TECHNOLOGY FOR SMALL FARMS: THE CHALLENGE OF DIVERSITY

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> The rice-wheat system is vital to food security in South Asia. . . .The rice-wheat system is concentrated in the most densely populated areas of India, Pakistan, Bangladesh and Nepal. . . . Annual cereal consumption in the region is expected to grow at a rate of 2 to 2.5 % until populations stabilize toward the middle of the 21st century. . . . However, arable land area in the region is limited, and per capita land devoted to food grain production is progressively decreasing. . . . grain yields in the region remain low when compared to their potential and when compared to yields obtained elsewhere in the world. (Preliminary workshop information)

All farms are not created equal. No one would argue with that statement. Obviously irrigated farms are different from rainfed farms, and temperate farms are different from those in the tropics. Livestock "ranches" are different from crop "farms." But are large farms different from small farms? Are family farms different from industrial farms? Many would argue that large and small or family and industrial are not characteristics that differentiate farms, particularly when new or "modern" technology is concerned. I once heard the research dean of a U.S. land-grant university declare, "Certainly our technology works on small farms as well as large ones. We test it on small plots, don't we?"

Average farms do not exist

An "average" Punjabi rice-wheat farm household might have 1.2 adult males, 1.4 adult females, 1.7 adolescent males, 0.6 adolescent females and 2.4 children. Half would have more land and half would have less. It could have from 0.4 to 1.6 cattle or buffaloes. Other averages could be mentioned, but few such farm households could be found. Yet

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we tend to use averages when discussing yields, farm size, available resources, or capabilities to adopt new technologies. But we ignore the fact that most rice-wheat farms do not achieve the average yield, nor are they average size, nor do they have the resources or capabilities appropriate for adopting new technologies such as minimum tillage, that suit the average situation.

Land is the most limiting resource on small farms

Increased production usually means increasing the amount of product produced per unit of land area, because arable land is most often the limited resource. Thus we tend to look for technologies that increase yield per unit of land area even if they require other resources such as more labor or more cash than many smallholders have available, such as mechanization, inorganic fertilizer or pesticides. Yet if we measured the productivity (yield) of any of these inputs when used with the new technology in terms of its product per unit of cash expenditure, this might well be lower than what the farmers are already getting. Alley cropping agroforestry, as an example, may produce less per unit of labor than farmers are already producing.

Because labor, cash or seed are often more limiting than land on small-scale, family farms, we first need to consider increasing the productivity of these critical resources. Increased productivity of land may follow. In crops like potatoes or beans which are staple foods and can readily be sold, yet somewhat difficult to store under rustic conditions, the amount of seed can be more of a limiting factor than land.

- In Nariño, Colombia, a well-known minifundio area, farmers planted potatoes in low densities to maximize the productivity of each potato planted. The size of their potato field was fixed by when they ran out of seed. Even on such small farms, seed was the limiting resource for potatoes, not land (Andrew, 1970).

- In the Pakistani Punjab, in the western part of the rice-wheat area in the 1960s, farmers with limited water spread it out on as much land as possible to maximize the productivity of the water. This, of course, gave less yield per unit land area. But if they had increased their per hectare application of water, this would have reduced the productivity of their water, resulting in less product (Andrew and Hildebrand, 1982).

"Our" crops are not necessarily the farmers' priority crops

We also tend to emphasize the crop or crops in which we are interested, forgetting that the farmer must allocate resources among all the activities and needs of the household. Intercropping can reduce the yield of one particular crop but increase the overall productivity of the land and labor involved in production. Also, "late" planting that reduces yield of a particular crop is often a compromise, enabling the farmer to get some production from another complementary crop, giving higher total yield between the two crops.

The farmer may put a higher priority on another crop rather than the ones in which we are interested. Planting the other one first and ours later than we think is optimal can be a very rational management decision. Seasonal needs of farmers can lead to what we think of as inappropriate technologies. For instance, early (short-season) crops usually have lower yields than later (longer-season) crops. Yet farmers grow them to provide food or cash at a time when these are needed even if the yield is less. For them, food harvested earlier has more value than higher yield later on when food is abundant.

We are in a hurry to see results

We tend to define “results” in different ways. Many of us define results as statistically significant differences among treatments. If our trials do not result in statistically significant differences, we do not see “results.” This leads to tight controls on non-test variables in experiments to reduce unexplained variance, thus increasing the probability of achieving statistically significant differences among test treatments. When this practice is followed in on-farm trials, it creates an artificially superior environment that farmers are unable to provide over time on a field basis (Hildebrand and Russell, 1996).

Another method of helping assure statistically significant results is to have higher yields, that achieve a lower coefficient of variance, thereby increasing the probability of finding significant differences among treatments. In on-farm trials this leads to selecting the best farms or the best fields or even the best spots in fields on which to conduct trials. The Director-General of one national agricultural research organization for which I worked said, “Pete, if you work in those hills (where the small farms were located), you won’t get any response.” By response, he meant results indicated by statistically significant differences.

But results can also be measured by breadth of adoption. Whether it is a cultivar, another input or a cultivation practice, broader adoption is always better than limited adoption. This is appreciated by industry. A limited number of broadly adoptable products is better than a larger number of narrowly applicable items. This biases our research toward practices and materials that require the modification of the field environment so that they can be productive, similar to what is seen in experiments, in varied locations. This practice has been very effective in areas such as the "corn belt" of the United States. It can also be effective in flooded rice paddies, which homogenize agronomic conditions. But small farmers with limited resources cannot modify the environments of their fields to suit the requirements of new technologies. Therefore technologies must be developed to match the constraints of the farmers' environments.

THE CASE FOR ATTENDING TO SMALL FARMS

They are not reducing in number

In 1970, 70% of the population of Pakistan in the western part of the rice-wheat area was involved in agriculture (FAO Database Collections). By 2000, only half of the population was involved in agriculture. During this time in India, the agricultural population dropped from 67% in 1970 to 54% in 2000. In Bangladesh, in the eastern part, the decline was from 84 to 56%. This interpretation makes it sound like these countries are urbanizing. Could it be that they are following the path of Western countries where farms are becoming larger and larger and farmers fewer and fewer? No, this is not the case. In these three countries, between 1970 and 2000, the agricultural population increased from 475 million people to 620 million people. The 145 million added people obviously are not operating large farms. If they are all on small farms, this would mean about 20 million more small farms in the region over the last 30 years.

Over this same 30-year period, even after realizing that Green Revolution technology has had little effect on limited-resource farmers on marginal lands, we have avoided the challenge of working with the great biophysical and socioeconomic diversity in which the world's small farmers struggle to survive. Perhaps we thought small farms would go away: “Get bigger or get out.” Perhaps we thought that our technology was scale-neutral and that it would just take time for innovations to trickle down to the late adopters and laggards, the small farmers who had not adopted them. Perhaps we thought that average farms represented all farms. Perhaps we felt we have to work where we can easily measure results as we are accustomed to doing. Perhaps we are convinced that land is the most limiting resource on small farms and that yield should be measured only in terms of unit land area. Perhaps we have forgotten, or did not know, that farmers have many priorities, and theirs may not coincide with ours.

Not all farms adopt new technology

For whatever reasons, over this period of time, only a small fraction of our research and technology development efforts have been oriented directly and adequately at intensification of the still increasing numbers of small-scale, family farms with limited or marginal resources. For forty years we have been convinced by Everett Rogers (1962) that many farmers are slow adopters or even laggards or non-adopters of new technological innovations. Because we have faith in our technology, we accept uncritically what Rogers tells us. We like to work with the “innovators” or the “early adopters,” those inclined to adopt our technology.

The theory tells us that it is not our responsibility when some farmers do not adopt what we consider to be good technology. It is not our fault that many farmers do not have access to credit, or the cash resources to acquire our good technology, or that this is not available in local markets. We are not surprised if it takes time for the benefits of our technology to be understood and for farmers to be “motivated” to adopt it (Hildebrand 1980).

As a result, the research affects a relatively small number of larger farmers, or those who work in better environments or with more resources (Figure 1). It seems natural that the innovation does little or nothing for the very large number of limited-resource farmers at the bottom of the pyramid. We have taken the easy road of asking those farmers with sufficient resources to change their agricultural environment to suit the technology. Now it is time for us to accept the challenge of creating technologies that suit the diverse biophysical and socioeconomic environments of most of the world's small farmers.

Agricultural intensification on small farms is possible

To be effective in helping intensify highly diverse small-farm agriculture it is necessary to comprehend the livelihood systems of these small farmers. A livelihood system is comprised of all the on- and off-farm activities available to farmers in an area from which they select their strategies to survive and thrive. This includes not only all the crops and livestock they raise, but different ways or times of raising them. Besides production activities, it is also important to understand reproduction and community activities as well because they also use scarce farm resources.

- Production activities are those that result in the production of goods such as food (for consumption or sale) or cash. Farming, fishing, carpentry, cottage industry, migrant work, paid labor, government jobs, etc. can be considered production activities whether on or off the farm.
- Reproduction activities are those like maintenance and care of the family unit that result in the survival and succession of the family or household. Meal preparation,

hauling water or fuel, childcare, laundry, house cleaning, re-roofing, house-building, or caring for elderly or disabled are among reproduction activities.

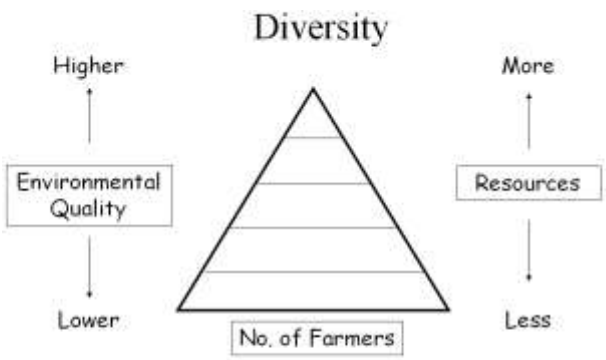

Figure 1. Farm resource diversity and relative numbers of farmers (Hildebrand, 1993)

- Community activities are more vague and more difficult to quantify in terms of inputs and outputs; however, they play a key role in understanding how households and communities function. These include: attending or organizing meetings; forming or participating in women's, men's, children's or producer groups; acting as part of a village or community council; household food-sharing; and the like.

Seasonality of activities and periods of cash or labor scarcities are important to understand as well as which of the household members is involved in each activity.

Households do not all adopt the same strategies. Livelihood strategies are a function of the characteristics of each household such as wealth, gender of the household head, relative age of the household, and household composition (sex, age and relationship of household members). Even though all households in a livelihood system have access, at least in principle, to the same set of activities, the constraints and resources reflected in these characteristics cause members to choose different subsets of activities as strategies. To help diverse households intensify their production, it is critical to assess the capabilities of each type of household to help them mold technologies to the needs and constraints of each type.

This sounds like anthropology, and it is feared that anthropologists need years to do ethnographic studies in remote villages and then do not really want anyone or anything to change “their” village. This is an unfortunate stereotype. Anthropologists with solid agricultural backgrounds can be productive members of multidisciplinary teams. Also, an increasing number of agronomists have anthropological training. Incorporating these kinds of scientists in teams working to intensify diverse small-farm agriculture is highly productive. Economists (heaven forbid!) with agronomic and/or anthropological training can also be useful members of such teams.

Modeling small-scale, limited-resource family farm livelihood systems, such as by ethnographic linear programming (Bastidas, 2001; Breuer, 2000; Cabrera, 1999; Grier, 2002; Gough, 2002; Kaya, 2000; Kaya et al., 2000; Litow, 2000; Mudhara, 2002; Pomeroy, 2000; Sullivan, 2000; Thangata, 2002) is one effective way to integrate crop, animal, anthropologic and economic knowledge gained through farmer participation to help predict which households may be able to adopt different kinds of new technologies even prior to their being developed or offered to farmers in the community.[2] These models help us understand the kinds of technologies that are needed by the different types of households in an area and thus can guide innovative thought into unique approaches to

[2] See Hazell and Norton (1986) for details on linear programming; see Hildebrand (2002) for details on ethnographic linear programming. For examples of ethnographic linear programming, see the authors listed above.

agricultural intensification that can help even the poorest kinds of small-farm households survive and thrive.

Figure 2 represents a highly efficient and very effective methodology for incorporating these different perspectives in a participatory process with farmers that incorporates diversity, in problem or constraint assessment, in technology, infrastructure or policy development, and in recommendations. With the availability of laptop computers, it is now feasible for modelers to work in the field with farmers in the process of creating, validating and using their models. When these models are validated (adequately simulate the existing livelihood system), alternatives can be pre-tested in the models, even while on-farm trials are being conducted, both to help researchers better understand how the alternatives would fit into the strategies of the different kinds of households, and to help characterize the recommendation domains for which the technologies are appropriate. The results of the on-farm trials and knowledge gained from continuous contact with the farmers can be used to improve the ethnographic linear programming models which should constantly be modified to make them even more useful.

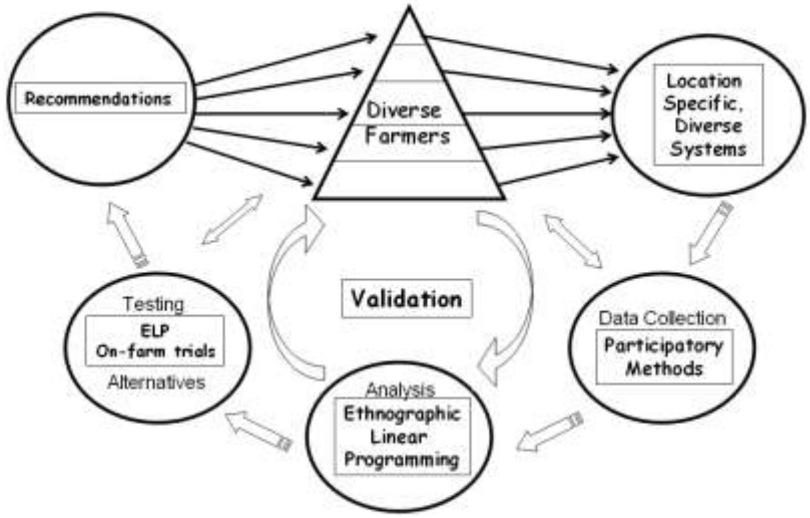

Figure 2. Schematic representation of the methodology for ex-ante evaluation of potential technological, infrastructure or policy changes (based on Bastidas, 2001)

It can be done

Miniaturization of computer hardware and advances in software have generated the potential to create and use sophisticated models in the field while working with farmers in their diverse environments in a participatory, ethnographic mode. We know these methods work. Now is the time to put them all to work together. This will require concerted, multidisciplinary and participatory efforts and the will to shed many approaches to which we tend to cling. The remaining challenge is for research and extension personnel, infrastructure managers and politicians to become more innovative in their search for technologies, infrastructure and policies specifically aiming to assist the still increasing number of highly diverse, small-scale, limited-resource family farms in many countries of the world, including those in the rice-wheat area of the Indo-Gangetic plains.

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