some observers (Miranda 1989,Bhuiyan 1989).

The issues in the "institutional" facet are also associated intimately with other facets. Planning and implementation of water delivery and distribution in a system for diversified crops are issues more of management (therefore institutional) than ofeagineering. in which agency's motivation arid accountability to farmers' needs, fanner-agency interaction, and information control are all more demanding than in the rice monoculture system. Needs exist not only on the side of the managing agency but also on the side of farmers to be better organized for ensuring more precise water management at tertiary as well as on-farm levels. More often than not, diversified cropping in an irrigation system requires collective actions of certain degrees among the farmersin the system, even for the choice of crops to be grown. If so, the choice of crops becomes an institutional issue rather than a narrow economic issur of an individual fanner's decision making.

In addition to the facets explained thus far, two more facets are. shown in Figure 1; extension service and socioeconomic factors. The importance of the former is obvious. The farmers in rice-based irrigation systems are used to growing rice, and nonrice crops to he grown may be exotic fur them. In such cases, productioii technology for nonrice crops,

without effective extension services, remains as potential, not available to the farmers. It may play a critical role, if the choice of crops is to be made collectively.

In Figure 1, socioeconomic factors are distinguished from "economic" factors in order to make the flow of issues in the latter clearer. If the related markets and production technology are given, and if fanners are profit maximizers, the issue of economic profitability and crop choice is fairly straightforward, even though risk and uncertainty inherent in nonrice crop cultivation, as compared to rice, complicate the issue. However, farmers operate in a certain cultural domain wherein class structure and other social traits restrict the process of agricultural production and the distribution of generated incomes in the community. To the extent that the markets, particularly labor and land markets, diverge from the typical impersonal market, and are endowedwith cultural and institutional traits, the socioeconomic factors as defined here give more decisive impacts and effects to the "economic" factors. The socioeconomic factors as such are also closely related to the "institutional" issues. Without due understanding of the basic cultural characteristics of the community, it is rather difficult to think of sustainable solutions to the institutional issues.

WEAK AND MISSING LINKS THE MARKET

Central to the interlocking issue of crop diversification in rice-based systems in Figure 1 *is* "crops to be grown," which replace rice. Unless a list of substitute crops is specified, neither agronomic nor engineering research on-farm water management can be designed. Even if some crops are recommended by authorities, farmers may not adopt them for economic or other reasons. Without viable nonrice crops, the whole business of crop diversification docs not go ahead at all, which would be the worst nightmare crop diversificatioii advocates can ever have. All this means that a series of issues in the "economic" facet of Figure 1 are vital to the whole issue.

Output Markets

First of all, it should be pointed out that the issue network in Figure 1 is open-ended toward the northeast corner of the figure. That is, the output markets in general lie out of the control of the system management and of the fanners in the systems, and in most cases, even of the government policymakers. All changes, which occur in the markets outside the systems, depending on changes in demand and supply, domestic as well as international, are brought into the system and affect directly the profitability of crops, and hence the list of crops to be grown. The input markets have similar characteristics, but to a much lesser extent. Fnr instance, a change in fertilizer price affects the agricultural income, through the production process, of certain crops grown. However, the cost of fertilizer is only a part of the total production cost, and the price. change affects, more or less alike, all crops that need the fertilizer.

This open-ended nature makes the issue of crop diversification elusive and keeps its target moving. There exists some uncertainty in other facets of the issue too. For instance, water availability in a system depends on rainfall which is beyond the control of managing agency and farmers. However, this problem of stochastic nature can, or should, be dealt with at the system level, and does not break the completeness of issue structure in that end. With less available water, for instance, crops which require less water can be selected, provided that such crops are economically viable, which depends eventually on the output markets.

The fact that crop selection at the system level is subject to market conditions outside the system means that crop diversification in rice-based systems as a research and policy issue comprises at least two different levels: the national and the system levels. Since any attempt at the system level to establish the list of crops is constrained by the conditions at the national level, and not vice versa, it is critical to have a clear understanding on the markets and a clear policy at the national level as to crop diversification. Although policies at the national level affect not only rice-based irrigation systems but also other subsectors of agriculture, such as rain-fed agriculture, firm policies at the system level cannot be spelled out without them. In most of the countries where effons have been made to diversify crops in rice-based systems, the most serious gap seems to exist in this macro-level policy/understanding, in general, and interaction between the macro-national level and the micro-system level. in particular.

The literature in the field, available at hand, gives a mixed picture about the nonrice.crops that perform better than rice in terms of economic returns and which can, thereby, replace it in rice-based systems. Some of the literature show that there are nonrice crops which are more profitable than rice (e.g., Adriano and Cabezon 1987, for the Philippines, Miranda 1989, for Indonesia, the Philippines and Sri Lanka). Some others fail to identify such crops (e.g., World Bank 1986 for Thailand). Our study in Sri Lanka reveals that possible nonrice crops for rice-based systems can be grouped into two broad categories: low-value crops which generate value-added at best as high as, or generally lower than rice, and high-value crops of which value-addcd is far better than rice (IIMI 1990b). Most traditional food crops such as corn and various legumes fall in the first category. The second group consists of traditional high-value crops, such as chili and onion, and exotic exportable crops, such as gherkin and asparagus. If nonrice crops were to be substituted for instead of adding to, rice in crop diversilication, only those in the second group could be candidate crops (Table 1). It should be noted that these high-value crops are characterized by very high labor and capital intensity as compared to rice production.

It should be noted further that these results are obtained using micro-level data. It is suggested therefore that, given the present price structure and technology, there are some nonrice crops that can be substituted for rice, though the list of such crops is rather short. What is not known is the list of nonrice crops in the medium- to long-run where both price and technology are variable.

Chili, in Sri Lanka, would be a good case to illustrate the nature of the problem, particularly of traditional high-value crops which are produced mainly for domestic consumption. This is the crop which has traditionally been planted, mostly in the Northern Province of the country, but, because of its high substitutability for rice, it has become an important nonrice crop in recent years in rice-based irrigation systems in Sri Lanka, particularly in the North-Central Province..The statistics in Table 2 are from the Agricultural Research and Training Institute (ARTI) of Sri Lanka (1989).

Table 1. Comparison of profitability, and requirements for irrigation, labor and capital, between rice and selected nonrice crops; the case for Sri Lanka.[a]

	Chili	Red onion	Gherkin	Sugarcane[b]	Green gram	Soybean	Cowpea	Rice
Crop duration (days)	200	90	100	300-400	85	90	85	90-120
Irrigation frequency (days)	6	3-4	3-4	–	7-10	10	7-10	
Number of irrigations	20	20	20	–	7	7	–	–
Water duty (mm)	500-700	600-800	700	1000-1500	250-450	250-450	200-400	600-1500
Yield[c] (mt/ha)	1.2	10.00	6.5	139	1.0	1.5	1.0	5.0
Price[d] (Rs/kg)	67.00	9.00	11.7	5.00	20.00	8.00	12.10	6.40
Value added[e] (Rs 1,000/ha)	72	72	52	32	17	11	11	27
Farmers' income[e] (Rs 1,000/ha)	56	54	41	19	12	7	7	21
Labor requirement[f] (days/ha)	700	600	800	260	220	170	290	108
Labor productivity	115	150	95	267	91	71	42	296
Capital requirement[g] (Rs 1,000/ha)	23	35	35	16	7	3	3	12

[a] For data sources, see IIMI (1990b, 206).
[b] Averages for plant cane, 1st and 2nd ratoons. In order to make the data comparable to other seasonal crops, for the rows on and below "value added," figures shown are in terms of average for six months.
[c] Average or typical yields under irrigated conditions.
[d] Average or typical prices prevailing in the 1989 yala (dry) season.
[e] Assumed typical value added ratio and farmer income ration for the crops.
[f] Average or typical labor requirements.
[g] The summation of costs of current inputs, fixed capital services, and hired labor.

Table 2. Domestic production and imports of chili, 1987-89, Sri Lanka.

Year	Annual domestic production		Imports	
	Quantity (mt)	As percentage of the country's requirement	Quantity (mt)	As percentage of the country's requirement
1987	27,624	86.3	2,100	6.3
1988	36,313	111.3	11,406	32.5
1989	45,727[a]	138.5	6,750[b]	na

[a]

The domestic production of chili bas been increasing quite rapidly due mainly to the increase in its cultivation in rice-based systems. As a result, it is estimated that the domestic production exceeds the domestic requirement of the crop by **10-40** percent. A puzzling picture however emerges, if we look **ai** the import statistics of chili which shows that the imports have also been increasing, makmg the total supply-demand ratio around or more than 1.5. Had these statistics been reliable, and should the demand elasticity of chili been rather **low** as slated in ARTI (1989), the domestic price of chili would have declined drastically. However, such a drastic decline in the price due to this oversupply has, fortunately to the farmers, not been reported yet, though !he real price to the farmers has declined slightly from the end of **1987** lo **1989.**

The puzzle is why the oversupply bas not resulted in a sharp price fall. There are three possible explanations: first, the data on production are not reliable; second, the data on consumption are not reliable or the domestic demand for chili is more elastic than expected; and third, a part of domestic production was exported (this means that the demand curve is highly elastic). Unless the right answer to this question is given through further research, it is too dangerous to promote chili cultivation beyond the present level. If the first explanation is right and if the demand curve for chili is indeed inelastic, the result of overproduction could be disastrous to the fanners.

What this "chili problem" suggests istheneed to have good knowledgeonoulputmarkets, international as well as domestic. Without it, no firm national policy for crop diversification can be established. In this sense, it was a quite legitimate approach that was taken for crop diversification research in the Philippines, in which IIMI-ADB irrigation management research was preceded by IFPR[1]-ADB food crop sector research (Rosegrant et al. **1987).** The type of analysis made in this study using the domestic resource cost approach (e.g., comparative advantage, import substitution, and export promotion), are quite useful and essential for realizing the configuration of nonrice crops to be adopted for crop diversification, although this approach itself is static in nature so that it has certain limitations. Going into crop diversification without this kind of information is just like sailing in an ocean without a compass. Not only in Sri Lanka but also in other countries, this kind of research should be done periodically.

It may he interesting to note that this Philippine study by IFPRI shows that rice still has a comparative advantage and is one of the most efficient crops to be grown in irrigation systems (Rosegrant et al. **1987:** Gonzales **1989).** This could **he** the case for other countries loo, implying that, if crop diversification is to be promoted, more research to improve the productivity of candidate nonrice crops relative to rice would be a prerequisite. A basic contention of promoting crop diversification in rice-based systems is that many developing countries in Asia have attained or are approaching self-sufficiency in rice. This study and some others (Bhuiyan **1989)** suggest a need to reexamine this contention periodically in the light of rapid changes in demand due to population increase and general economic development, and in agricultural technology. The national policy on crop diversification in rice-based systems cannot be independent of the national policy on rice.

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Marketing

Marketing is the most often mentioned weak or missing link in crop diversification. This pertains to the issue of the "market" as explained earlier. The existence of a "marketing" problem could be an obvious sign of insufficient demand in the market. More often than not, however, the problem could be due to the underdevelopment of market channels through which price signals are transmitted from the markets to the fields and through which crop products are marketed the other way around. The agricultural/rural marketing systems in developing countries are complex, comprising numerous actors, such as middlemen, local traders, transportagents, processors, export agents, and governmental or semi-governmental marketing agencies. In spite of the fact that an efficient marketing system is critical not only for crop diversification but also for agricultural development in general, little attention, beyond the mere mentioning of its importance (Schuh and Barghouti 1987, World Bank 1988), has been paid to this sector.

This negligence of rural marketing systems can be explained partly by the traditional, stereotype image of middlemen and merchants: the ones who exploit peasants through the practice of monopolistic pricing and usury. The fact that most of rural marketing systems in developing countries belong to the informal sector has also made it difficult lo study this sector. However, recent studies have been accumulating evidence that indicate that indígenous rural marketing systems are quite competitive and thereby efficient in transmitting price incentives (Siamwalla 1978, Unnevehr 1984, Hayami et al. 1987). It should be remarked that these studies were done in the areas where crop diversification has been most progressive, such as Thailand and Java, Indonesia. This evidence, coupled with the evidence that governmental organizations are typically less efficient in the field of marketing, imply that the role of the government with respect to rural marketing lies not in direct intervention in the markets through controls on prices and profits but in providing conditions under which the markets are well-developed and functioning.

It seems that Sri Lanka is a country where the traditional negative image of middlemen and traders has rather been prevalent and government intervention into the rural markets has been pervasive. If so, the first policy step necessary for a long-term success in crop diversification would be to foster efficient rural marketing systems, no inaner how long it takes. Without it, any effort at crop diversification is bound to face failure in the long run. Crop diversification is synonymous with building flexibility into traditional agriculture, and it hinges on the flexible, efficient marketing sector. The so-called "dependency syndrome." in agriculture and other sectors of the economy is the antonym of flexibility as such.

Credit

Credit is another problem quite often mentioned in the crop diversification business. Although credit is not an input in an ordinary sense, this is a part of the market problem. It is said that while market-oriented nonrice crops require high cash inputs, credit is not available to farmers, or if available, it is at too high rates of interest. Provided that there is a well-functioning marketing sector. nonavailability of credit could be an obvious sign that the crops are not economically viable and/or too risky to grow. High interest rates in informal

lending are nothing but a sign that opportunity costs of money, loan-default risk, and costs involved in financial transactions are all high.

Negative image of, or prejudice against, informal money lenders has been even more serious than that of middlemen and traders, and this has given way to cheap credit policies in the primary sector adopted in almost all developing countries. Confusion among policymakers on the role and function of rural financial markets has been widespread. Just as in the case of middlemen and traders, however, the empirical evidences from recent studies indicate that the informal financial market in rural areas in developing countries are much more efficient than ever thought, and, more importantly, that the cheap credit policies adopted in these countries have contributed negatively to rural development, in spite of all good intentions envisaged in these policies (Howell 1980; Adams et al. 1984).

This does not necessarily mean that a government **must** not intervene in the financial markets. Under the condition of underdeveloped financial markers, a government would do so in such a way to help the markets develop. The introduction of a formal credit system may be one of them, but it should be implemented so as to be effective in mobilizing rural financial markets. The traditional cheap credit policy has little economic ground to be justified even as a means of infant industry protection.

If there exist good economic opportunities for nonrice crops, credit would become available to farmers in one way or another. As a matter of fact, it is a widespread practice in rural Asia that middlemen and traders advance credit to farmers to purchase cash inputs in exchange for the exclusive right to purchase crops to be marketed from the farmers (Siamwalla 1978; Hayami et al. 1987; Pingali et al. 1989). This kind of credit is usually interest-free. It should also be noted that, contrary to the popular view, this kind of credit arrangements emerge when the market is fairly competitive; it is neither exploitative nor of the feudal bondage type. A typical case is reported by Pingali et **al.** (1989) for an irrigation system in Central Luzon, the Philippines, in that middlemen and traders advance interest-free loans to the rice farmers who grow onion in the dry season. If crops are "economically viable," then, credit follows.

It may seem that the situation in Sri Lanka in this respect too is not so encouraging. However, there are signs indicating that the rural financial market is working. For example, IIMI (1990b) reports that fairly large amounts of informal loans are available to fanners in an irrigation system in the southern part of the country. Bouman (1984) reports that informal financial arrangements in Sri Lanka provide very valuable services to many rural people. Although much research needs to be done in this field, it is certain that there is a potential. What is important for policymakers is not to demolish such a potential but to set up policies that will help develop efficient and flexible rural financial markets.

As pointed out by Schuh and Barghouti (1987) and World Bank (1988), an important and effective policy towards this end would be credit programs for middlemen and traders. Since the primary bottleneck for crop diversification could be in marketing the output, not in getting fanners to grow the crop when profitable, such programs could be instrumental in building flexibility in the marketing system in general and for speeding up the crop diversification process in particular. In this sense, the two-step loan now envisioned in Sri Lanka, if implemented properly, could be an effective means to mobilize rural markets.

Input Markets

The need to make rural markets flexible applies to the input markets as well. As complaints in Sri Lanka are often heard that seeds, fertilizers, and agrochemicals are not supplied to farmers in time, rigidity in these markets is presumably relatively well-recognized. Policies should be taken to ease such rigidity through the development of efficient markets for these inputs. What is not sowell-recognized are the workings of other input markets such as labor, land, and draft power.

Farmers in developing countries in Asia, unlike the typical peasant described by Chayanov, are integrated with the market economy not only in the output side but also in the input side. They purchase inputs in the market. Labor and land are not the exception. Particularly in well-irrigated rice growing areas, the existence of landless laborers, whose income depends on hired labor in rice farming, is substantial. It is not uncommon in many Asian countries to find rice villages where the population of the landless laborers is much more than that of "farmers" who cultivate land as owners or as tenants of some sort. A significant portion of the income generated in rice farming is earned by these landless laborers. Sri Lanka is not an exception in this respect. The percentage of rice income earned by hired laborers is as high as 20-30 percent of the total rice income generated in many irrigation systems. In some areas, more than 90 percent of the total labor requirements in rice production is met by hued laborers.

Crop diversification under such conditions would have profound implications in the local labor markets. One implication is its impact on income distribution among rural people. It is often said that crop diversification is necessary in order to increase "fanners' income." In many rice growing areas, this should always be restated as including landless laborers' income. Should the income of rural households be of concern, more emphasis should be put on landless laborers who are the poorest of the poor in rural communities. This point of view seems to be usually lacking in policy consideration for crop diversification.

Another implication is changes in labor requirements due to crop diversification. In Asia, rice is a labor-intensive crop. Some nonrice crops are, however. more labor-intensive than rice. Although the labor is generally a relatively abundant resource in these countries, there could be a case in which seasonal bottlenecks in labor supply emerge with new cropping patterns. The solution to this depends critically on how flexibly and efficiently the labor market works.

As to the income distribution implication, the land market is even more important than labor, because land is the resource that ismostscarce in Asian countries, and because tenancy arrangements are pervasive in many rice growing regions there. It is also important in terms of efficient resource allocation. Even if legal restrictions to tenancy arrangements exist, tenancy transactions are popularly practiced by fanners. There is a tendency for the incidence of tenancy in rice growing regions to be more in the dry season than in the wet season, and that diversified cropping in these regions increases it even further (Kasryno et al. 1982; Pingali et al. *1989).* For example, Pingali et al. (1989), studying an irrigation system in the Philippines where crop diversification is in progress in the dry season, reports that farmers adopt seasonal tenancy arrangements to cope with labor constraints and inherent risks in the nonrice crops grown. This suggests that the flexible land market helps crop diversification, and that rigidity in it. if any, should be minimized. It is counterproductive to treat the land

market as if no tenancy problem exists. In order to maximize the efficient use of the land resource, crop diversification should be promoted on the basis of a flexible land market.

Mechanization in peasant agriculture in Asia has been progressing. It is nowadays popular to see tractors and threshing machines in rice growing areas in this region. A distinct characteristic of this kind of input. as compared to inputs like fertilizer, is its indivisibility which could bring a scale economy into peasant production. Once this comes in, farm size becomes an important issue not only in terms of income distribution but in terms of efficiency. However, it is fairly common throughout the rice growing areas in the Asian tropics to see well-developed custom service markets for these agricultural machines (Siregar and Kikuchi 1988). Therefore, if there is a bonleneck in these services, as in Sri Lanka where such bottlenecks reportedly exist in many irrigation systems, in relation to the time allowable for land preparation, the reasons why the markets are not working properly should be looked into.

In essence, how these input markets work is crucial to a successful promotion of crop diversification. It determines not only the supply of inputs necessary for diversified cropping, but also how the income generated is distributed among the agents involved in the production process. The flexibility of these markets is an integral part of the flexibility that is needed for crop diversification. Understanding of the role lo be played by the markets is grossly insufficient both in research and in policy arenas related to crop diversification.

Market and Collective Action

Mention should be made of the link between the markets and the nonmarket elements inherent in the management of irrigation systems. Irrigation water could be "marketed" under certain technological conditions, which the irrigation system in Asia generally lack. This entails the free supply and utilization of water in an irrigation system in this part of the world which makes the market mechanism inoperative and which necessitates collective action among the agents involved in the system. For instance, such matters as the ensuring of adequate water distribution, regulation of timing of water supply, and prevention of excess water use can only be dealt with by coordination among the agents through collective action, not through the market in a narrowly defined sense (Pingali 1990). A shift from a rice monoculture pattern to diversified cropping makes this need for collective action more imperative.

In almost all the countries under consideration, a major means of attaining this collective action is through the fonnation of strong water users' associations or farmers' organizations. As shown in Figure 1, the facets of "Institutional issues" and "Socioeconomic factors" are all related to the issues of farmers' organizations and their linkages with the managing agencies, if any. These are the facet? that constitute the links where the markets outside as well as inside irrigation systems meet with the nonmarket elements of system management. Although it is well-recognized that the institutional aspects of irrigation management are of critical importance for better system performance, particularly when diversified cropping is envisaged, what is not clearly understood is how they are related to the markets.

These market and nonmarket linkages in system management range over a wide spectrum; some need collective action more than others. Moreover, even fora certain aspect,

the degree of need could differ from one system lo the other, depending on the prevailing socioeconomic and sociocultural environmenls. For instance, solutions to conflicts in water distribution between the head-end and tail-end sections of a system may require collective action, in the absence of any market solution under usual circumstances. But some market, may exist under othercircumstances where waterrights are clearly specified and some compensation paymenls to losers can be enforced.

There seems to be a tendency among those involved in irrigation management in Sri Lanka, as well as elsewhere, to consider that market mechanism and system management are two independent things which never go together. Needless to say, the market is not always a substitute for collective action. It is equally counterproductive lo assume that institutions such as farmers' organizations can always be a better substitute for the market. The need is for certain amicable combinations of these two extremes. which is perhaps the most serious challenge that research has to confront in paving the way for successful crop diversification in rice-based systems in the long run.

CONCLUDING REMARKS

Crop diversification in rice-based irrigation systems is often treated as if problems in it can be solved by government or system management directives; if there is a need to diversify crops, the need should be there; if certain crops are to be substituted for rice, farmers should plant the crops; ifcertain inputs are needed to these crops, they should be there; and so forth. Crop diversification is an inevitable process that the agriculture sector has to adopt as the economy grows; it is a part of the structural transformation process of the economy. This process is designed to build flexibility into agriculture. Acommand type mode of operation is furthermost to this approach. Instead, the success of crop diversification critically hinges on the markets. Only with well-functioning markets could its objectives be attained, while being consistent with the long-run need of structural transformation and efficient resource allocation.

Crop diversification in rice-based systems is not easy to attain. Timmer (1987), which is an earlier version of the World Bank (1988) report, mentions Thailand and Japan as the countries where agricultural diversification has been successful; Thailand without government intervention, and Japan with heavy intervention. It should be noted that the major type of diversification that has progressed in both countries is not the one in rice-based systems but that through regional specialization away from rice. In the case of postwar Japan, agriculture as a whole has been diversified adding livestock and horticulture production lo staple food production, but the rice sector itselfhas failed to diversify. The failure is twofold: rice farming has remained largely as monoculture despite all policy efforts made by the government lo promote diversification, and it has totally lost its economic viability because of too heavy protection through rice price-support. This experience in Japan clearly suggests that crop diversification policy is not independent of rice policy. Both should be consistent with each other and with long-run needs of the economy.

Unlike policies to attain rice self-sufficiency, policy targets for crop diversification keep moving, and the issue structure of crop diversification is open-ended towards the output markets. Research, that makes clear the conditions of the crop markets, both domestic and foreign, for both rice and nonrice, needs to be carried out periodically. The comparative advantage of producing certain crops domestically relative to imports should be examined carefully according to changes in the markets and in the economy, in order to keep renewing the list of crops to be grown in rice-based systems.

It is worth remembering that major success cases of agricultural diversification in the past accompanied technological as well as institutional innovations consistent with the conditions of product and factor markers. In the case of the eighteenth-century English Agricultural Revolution, new technology in the form of new crop rotation systems was the technological basis with the enclosure as the institutional basis; the consolidation of communal pasture and farmland into single private units facilitated the introduction of an integrated system of crop-livestock production. At the turn of the century in Denmark, small grain farmers succeeded in introducing efficient dairy farming; accompanied were the technological innovation in the fonn of the centrifugal cream separator and the institutional innovation in the form of the cooperative creamery. Similarly, in Meiji, Japan, the introduction of sericulture alongside rice fanning was made possible by the invention of the summer-fall cocoon rearing technology supported by a series of institutional innovations such as the establishment of silk inspection stations, national and prefectural silkworm egg multiplication stations, sericulture colleges, and sericulture cooperatives. As stated by Hayami (1989), "the scope of success for agricultural diversification strategy is but limited if it simply attempts lo divert resources from the production of basic cereals to other crops and livestock products with no major technological innovation in either farm production or processing and marketing. If this resource reallocation would be enforced by government programs such as price supports and input/credit subsidies, it would prove to be counterproductive for the purpose that agricultural diversification tries to achieve.

In spite of all difficulties, crop diversification will be the direction that many rice-based irrigation systems have to take in the long run as well as in the short run, if they are to be a part of the agricultural sector which is bound to diversify as the economy develops. Research efforts in irrigation management for crop diversification should all be aimed at the ultimate objective of making rice-based systems as flexible as possible. To build flexibility into the systems is nothing but to provide necessary conditions for diversification. A part of sufficient conditions for diversification is coming from outside the systems, but necessary conditions can be prepared within the systems as well.

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