AGRICULTURAL KNOWLEDGE AND INFORMATION SYSTEMS AND POVERTY REDUCTION

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EXECUTIVE SUMMARY[1]

The purpose of this document is to present and discuss alternatives for stimulating the development and improving the performance of agricultural knowledge and information systems (AKIS), with the goal of contributing to poverty reduction. The paper is based on an extensive review of recent literature. In line with the concept of AKIS, our analysis emphasizes the impact on poverty of agricultural innovation processes, and the recommendations aim primarily at the institutional factors that can favor poverty-reducing innovation in agriculture.

The main findings are:

1. *Poverty is multi-dimensional and is a highly heterogeneous phenomenon*. Failure to recognize this fact has led to a succession of fads of simplistic 'one size fits all' approaches. It is time that we learn to deal with diversity by means of customized approaches.

2. *Agricultural innovation is a socially constructed process*. Innovation is the result of the interaction of a multitude of agents and stakeholders. If agricultural research and extension are important to agricultural innovation, so are markets, systems of government, social norms, and, in general, a host of factors that create the incentives for a farmer to decide to change the way in which he or she works, and that reward or frustrate his or her decisions.

3. *When the goal is poverty reduction, agricultural innovation policies and programs cannot start from agricultural research and extension towards poverty*. This can only lead to standardized, 'one size fits all' solutions. The starting point has to be the analysis of the different types of poverty (rural and urban), their determinants, the contexts in which they occur, and the livelihood strategies that the poor implement to respond to their condition. From there we can then move back to determine possible strategies for agricultural innovation, and only then can we look at the potential role of agricultural research and extension within each strategy.

4. *Not all poor rural households are agriculturalists, and agriculture is not the best avenue for reducing income poverty for all rural households*. Given the heterogeneity in the assets and contexts of the poor, and of the determinants of poverty, it is no surprise that rural households pursue a number of different livelihood strategies. Agricultural production can be a major element in those strategies, or it may play no role at all. The agricultural path out of income poverty is relevant only those who have access to sufficient land and other assets relevant to agricultural production, and who operate in contexts that provide the correct incentives for those assets to be sufficiently productive over long enough periods of time, to leverage the household out of poverty.

5. *Agricultural innovation has direct and indirect effects on the income and employment opportunities of the poor*. Considering the magnitude of the challenge of poverty reduction, it would be unwise to chose one type of effect at the expense of the other, at least because of the following two reasons: (a) no single type of effect can adequately deal with and

[1] For reasons of space, references have been left out of this Executive Summary. They can be found in the main body of the document.

support the many and highly differentiated livelihood strategies chosen by the poor to escape poverty; and (b) the appropriate strategy can only de defined and designed at the national and sub-national level.

6. *Under the increasingly prevalent condition of liberalized agricultural markets, those farmers who are early adopters of new technologies and who can keep the pace of continuous innovation, stand to gain from the direct effects of technological change*. In the long run, many poor farmers in developing countries will only be able to benefit from the direct effects of agricultural innovation if they operate under conditions of *de facto* or *de jure* protection from international trade, or if public policies are put in place to allow them to significantly increase their productivity and/or to diversify into production systems in which they can have a competitive advantage.

7. *The indirect effect of agricultural innovation – mainly through lower food prices - are a fundamental contribution to increasing the welfare of the urban poor and of the large proportion of the rural poor who are net buyers of food*. There is little hope for progress in the fight against poverty on a global scale, if agricultural research and extension diminish their overall support to those regions and farmers that can create this type of indirect effect. The rise of privately-funded R&D in developing countries offers a new set of conditions for defining the contribution of the public sector to agricultural innovation that seeks this type of indirect effects on poverty.

8. *Rural non-farm employment and income deserve much greater attention in poverty reduction strategies*. A growing number of rural households are deriving an increasing share of their total income from this source. Non-farm income is of particular importance to the rural poor, including to many small scale farmers. Some traditional concepts need to be deeply revised, such as that which states that pro-poor agricultural technologies must always be labor-intensive, as if the poor do not have other employment opportunities that can be better remunerated. Agricultural research should actively seek and exploit opportunities for developing and strengthening production, expenditure and investment linkages with the non-farm economy.

9. *New opportunities for reducing poverty grow out of the significant institutional changes that have taken place in the past two decades*. The public sector contribution to agricultural R&D has decreased in absolute and relative importance. This 'downsizing' has often been accompanied by a more general weakening of the capacities of these public organizations. At the same time, a positive development has taken place in many countries, that have seen the growth of a number of private, quasi-private, non-for-profit, and community-based organizations, that have taken over many of the tasks and services that used to be under the domain of governmental entities. Many of the new organizations are primarily or exclusively dedicated to working with poor rural communities, and in issues of direct relevance to them. These organizations have equipped themselves with new approaches and methodologies that are more responsive to the demands and the direct participation of the rural poor, who often had no voice under the old status quo.

10. *Agricultural innovation policies aiming at poverty reduction, should employ differentiated strategies*. The document discussed three broad types of strategies: (a) promotion of indirect effects by supporting innovation in commercial farming in favorable environments; (b) promotion of both indirect and direct effects by supporting small scale family farms who often have the incentives to innovate but lack the assets required to respond to those stimuli; and (c) promote direct effects by supporting innovation (agricultural and non-agricultural) by poor rural households living in marginal environments. The calls to place all the effort on working with the poorest of the poor in marginal environments, are as wrong as those that call for placing all bets on the indirect effects of high growth and productivity in the more favorable regions of the developing world.

11. *Agricultural innovation by commercial farmers in favorable environments can lead to poverty reduction only if there are conducive institutional environments that favor sharing of benefits across society*. Public policies and interventions should have the goal of exploiting the linkage between public goods and private interests. Specific policies that could lead to this win-win scenario include: developing clear regulatory frameworks and strengthening intellectual property rights; protecting these agricultural systems from unfair trade competition and non-trade barriers to commerce; promoting private-public cooperation; developing national science and technology policies that do not discriminate in favor of any one particular kind of research organization; supporting basic and strategic research; funding the training of scientists; promoting the establishment of cooperation agreements between national universities and research institutes and their counterparts in other countries; stimulating stronger linkages and more explicit cooperation for innovation between different actors within agroindustrial and marketing chains; investing in public but non-governmental organizations for R&D; adopting policies that create favorable conditions for foreign investments in R&D and in innovative for-profit enterprises.

12. *The development of small scale family farms offers the greater potential for poverty reduction through agricultural innovation in developing countries*. There are millions of small farmers in developing countries that have the right incentives to embark in market-oriented agricultural innovation processes, but that lack the capacity to fully respond to that favorable context, either because their assets are too limited, the productivity of such assets is low, or because the transaction costs they face are too high. Developing the full potential of these small farmers and their communities requires pro-active public policies that are market-oriented. These public policies should aim at increasing the assets available to small farmers, as well as their productivity; lowering transaction costs and diminishing the institutional constraints and the market failures that hamper the productivity and innovation potentials of family farms, and; promoting the development of an effective AKIS by stimulating synergistic interaction between public and private agents.

13. *Agricultural innovation policies aimed at very poor households in unfavorable environments can only lead to sustainable progress in poverty reduction if they are part of broad-based efforts that recognize the diversified livelihood strategies of those households*. Millions of poor rural households lack most types of assets, and at the same time operate in unfavorable environments. Some (but not all) of those households engage in semi-

subsistence farming as part of diversified livelihood strategies. Policies aiming at facilitating innovation under these conditions should aim at enhancing the asset position of those households, and at improving the context in which they operate. In the absence of such changes, the potential for agriculture-based development will remain very low. Successful innovation in these conditions depends on building local institutions, networks and organizations that help mobilize the very scarce resources of these communities, and link them to external networks. The biggest challenge - yet unsolved – is to find a way in which these local experiences can be upscaled so that their impacts are commensurate with the magnitude of 1 billion poor rural people.

1. INTRODUCTION

According to World Bank (2000a) estimates, 1.2 billion people lived in absolute poverty in 1998, that is, they depended on an income of less that $ 1 per day. An additional 1.6 billion lived on less that $ 2 per day. The number of people living in absolute poverty has remained constant in the last decade, while there are an additional 250 million persons living with less than $ 2 per day.

Table 1. Extent of poverty in developing countries and transitional economies

Regions	**Millions of people living of less than:**			
	$ 1 / day		**$ 2 / day**	
	1987	**1998 (est.)**	**1987**	**1998 (est.)**
East Asia and the Pacific	471.5	278.3	1,052.3	892.2
Eastern Europe and Central Asia	1.1	24.0	16.3	92.9
Latin America and the Caribbean	63.7	78.2	147.6	182.9
Middle East and North Africa	9.3	5.5	65.1	62.4
South Asia	474.4	522.0	911.0	1,095.9
Sub-Saharan Africa	217.2	290.9	356.6	478.8
Total	1,183.2	1,198.9	2,549.0	2,801.0

Source: World Bank, 2000a and 2000b

The recent evolution of poverty varies by region, by countries and by specific areas within countries (table 1). East Asia has made much progress in the fight against poverty, accomplishing a 40% reduction in the number of the poor in the short period between 1993 and 1996 However, the recent financial crisis has in part reverted that trend; for the first time since the mid-80's, the number of people living in absolute poverty in this region has actually increased between 1996 and 1998, by 5%. In Eastern Europe and Central Asia, the trend is disastrous: the number of poor people living with less than $ 1 per day, has increased by more than 2,000% since 1987. In Latin America and the Caribbean, the fight against poverty has stagnated, and the number of people living with less that $ 1 per day has increased by 22% since 1987. For over a decade, the Middle East and North Africa have been able to maintain a low number and very low share of people living in absolute poverty. In South Asia, despite positive GDP growth rates during the 1990's, the total number of people living in absolute poverty increased by 10% between 1987 and 1998. In India, which accounts for a large number of the world's poor, poverty reduction has slowed

down, in particular in the rural areas. In Sub-Saharan Africa the situation is extremely worrisome: the number of people living with under $ 1 per day has increased by 34% since 1987.

Around two thirds of the world's poor live in the rural areas of the developing world, and the share can be as high as 65 to 90% in Sub Saharan Africa (World Bank, 2000c). In total, it is estimated that in the late 1980s there were nearly 1 billion poor rural people in 114 developing countries. This means that about 36% of the rural population was classified as income poor (Jazairy et al., 1992).

While there is a broad consensus that agricultural development by itself cannot overcome the state of deprivation of 1 billion rural people, there is also little doubt that without the long term and significant growth of the agricultural sector, there would be less opportunities for significantly reducing rural poverty. One main reason is that in the year 2000, almost 60% of the total population of the developing countries, lives in the rural areas (FAO, 2000a).

As will be discussed later in this paper, there is also little doubt that in the past, agricultural growth has made a substantial contribution to poverty reduction in many areas of the world. One of the most effective tools has been the acceleration of technological innovation in the developing and developed world. Net per capita food production has increased worldwide by 22% since 1961 (FAO, 2000a). In the absence of this growth, poverty and hunger would be much more widespread than they are today. Yet, given the figures on poverty shown above, few will disagree with the urgent need to improve the ways in which agriculture and agricultural technology can contribute to the global fight against poverty.

This goal must be achieved within a context of declining public investment in agricultural research and extension in many developing countries, of increasing institutional diversity and complexity of the agricultural innovation systems, and of new roles of the public vs the non-public sectors in agricultural research and extension. In addition, the agenda for agricultural innovation is also more complex; while in the 1970's increasing output and

productivity were the dominant objectives, today it is expected that it also addresses the competitiveness of agricultural systems, poverty reduction and improved natural resource management (Byerlee, 1998).

The purpose of this document is to present and discuss alternatives for stimulating the development and improving the performance of agricultural knowledge and information systems (AKIS), with the goal of contributing to poverty reduction.

Agricultural Knowledge and Information Systems (AKIS)

The concept of AKIS was coined by Röling (1986). According to FAO and the World Bank (2000), "an Agricultural Knowledge and Information System links people and institutions to promote mutual learning and generate, share and utilize agriculture-related technology, knowledge and information. The system integrates farmers, agricultural educators, researchers and extensionists to harness knowledge and information from various sources for better farming and improved livelihoods."

An essential element in the AKIS concept is that it views agricultural research and extension as necessary but, by themselves, insufficient elements in complex innovation-oriented institutional arrangements. The concept clarifies the distinction between agricultural research and extension, and innovation and technological change. As Anderson (1997) has pointed out, it is not correct to attribute all the effects of technological change to agricultural research and extension. The focus in not on research or on extension per se, but on *innovation* and on the institutional arrangements that can favor it.

This is a sharp departure from the conventional view of innovation as a linear and rather mechanistic process that starts in highly skilled and specialized organizations (usually in the North) conducting basic and strategic research, and then moving down the line to applied research, adaptive research, technology transfer, extension and, finally, farmers as passive adopters of knowledge and information generated elsewhere.

As Röling and Jiggins (1998:304) have has recently put: 'It has become common practice to speak about 'agricultural knowledge systems', i.e., to use a (soft) systems approach for looking at the interaction among the (institutional) actors operating in a 'theatre of agricultural innovation'. Innovation emerges from this interaction and is no longer seen, as was customary in the 'transfer of technology perspective', as the end-of-pipe product of a sequential process. The knowledge system perspective looks at the institutional actors, within the arbitrary boundary of what can be considered the theatre of innovation, as potentially forming a soft system. A soft system is a social construct in the sense that it does not exist. One cannot, therefore, say that such actors as research, extension and farmers are a system. In all likelihood they are not, in that there is no synergy among their potentially complementary contributions to innovative performance, but by looking at them as potentially forming a soft system, one begins to explore the possibilities of facilitating their collaboration and hence the possibilities for enhancing their synergy and innovative performance'.

The question of how to improve the performance of AKIS with respect to poverty reduction could be approached at least in two different scales: (a) at the level of specific projects, or (b) at the level of the agricultural sector and the poor in one country, a region or the world.

Only a fraction of the world's poor are directly involved in agricultural research, extension and/or development projects. The World Bank - perhaps the largest agency in terms of supporting agricultural research, extension and development projects - in the 16 year period up to 1992, committed $ 3 billion to research and $ 2 billion to extension (Purcell and Anderson, 1997). By 2000, the World Bank had committed $ 5 billion each to agricultural research and extension projects[1]. Pardey and Alston (1995) report that in 1990 developing countries invested PPP $ 8.8 billion in agricultural research (much of it probably financed by multilateral loans such as those of the World Bank). With this kind of resources, an optimist gross estimation is that in that period agricultural research and

[1] Derek Byerlee, personal communication.

development projects must have involved less than 10 million *direct* beneficiaries. Even if we assume that all of them were poor, and that our estimate is too conservative by a factor of ten, we must still conclude that agricultural research and extension projects at any one time only *directly* benefit a small fraction of the world's 1 billion rural poor[1].

Hence, while it is very important that these agricultural research and extension projects are better designed and managed so that they improve their performance in poverty alleviation, it is apparent that the largest impact of these interventions will be through their *indirect* effects, including of course the diffusion of innovations propelled by factors not under the direct control of projects. If we are concerned with reducing poverty at a scale which is compatible with the global magnitude of poverty and of rural poverty in particular (1 billion people), we must emphasize policies and processes that can have wider effects at the national and international levels.

The organization of this paper is as follows: in section 2 we show that poverty is multi-dimensional, its causes are diverse, its manifestations and meanings are contextual, and it is not only a state of deprivation but also a dynamic set of processes. Hence, poverty is a highly heterogeneous phenomenon, even within countries. Agricultural innovation policies that aim at reducing poverty must recognize the heterogeneity of poverty even within countries, and avoid simplistic "one size fits all" approaches. Section 3 discusses how agricultural innovation can impact on poverty through both direct and indirect effects, and shows that public policies should try to stimulate and combine both of them in different ways, to fit different objectives, populations and circumstances. Section 4 is a discussion of some fundamental changes in the agricultural knowledge and information systems of developing countries; it shows how the decreasing trend of public funding for agricultural R&D, the more complex institutional arrangements, and the important changes in targeting strategies and methodologies, affect efforts to reduce poverty through agricultural innovation. These evidence and arguments are used in section 5 to propose a broad

[1] This does not apply to basic and strategic research, that by their very nature have the potential to impact on very large numbers of farmers in many countries and regions, if their results manage to move down the line to more applied forms of research.

typology of strategies to harness agricultural innovation for the purpose of reducing poverty. The document ends with a conclusions section.

2. RURAL POVERTY OR RURAL POVERTIES?

A major recommendation of this document is that developing countries and international agencies should avoid standardized, "one size fits all" public policies when wanting to support agricultural innovation for the purpose of reducing poverty. To a very large extent, this is because poverty is far from being a homogeneous phenomenon.

Poverty and its determinants

Poverty is multi-dimensional. Its causes are diverse, its manifestations and meanings are contextual, and it is not only a state of deprivation but also a dynamic set of processes (Carney, 1999; World Bank, 1999; Ravnborg, 1996). Maxwell (1999) identifies nine "fault-lines" in the conceptual debate about the meaning and measurement of poverty: individual or household measures; private consumption only or private consumption plus public goods; monetary or monetary plus non-monetary components of poverty; snapshot or timeline; actual or potential poverty; stock or flow measures; input or output measures; absolute or relative poverty; and objective or subjective perceptions of poverty.

Measures of poverty which attempt to capture this diversity do exist, notably the Human Development Index of the UN Development Program. However, for the purpose of this paper we have chosen to use the more conventional definition of "income poverty" or "economic well-being" (OECD, 1999), which refers to the proportion of people whose income is below a certain standard (a national poverty line, or, for the purpose of international comparisons, $ 1 per day). This choice does not reflect any particular conceptual preference, but rather it is driven by the fact that information is more readily available for income poverty that for other, more complex measures. Besides, at a global

scale there is certainly a significant and strong relationship between household and per capita income and other indicators of poverty.

Rural people, their goals and the livelihood strategies they adopt to achieve them, are very diverse (Ashley and Carney, 1999; Carney, 1999; Barret et al., 2000). The livelihood strategies of rural people aim at increasing income, reducing vulnerability, improving well-being and food security. These outcomes are explained by the asset position of households, and the characteristics of the context where assets are used (including institutions, power structures, markets and policies and their organizations, trends and shocks) (de Janvry and Sadoulet, 2000). Assets include human, natural, physical, financial and social capital. Rural poverty is highly heterogeneous because of the differences in the asset position of households, the income earning opportunities of the regions in which they live, and the contexts in which they make decisions.

Access to land is a major determinant of the livelihood strategies of rural households (Lipton, 1985). The highly uneven distribution of land is a major reason for rural poverty in many countries of Asia and Latin America, while, according to paper published by the International Monetary Fund, in Sub-Saharan Africa, "the poor quality of land and the erosion of customary land rights have become the major obstacles to agricultural growth and alleviation of poverty" (Khan, 2000:17). In India, about 70% of the rural households own less than 1 ha of land, 11% are landless, and 24% do not operate any land at all, even when sometimes they own it (Mearns, undated). In Sub-Saharan Africa and Asia, one third of smallholders subsist on plots too small to support their families (Oxfam International, 1997). In the more favorable environments of Nepal, 40% of the landless or almost landless households are poor, while only 18% of medium and large farmers are in this condition; in the mountains, poverty incidence among the same groups are of 77% and 24%, respectively (Sharma, 1999). In Egypt, only 39% of the rural households report agricultural cultivation as an activity, and poverty is more widespread and more severe among the noncultivators than among the cultivators (Datt et al., 1998). In the same country, land ownership is found to be the most important determinant of agricultural income, and since land is distributed very unevenly, Adams (1999) concludes that this is a main factor in explaining income-

inequality in the rural areas of Egypt. In Mexico, access to land is the most important determinant of total rural household income (de Janvry and Sadoulet, 2000). Access to irrigated land has a particularly strong effect on total income. In Haiti, the poorest fifth of the farming population has 42% less land than the richest fifth, and the productivity per hectare is 82% lower in large part because on average only one third of the plots of the poorest have good quality soils (World Bank, 1998). In Bangladesh, differential access to land is found to be the largest contributor to inequality (Wodon, undated).

Human capital assets are another major determinant of the livelihood strategies of rural people. In Mexico, the number of years of education of the adult members of the households has a strong positive effect on total income (de Janvry and Sadoulet, 2000). However, this study also concludes that access to education has a higher pay off in the non-agricultural rural labor markets, and that in fact education has a negative effect on agricultural income because educated household members seek employment in other sector of the economy. In Haiti (World Bank, 1998), 65% of the heads of households in the poorest quintile of the population, are illiterate, as compared to 49% for the richest fifth of the population. In Ghana education plays a role in increasing household welfare only after completion of primary or secondary school. In this country, the poor benefit less from education than the non-poor, since there are significant entry barriers to secondary education (Canagarajah et al., 1998). In China, increased literacy due to higher investment in education has made the largest contribution to rural poverty reduction (Fan et al., 2000a).

Gender is another important determinant. Female-headed households in the rural sectors of Egypt have higher proportion of poverty than the male-headed households, and female unemployment rates are four times higher than for males (Datt et al., 1998). In Ghana, household expenditure levels decrease with an increasing number of female earners (Canagarajah et al., 1998).

Poor rural households are characterized by larger numbers of members and by high dependency ratios, reflecting high population growth rates. Poor families with few assets of any kind, can only rely on human labor to generate income (Khan, 2000). This is seen in

Bangladesh, for example, where the size if the household is negatively related to per capita consumption (Wodon, undated)

Access by the poor to credit and technical assistance conditions the options of rural households in terms of livelihood strategies. Such access is minimal for Mexico's rural poor; according to de Janvry and Sadoulet (2000), the poorer households are 25% less likely to have access to credit and 62% less likely to have access to technical assistance.

Rural infrastructure affects in direct and indirect ways the livelihood strategies of rural households. In China, improved rural roads, electrification, telecommunications and irrigation infrastructure, have significantly contributed to the reduction in poverty (Fan et al., 2000a). It has been shown that in India, public investment in roads has made a major contribution to poverty alleviation in some of the less favored agroecoregions (Fan and Hazell, 1999).

Location is another factor than conditions livelihood strategies and their outcomes, although its influence appears to vary from place to place. In Ghana, Canagarajah et al. (1998) found that locality was more important than the differences between socio-economic groups within localities, in explaining changes in the distribution of poverty, suggesting that the population in different socio-economic groups are integrated within the same local economy, and that regional integrated development strategies would be appropriate to reduce poverty in that country. In Egypt, Datt et al. (1998) have found that geographical targeting is unlikely to reduce poverty substantially unless combined with other non-geographic determinants of absolute poverty. In Mexico, de Janvry and Sadoulet (2000) found that geographic location did have a differential effect on total household income, but not on agricultural income. Fan et al. (2000a) found that in China there are regional tradeoffs in achieving growth and poverty alleviation, and that if the objective is to maximize poverty reduction, then public investments should be targeted to the western region, and that if the goal was to maximize agricultural growth, then the central region should be the focus of public programs. In Vietnam, Glewwe et al. (2000) have found significant differences in returns to living in the different regions. In Peru (Escobal and

Torero, 2000), the apparent geographic differences in standard of living conditions between the coast, the Andean highlands and the Amazonian jungle, can be almost fully explained when one controls for the characteristics of households and by the degree of public and private infrastructure and other assets. In Bangladesh (Ravallion and Wodon, 1999) there are significant and large geographic effects on living standards, after controlling for a wide-range of non-geographic characteristics of households.

Given the heterogeneity in assets and contexts, it is no surprise that rural households pursue a number of different livelihood strategies. Agricultural production can be a major element in those strategies, or it may play no role at all. The notion that all rural households are agriculturalists, or that agriculture is the best avenue for reducing income poverty for all rural households, are concepts that must be discarded as untrue and unrealistic.

Diversification of rural employment and income is an increasingly important fact of life in all developing regions in the world. Based on a review of a large number of national and sub-national studies, Reardon et al. (1998) estimate that non-farm activities account for 36% of the total rural income in West Africa, 45% in East and Southern Africa, 35% in East Asia, 29% in South Asia, and 40% in Latin America.

In rural China, employment in the nonfarm sector grew from 7% in 1978 to 29% in 1997. In 1997, 36% of rural income came from nonfarm sources, although agricultural income accounted for up to 90% of total income in the less developed areas of the country. In 1997 rural nonfarm enterprises accounted for more than 25% of the national GDP, up from nearly zero in 1978. Without this growth of the rural nonfarm economy, China GDP growth rate would have been lower by 2.4 % per year (Fan et al., 2000a).

Poverty reduction in Ghana has been linked to increases in the informal, nonfarm sector in the rural areas. The informal nonfarm sector absorbed the labor that left the farming sector; this change in the structure of employment can be explained by the raising income of the nonfarm informal sector. In fact, in that country being part of the food crop or the export

farming sectors, will have a significant negative effect on expenditure levels per person (Canagarajah et al., 1998).

In Bangladesh (Wodon, undated), nonfarm rural households are found to be better off than many farm households, especially when compared to agricultural workers.

In Egypt, Adams (1999) has shown that nonfarm income is of great importance to the poor, representing almost 60% of their total per capita income. The same study concludes that nonfarm income represents the most important inequality-decreasing source of income, while agricultural income has the opposite effect on income inequality. The inequality-increasing effect of agricultural income is explained by the uneven distribution of land. Lack of land "pushes" the rural poor into the nonfarm sector in this country.

In Vietnam, those households who left agriculture for other occupations experienced a growth in consumption that was 10 percentage points higher than those who remained in agriculture (Glewwe et al., 2000).

In Latin America, close to 40% of total rural income comes from nonfarm rural employment, and the share is often higher for the poorest households, for women in the rural labor force, and for the poorest regions (Reardon et al., forthcoming). The rural poor tend to depend more on non-farm rural employment and income, even if they can only access low quality, low wage non-farm jobs.

Conducive environments for poverty reduction

Aside from the determinants of poverty, efforts to support the development or enhancement of agricultural knowledge and information systems to reduce poverty, need to consider the policy and institutional environment in which those policies and interventions will operate.

Agricultural research, extension and /or development projects may sometimes create "artificial" environments for the development and strengthening of local and national

AKIS, by applying as incentives the resources commanded by the project. However, the developing world is littered with examples of unsustainable effects and impacts of these projects, precisely because they turn out to be unviable once this "artificial" environment is removed when the project comes to an end. For example, Purcell and Anderson (1997) reviewed the evaluations of 64 agricultural research projects in 32 developing countries, and found out that while 63% had had satisfactory outcomes, 69% had "uncertain" or "unlikely" sustainability prospects.

As institutional arrangements, AKIS are never closed systems. While for reasons of practical expediency we may want to define them with sharp boundaries, the truth is that agricultural innovation processes for poverty reduction are fundamentally influenced and determined by what is happening around them.

Strong, widespread and sustainable agricultural innovation will not take place, and/or its results will not benefit the poor, if the following conditions are not present:

- Sustained economic growth. Agricultural growth does not occur in the absence of economic growth (Dollar and Kraay, 2000; Bruno et al., 1998).

- Equality. Large income inequality, as well as dualism in the agrarian structure, hamper poverty reduction (Khan, 2000; Rodrik, 1997).

- Functional institutions (markets, contracts, property rights, trust and reciprocity norms, legal systems...). Institutions unfavorable to the poor "can endure for long periods because they are favored by powerful groups for whom they secure distributional advantage. For this reason inequality in assets may impede economic performance by obstructing the evolution of productivity enhancing institutions" (Bardhan et al., 1998: 67).

- Political and social stability. Instability increases risk, and risk is a major consideration for poor farmers' decision making (Abadi Ghadim and Pannel, 1999; Rodrik, 1997).

- Basic rights. Exclusion based on ethnicity, race or caste marginalize certain rural groups (Khan, 2000; Rodrik, 1997). "Only with political freedoms can people genuinely take advantage of economic freedoms" (UNDP, 2000: iii).

- Effective governance. Rent seeking and corrupt bureaucracies impose additional costs on the poor by appropriating in different ways the surplus of their labor, and by debilitating or not providing many of the services that the poor need to improve their condition (Kahn, 2000; Rodrik, 1997).

- Conducive national policies. National policies can be biased against the rural poor by discriminating against public investment in the rural areas; through implicit or direct taxation of agricultural products and inputs; through the introduction of biases in favor of certain crops, areas or technologies, which more often than not are not precisely those of greater importance to the poor; or through public services that are designed and implemented in such a way that the richest farmers are able to capture a disproportionate share of the benefits (Khan, 2000).

- Absence of epidemics such as that of HIV/AIDS in Sub-Saharan Africa, where 26% of the population aged 15 to 49 is living with HIV or AIDS. These disasters can disrupt the gains of agricultural development, as in the case of Zimbabwe where the agricultural output of small farmers has decreased by 50% largely because of this epidemic (FAO, 2000b)

These are the conditions in which agricultural research, extension and development projects (a) can have strong multiplier effects outside their immediate range of beneficiaries or target regions, (b) can have impacts which continue to be felt after the project comes to an end, and (c) can benefit from incentives that stimulate the mobilization of the new assets

and capabilities developed by the project in the farms, households, communities and regions where they are operating.

For these reasons, effective poverty-reducing agricultural research and extension must be seen as only elements of much more comprehensive development policies and programs. In isolation, agricultural research and extension are largely powerless to affect poverty in a meaningful and sustainable way.

The agricultural path out of income poverty is directly relevant only for a share of all the rural poor: those who have access to sufficient land and other assets relevant to agricultural production, and who operate in contexts that provide the correct incentives for those assets to be sufficiently productive over long enough periods of time, to leverage the household out of poverty. Attempting to force households and communities who lack these resources and contexts to base their development on agricultural production, is to push them deeper into a poverty trap.

Von Braun (1995) has shown that market-linked small farmers increase their household income and generate direct employment for other poor households. As Reardon (1999) has put it, "the rural poor are knee-deep in the market economy, and want it that way: both are contrary to persisting but outdated traditional images. That the poor are somehow living happily or unhappily far from the labor and product markets, is an image from a past long-gone.... small farmers want to go commercial"

This of course does not mean that market participation is without large risks. And it does not mean that all poor farmers can in fact achieve market participation in a sufficient scale as to make agriculture their prime strategy out of poverty.

3. DIRECT AND INDIRECT EFFECTS OF AGRICULTURAL INNOVATION ON POVERTY

Agricultural innovation can contribute to poverty reduction through both direct and indirect effects. The relative importance of each of these will be largely determined by the speed with which households adopt new technologies relative to others, by the condition of the household as net food buyer or seller, by the degree of market liberalization that conditions whether the particular products is tradable or non-tradable, and by the institutions and incentives facing farmers.

In the last decades, there have been profound changes in the systems of incentives affecting farmers; market liberalization has become a dominant trend in many developing countries; and urbanization and the growth of the non-farm economies have moved many former agricultural households to a position as net food buyers. Hence, there are large changes in the relative importance of direct and indirect effects of agricultural innovation on poverty, as compared to what was observed during the days of the Green Revolution. Understanding these changes is of fundamental importance in designing public policies that seek to enhance the contribution of agricultural knowledge and information systems to poverty reduction.

Direct effects

The direct effects of technological innovation on poverty reduction are those benefits that are captured by the farmers who actually implemented the changes. The main form of direct effects is higher profits from agricultural production.

New technologies can improve a farmers' income when they reduce the marginal cost of producing one unit of output. Since for a time output prices will still be driven by the

prevalent (old) technology, profits will increase for those farmers who adopt the new technology.

Early adopters will benefit the most. Eventually all or many farmers may adopt the new technology, causing increases in output and a possible reduction in output prices. The profit margin created by the new technology may or may not disappear completely. Late adopters or non-adopters (who continue to produce with the old technologies when costs and prices are already determined by the new ones) may be negatively affected.

If this occurs in a closed economy, or in a region which is protected *de facto* due to poor access or any other variable, the adverse (from the point of the producer) effect of a new productivity-enhancing technology on farm prices, will be faster, and there will be a higher premium on early adoption. If the process takes place in an open economy, local innovation will have a very small or even negligible effect on reducing the price of agricultural products, but increased productivity will reduce costs per unit of output, and adopting farmers will benefit from larger profit margins. However, farming in an open economy means that agriculturalists will compete on a global scale, and that output prices will be determined by those who have the highest productivity. Poor farmers usually will not be among the early adopters, because of their lower access to information, capital, skilled labor, roads, and many other such factors. It follows that they stand to gain much less than larger, commercial farmers from the direct effects of technical change, in particular under conditions of open economies. Millions of poor farmers in recently liberalized economies are having great difficulties in matching the costs per unit of production of those who farm under better conditions, in a very real sense, they will be running behind the international prices determined by the higher productivity of their counterparts of those regions of the world with better comparative advantages due to better asset positions, more favorable production environments, better technologies and more conducive policy and institutional incentives.

In summary, under the increasingly prevalent condition of liberalized agricultural markets, those farmers who are early adopters of new technologies and who can keep the pace of

continuous innovation, stand to gain from the direct effects of technological change, to a larger extent of what would have been possible under closed or highly protected economies. In the long run, many poor farmers in developing countries will only be able to benefit from the direct effects of agricultural innovation if they operate under conditions of *de facto* or *de jure* protection from international trade, or if public policies are put in place to allow them to significantly increase their productivity and/or to diversify into production systems in which they can have a competitive advantage.

Indirect effects

The indirect effects of technological innovation on poverty reduction are those benefits that are captured by individuals different from those farmers who actually implemented the changes.

These indirect contributions can take one or more of the several forms: (a) Lower food prices due to higher agricultural productivity and output, (b) employment generation in agriculture, and, (c) broad-based economic growth through production and consumption linkages with the non-farm economy.

Lower food prices

Lower food prices are an inevitable consequence of increased productivity due to technical change. Authors like Ayer and Shuh (1972), Akino and Hayami (1975), Pingali et al. (1998), Scobie and Posada (1978), and Lipton and Longhurst (1989), have shown that the Green Revolution has made a major contribution to poverty thanks to its effect on grain prices since the 1970's. Recent studies have established that in the absence of Green Revolution technologies, food crop prices would have been 27 to 41% higher over the past 25 years (CGIAR, 2000).

Lower food prices are a fundamental contribution to increasing the welfare of the 300 million urban people who live in absolute poverty and that spend very large proportions of their meager income on food. In India, the poorest two thirds of the population - which include a majority of the rural people - spend 73% of their income on food (Ravallion, 2000). In Haiti, the poorest country in the western hemisphere, the poorest fifth of the population spend 65% of their total consumption expenditures on food (World Bank, 1998).

Lower food prices also have a major impact on the vast majority of the rural poor, who are net buyers of food either because they are landless, or because the amount of land that they own or have access to is so small that it is insufficient to provide all the food necessary to meet household consumption needs. Eleven percent of India´s rural inhabitants do not have access to land, and 27% do not operate a farm (Mearns, undated). In Mexico, only 28% of the peasants in the land reformed sector (*ejidos*) are net sellers of maize, the main food staple of the rural population and the main component of the traditional peasant farming systems (de Janvry et al., 1997). In Nicaragua, 23% and 28% of rural households are net buyers of maize and beans, respectively, while only 39% and 37% are net sellers of these two major food crops (Davis et al., 1997). Because of this, it has long been argued that the main effect of agricultural innovation on both urban and rural poverty should come from increased productivity that results in lower food prices.

As in the case of the direct effects, market liberalization alters the importance of indirect effects on poverty through food prices. The key fact is that the price of food that will be paid by the urban poor and the rural net food buyers, will be largely defined by trends at a global scale, and much less by what occurs at the local or even national level. Whether a country with a liberalized agricultural economy is or not self-sufficient in a particular tradable product, will mean little in terms on the average price to consumers of that product.

However, for many poor households who are net buyers of food, in particular those living in remote rural regions, the actual price of food will be the market price *plus* the transaction

cost of purchasing food, faced idiosyncratically by those households. When these transaction costs are high, as is the case in many rural regions in the developing world, the net result will be that those households will continue to have a strong incentive to remain as food producers, even in the face of decreasing world prices for their basic food staples. This justifies the need to continue supporting semi-subsistence agriculture in many areas of the developing world, notably in much of Sub-Saharan Africa. Yet, we must keep in mind that this is a second-best option, forced upon us by a condition of underdevelopment that limits the choices of rural households.

Agricultural employment and wages

Some improved agricultural technologies can increase total on-farm employment, in particular when they stimulate agricultural output per unit of land per year. Depending on the conditions of the labor market, this can result in increases in wage rates.

Otsuka et al. (1994) and Otsuka (2000) studied the effect of agricultural innovation on labor demands in the Philippines and other Asian countries. While the first round effect of the adoption of modern varieties of rice did increase labor use (both because of greater yields per cropping season and because of multiple cropping), they also found that such innovation soon lead to the adoption of labor-saving technologies (agricultural machinery in particular), that more than offset the gain. In the Philippines, for example, the average use of labor per hectare of rice declined by 20% between 1985 and 1998.

Localized increases in labor demand, and the concomitant increases in wages, generate an incentive for seasonal or permanent migration of workers from other regions in the same or different country. Hazell and Anderson (1984) have shown that overtime this migration did result in higher wages in non-adopting areas until the 1980's.

Otsuka (2000) has demonstrated that the share of labor in villages that lagged in the adoption of modern rice varieties in the Philippines, increased from 46 to 59% between 1985 and 1998, and that this increase was the result of higher wages. However, much of the

pressure on agricultural wages in the non-adopting regions came from the competition of the higher labor demands of the non-farm economy.

After reviewing the evidence on the impact of technological change on the labor markets, Renkow (2000:470) concludes that "although rising real wages might appear to be the obvious result of increased labor demand caused by technological change, empirical confirmation for this is small. Rather, available evidence indicates stagnation or, at best, small increases in real wages..."

Linkages with the non-farm economy [1]

The farm and non-farm sectors can be linked via production linkages. Upstream linkages are those stimulated by the growth in the farm sector, that induces the non-farm sector to increase activities to supply inputs and services to the farm sector. Downstream linkages arise when the non-farm sector is induced to invest in capacity to supply agro-processing and distribution services, using farm products as inputs.

The characteristics of agriculture will play an important role in determining the incentives for these kinds of rural nonfarm (RNF) activity, as those characteristics affect the profitability of and market outlets for RNF products and services. On the farm implements side for example, average farm size determines whether there is a profitable market for tractors versus only hand tools. On the farm output side, the composition, timing, and quality of output of local farms can influence the profitability (and optimal plant size) of agro-processing. Cattle husbandry technology affects the health and milk productivity of the animals, which affects the profitability of non-farm activities such as cheese production and milk pasteurizing.

Expenditure linkages involve the spending of incomes generated in one sector on the output of the other, as in the case of farm workers being able to buy consumer goods, or of the

[1] This section borrows liberally from Reardon et al., forthcoming and 1998.

growth of a nearby town due to a new mining investment, increasing the demand for fresh vegetable products. Therefore the profitability and market outlet for expenditure linkages for these are determined by local incomes (level and distribution) and tastes. The poor, are more likely to spend on local goods and services in the RNF sector, while the richer households tend to spend on items from the modern manufacturing sector located in cities, or on imports. The implication of this is that technical change in agriculture that benefits smallholders will have greater impact on the local economy via expenditure linkages than if it were to benefit largeholders.

Finally, the sectors can be investment linked, i.e. profits generated in one are invested in the other. In situations where there are constraints in access to credit, investment linkages between RNF activities and the farm sector may be very important. In such circumstances non-farm income may be crucial for farm households' capacity to make farm capital investments and purchase modern inputs. Likewise, savings generated by farm activity may be the basis of investments in non-farm activity

Household market integration and the impact of direct and indirect effects

The net impact of direct and indirect effects on poverty reduction will depend to a large extent on the influence of three factors: (a) the tradable status of the product; (b) the position of the household in the market as net buyer or net seller of the product; and (c) if the household is a farming family, its position as an early or a late- or non-adopter of the technology.

Table 2 summarizes the discussion that follows. The effect of agricultural innovation on food prices is highly dependant on how tradable is the commodity in question. As a general rule, when a commodity is non-tradable, increases in productivity will have a faster and stronger effect on the price of outputs, and consumers will tend to benefit the most, followed by those farmers who are among the early adopters. Late or non-adopters (which

often include most poor farmers) will benefit the least or even loose, although they may benefit if they are net consumers of that particular product.

Table 2. Aggregate impact of direct and indirect effects under different contexts

Effect	**Net buyer of food**		**Net seller of food**			
			Early adopter		**Late or non-adopter**	
	Product is tradable in the location where household lives	**Product is non-tradable in the location where household lives**	**Product is tradable in the location where household lives**	**Product is non-tradable in the location where household lives**	**Product is tradable in the location where household lives**	**Product is non-tradable in the location where household lives**
Direct (farm profit)	Not applicable	Not applicable	Very positive Prices remain unaffected but marginal cost is lower	Positive Profits increase for a time, but product prices tend to go down	Neutral Although adopters are benefiting from technical change, prices remain unchanged	Negative Prices driven down by technical change in other farms
Indirect (food prices)	Neutral. Food prices determined by world market are not affected by local technical change	Positive Local technical change drives food prices down. Household benefits in proportion to share of expenditures on food	Not applicable	Not applicable	Not applicable	Not applicable

On the contrary, when a commodity is tradable, local prices will reflect international prices. Local increases in productivity will not have a significant effect on lowering food prices, and thus adopting producers stand to gain while the effect on consumers in neutral. While a commodity might be a tradable in the world market and in the urban centers of a given country, it can also be a non-tradable in another region because of poor roads, long distances, or cultural food preferences (Byerlee, 2000). In regions such as Latin America, West Asia and North Africa where many or most of the poor are located in urban areas and

where local prices reflect international prices, the indirect effect of local gains in productivity due to technical change in agriculture will be low, but the direct effect on the farm income of adopting net producers will be high. In countries - such as many in Sub-Saharan Africa and some areas of South East Asia - where most of the poor live in areas affected by de facto protection due to poor roads and high transaction costs, the indirect effect on food prices of local gains in productivity due to technical change in agriculture will be high for consumers, but the direct effects on the farm income of net producers will be low (Byerlee, 2000).

De Janvry et al. (1991) have shown that many poor rural farming households operate in imperfect markets, due to high transaction costs, and may face incentives to operate outside the market exchanges described in the previous paragraphs. They emphasize that it is sufficient that the market imperfections be specific to the household and not necessarily to the commodity, to explain why some small farmers chose to engage in non-market transactions. In their model, a market failure occurs when "a transaction through market exchange creates a disutility greater than the utility it produces, with the result that the market is not used for the transaction. Either surrogate institutions will emerge for the transaction to take place or the transaction simply does not occur. Non-existence of the market is thus the extreme case of market failure. In a more general sense, the market exists, but the gain for a particular household may be below or above cost, with the result that some households will use the market while others will not" (p. 1401).

What is important for this discussion from the point of view of poverty reduction, is not the status of the market per se, but the idiosyncratic position of each household vis-à-vis that market (de Janvry and Sadoulet, 1998). For net buyers of food, the relevant price is the market price plus the transaction costs of purchasing. For net sellers it is the market price net of the transaction costs of selling. Households that do not sell nor buy a particular crop, find themselves with a farm gate implicit price that is too low to sell, and too high to buy (de Janvry and Sadoulet, 1998).

Even if the net aggregate contribution of agricultural research and extension to poverty alleviation has been established as having been positive, that does not mean that there have not been many particular instances in which technological change has resulted in negative impacts on poverty reduction. Kerr and Kolavalli (1999) describe a number of conditions in which technical change could result in lower income and loss of assets for non-adopters, labor displacement, adverse effects of agricultural inputs on the health of farmers, farm workers and consumers, and increased natural resource degradation. Kerr and Kolavalli call this the "rich get richer and the poor get poorer scenario"

The same process of technical change can have winners and losers, simultaneously. As Kerr and Kolavalli point out, the distributional effects of technical change (among different types of farmers, between farmers and wage laborers, between producers and consumers, among regions) will depend on policies and institutions. de Janvry and Sadoulet (2000) add that trade offs between the direct and indirect effects of agricultural technology on poverty reduction will be higher when there are institutional gaps or barriers that discriminate against the poor in their access to public goods, when there are large market failures, and when land and other assets are unequally distributed.

The bottom line of the above discussion is that it does not make sense to *a priori* select one single strategy as the most convenient to reduce poverty. The constituency of poverty-reducing agricultural innovation includes the urban poor, small farmers who are net sellers of their outputs, small farmers who are net buyers of food, agricultural wage workers, the rural non-farm wage and self-employed, and, of course, the very large number of those whose livelihood strategies combine elements of several of the above.

The correct mix of policies and instruments has to be determined on a case-by-case basis. Standardized and universal recipes, such as "prioritizing poor farmers in marginal regions" or "prioritizing resource rich farmers in high potential areas" is not what is needed if the goal is to improve the impact of agricultural innovation on poverty. More likely than not, what developing countries need are comprehensive sets of differential policies, each of them aimed at addressing specific populations and objectives. A problem of this approach

is that designing, managing and implementing a comprehensive set of differential but well coordinated policies, is a much more difficult and demanding task than a "one size fits all" strategy.

4. INSTITUTIONAL CHANGES IN THE AKIS OF DEVELOPING COUNTRIES

Box 1. Impact of agricultural research on poverty alleviation in East Asia

Fan et al. (2000a) in a study of China (1978-97) conclude than public investment in agricultural research and extension had the largest impact on agricultural growth, and the third largest impact on poverty reduction. One should consider that in that period China reduced its poor population by 210 million people (a number close to the estimated total number of poor people in Sub-Saharan Africa in 1998). A separate study confirms that higher food grain yields in China have made a significant contribution to reducing chronic poverty (Jalan and Ravallion, undated)

In Vietnam during the 1990's, the incidence of poverty decreased from 58% to 37%. In the same period, this country became the second largest exporter of rice in the world. In this transition, a one ton per hectare increase in the yield of rice lead to a 17% increase in the probability of a household escaping poverty (Glewwe et al., 2000).

Agricultural development is essential for widespread poverty reduction. Most of the poor are rural-based. Even when much of their income is derived directly from rural non-farm employment (RNFE), these alternative activities are often directly of indirectly linked to and dependent on agriculture. Precisely because of these linkages, agricultural development can spur broad-based economic growth and development in the rural and urban areas (Mellor, 1976; Reardon et al., forthcoming; Reardon et al., 1998; Barrett et al., 2000).

While economic diversification out of agriculture and urbanization are powerful trends that can offer new and better opportunities for many of the rural poor, they are not viable alternatives in the short term for most of the least developed countries, nor for a large proportion of the poor who lack the skills and resources to become employed or self-employed in the industrial or services sectors (Pinstrup-Andersen and Pandya-Lorch, 1995).

Box 2. Impact of agricultural extension on poverty alleviation in Chile

The Government of Chile evaluated the impact of its publicly-funded but privately-delivered extension service for small farmers (Comité Interministerial de Desarrollo Productivo, 1999). The study found that, on average, the small farms that receive this service are more profitable and competitive than those that have not had access to it. The gross margin of the participating farm was two times larger than that of the non-participants. The study also found that the net per capita household income of those families that received the support of this extension system, was 1.22% greater than that of those who did not have access to this public service. While the average impact of extension was found to be positive and statistically significant at the national level, the study also concluded that many rural households failed to benefit, in particular if a large share of their income did not come from agriculture.

Box 3. Impact of agricultural research on poverty alleviation in India

In India, the share of people living in poverty has decreased from 55% in the 1970's to about 35% in 1999. Economic growth, particularly agricultural growth, has been the main source of poverty alleviation (IFPRI, 2000).

Fan and Hazell (1999) have estimated the marginal impact of different types of investments on production and on poverty alleviation. The impact on production of research on high yielding varieties ranges between 63 and 688 Rps/ha. The same research raises the share of the population above the poverty line by 2 to 5 percentage points. The impact of agricultural research on both production and poverty is greatest when the investment is focused on rainfed areas as compared to investments in irrigated regions.

Past experience and a significant body of research show that agricultural research and extension can have strong and positive impacts on agricultural growth and on poverty reduction, when contextual conditions are right (Lipton and Longhurst, 1989; Hazell, 1999; von Braun, 1995). Echeverría (1990) reviewed more than 100 agricultural research and extension impact assessments; of the 42 studies that referred to crops and enterprises of major importance to small farmers in developing countries, all but five report significant returns to public investment. Other studies have addressed more specifically the impact of agricultural research and extension on the welfare or rural households and on poverty, and provide evidence of frequent and significant positive impacts (for Asia, Pingali et al., 1998; China: Fan and Pardey, 1997; Fan et al. 2000a; the Philippines: Hayami and Kikuchi,

1999; Otsuka, 2000; India: Saith, 1981, Bell and Rich, 1994, Datt and Ravallion, 1998, Fan et al., 2000b; Mexico: de Janvry and Sadoulet, 2000; irrigated areas of Somalia: Purcell and Anderson, 1997). On the other hand, Purcell and Anderson (1997) show that often research and extension projects fail to meet some of their objectives and, in particular, some that are more relevant to the purpose of reducing poverty.

Should the public sector invest in agricultural research and extension?

Agricultural knowledge and information flows through a variety of channels, including private sector firms, universities, NGOs, and agroindustries and commercial suppliers of agricultural inputs and equipments. According to the concept of subsidiarity of the state, public action is justified when there are market failures that prevent the provision of a socially optimal level of a good or service, when the good or service in question is a public good that will not be provided by the private sector, and/or when there are externalities associated with that good or service (McMahon and Nielson, 1998).

In the case of rural poverty reduction, the key argument is that in the absence of public intervention, a large number of potential users of agricultural knowledge and information, will not have equal access opportunities when compared to other, non-poor farmers. Most people would agree that "leveling the field" of opportunities to access knowledge and information, should be a basic public responsibility. In addition, the argument that much of the knowledge and information generated and disseminated by research and extension is of a public good nature (non-rival and non-excludable benefits), also applies to the case of small farmers.

A more complex environment

The environment in which agricultural research and extension must operate today, is increasingly more complex than those of the Green Revolution.

Decreasing public funding for agricultural research and extension

During the 1960's and 70's, investment in research grew at a rapid pace, estimated at a global average of over 6% per year (Alston et al., 1998; Pardey and Alston, 1995). During the 1980's, investment stagnated or declined, in particular in Africa and Latin America (Echeverría, 1998). The reversal of this trend was influenced not so much by a new formulation of public policy vis-à-vis research, but more by the across-the-board efforts to cut down public spending as part of the structural adjustment programs of the 1980's.

The decline in public funding caught the national research organizations badly prepared, as in many countries the number of scientists and the fixed administrative costs of the research institutes grew at a faster pace than the share of the budget covering new investments and operational expenses. In Latin America, for example, between 1981-85 and 1992, the number of researchers grew by 22%, while total budgets decreased 15% (Echeverría, 2000). Many of the better qualified scientists left the public institutes as their real salaries and the possibilities to do effective research dropped.

Similar trends were experienced by the international institutes of the CGIAR, who suffered important budget cuts at the same time that the number of centers – and the demands placed on them – increased. In the 1980's, these trends were even more drastic in the case of extension. In Latin America, many national governments (such as in Mexico and Brazil) simply abolished their extension services, which were widely seen as having become grossly inefficient, burocratized and ineffective (Berdegué, 1998).

The decline in public funding has been only partly offset by the growing importance of private research efforts, which by the late 1990's accounted for only 10% to 15% of the total investment in developing countries (Echeverría, 1998; Byerlee, 1998). Moreover, much of these private research is concerned with commodities and technologies which are not those of greatest importance to small and poor farmers.

The result is that in many developing countries, the current calls for greater research and extension support to poverty reduction policies are constrained by the lack of research and extension systems capable of rising to the challenge. In many countries, efforts to revive these national organizations through internationally-funded programs, have led nowhere.

Greater institutional complexity

At the same time that the official research and extension agencies were experiencing the decline described above, new institutional actors began to appear with greater force in developing regions. These include private sector firms, NGOs, universities and research institutes, foundations, farmers organizations, new ministries for environment, social welfare and science and technology, agroindustries, and, more recently, local governments at the regional and municipal levels. Some of these became involved directly in the organization and delivery of agricultural knowledge and information, while others have played a major role in the formulation and advocacy of policy. A recent study (Rees, 2000) of four rural districts in Kenya, for example, reports the active involvement of over 30 different organizations in each of them, from local community groups to seed suppliers, to NGOs, to traders, to official research and extension programs and institutes. All of them provide farmers with services of direct importance for agricultural innovation at the local level.

At the same time, many studies conclude that these numerous agencies often act with little or no coordination or even contact among themselves. Each promotes their own agendas or pursue their private objectives. Farmers' and community organizations often lack the skills and the resources to take control and manage this complexity on behalf of their members (Carney, 1996).

It is not only that there are many more actors involved in agricultural innovation in developing countries, but also that the mechanisms for planning, designing and delivering services are themselves also more diverse. In many countries, like Chile, the financing and the delivery of extension services are now separate functions, for which different

institutions are responsible. In Mexico, the national government is responsible for the formulation of general policies, but it must negotiate with each of the 32 state governments and their respective Foundations to define how those policies will be operationalized and implemented. In Zimbabwe, a national level institution (Agricultural Research Council) focuses on policy, while other governmental and non governmental agencies are in charge of executing the research programs. In Latin America, private agroindustrial firms contract production with tens of thousands of small and medium farmers and define the grades and standards for the outputs and the technical characteristics of the production processes; sometimes these private firms sign specific contracts with government agencies or universities to conduct applied and adaptive research to solve specific bottlenecks. NGOs often formulate their own programs and projects, taking advantage of a very well developed networking capacity to mobilize knowledge, know how and mutual support on a continental or even global scale. In other occasions, NGOs act as subcontractors for official programs, or develop joint venture agreements with them. Governments – often with the support of multilateral or bilateral agencies like the World Bank and USAID -in many Latin American countries have established Foundations that act as quasi private organizations. The privatization or closing down of many governmental agencies in Asia, Africa and Latin America that used to be in charge of seed and fertilizer supply, marketing, management of irrigation systems, and technical advisory services, has opened up a market for small and medium private entrepreneurs and local community organizations to take charge of the delivery of these services. Governmental agricultural research organizations in many countries now are managed by Boards and top executives largely controlled by the private sector and by representatives of national farmers' organizations.

Funding mechanisms for agricultural research and extension have also evolved. The old ways of block grants or regular financing through the national budgets are giving way to an array of procedures that share the common characteristic of linking funding to the delivery of specific and well defined outputs. Competitive Funds are increasingly being used in Latin America, Asia and Africa for this purpose (Gill and Carney, 1999). While the move to emphasize delivery of outputs is healthy in many situations, it has also resulted in a significant dispersion of research efforts, lack of strategic goals, exacerbation of

competition for funds, weakened cooperation among different agencies, and dwindling support for long term investment in research facilities and human resources (Gill and Carney, 1999; Echeverría, 1998). Of particular concern is that often these Competitive Funds in practice discriminate against the poor and the marginal regions, simply because the supply side of the equation tends to be weaker as compared to that for dynamic regions, profitable and competitive commodities, and commercial farmers.

Full or partial cost-recovery has been another mechanism implemented by many agencies, in particular in relation to extension services and those areas of research which produce results that are not complete public goods. At least in Latin America, the success of these mechanisms has been way below expectations. On the other hand, the involvement of local governments as the leading agencies in agricultural extension in Colombia and Venezuela, has resulted in a very significant expansion of the financial base of these systems, as municipalities are able to tap into many non-traditional sources of funding (Berdegué, 1998; McMahon and Nielson, 1998).

National research agencies are also attempting to commercialize research results and services, applying intellectual property rights when needed. Most of the Latin American agricultural research institutes now have procedures in place or have developed subsidiaries to patent and charge royalties for their products or to establish contracts with private firms to evaluate inputs, conduct soil tests, or multiply seed (Echeverría, 1998). As governments push research agencies to generate an increasing share of their budgets from these commercial operations, problems of priority interest to small and poor farmers and marginal regions often are left behind since they offer fewer opportunities for commercialization.

In summary, while all of these developments have helped in solving, at least partially, many important shortcomings of the traditional agricultural research and extension systems, and while the diversity of agencies involved contributes to the richness of a country's agricultural knowledge and innovation system, one cannot lose sight of the fact that very often the poor have ended up at the narrow end of the funnel. The emphasis on shorter term

results, on better rates of "success", on greater financial self-sufficiency, on relatively simpler problems that can fit the framework of three or four year projects, on a greater capacity from the supply side to formulate and prioritize problems and place them in project formats, on improved ability to seek information about the multiple options and to negotiate with multiple potential partners, all of these are "rules of the game" of the new institutional environment of agricultural research and extension, that the poor have much more difficulties in meeting.

Targeting the poor in research and extension

Partly in response to these trends and their effects on the poor – but also because of other reasons – there has been a move to develop new approaches to prioritize and target the needs of small farmers in agricultural research and extension. Byerlee (2000) discusses different approaches to improve the targeting of agricultural research for poverty reduction. The basic economic surplus models used by many NAROs to prioritize research, can be refined to differentiate between different categories of consumers (typically, income or expenditures groups) and producers (normally represented by classes of farmers according to farm size). Also, geographical information systems are used to add a regional perspective to the allocation of research, and this can relate to poverty alleviation if there are differential spatial distributions between the poor and the non-poor. According to Byerlee (2000: 434), "the effectiveness of targeting will depend on the extent that; (i) benefits of research are captured by producers, (ii) poor producers depend on agricultural incomes, (iii) poverty is correlated to the targeting variable, (iv) the targeted research can generate economic surplus higher than the cost of the research and (v) the degree and nature of technological spillovers."

Targeting is a moving target. Many studies find out that technical change spills over to regions remote from those of the initial impulse (Hazell, 1999). Jayaraman and Lanjouw (undated) in a study of the evolution of poverty and inequality in Indian villages, found out that although many of the inputs introduced by the Green Revolution since the 1960's were

not suited for many parts of the country, new seeds, fertilizers, mechanization and expansion of irrigation were eventually incorporated to some extent in virtually all of the villages studied, and, moreover, that the new technologies do not appear to have systematically conferred an advantage to large farmers.

Demand-led, participatory targeting and prioritization approaches are being increasingly applied in agricultural research, extension and development (Scoones and Thompson, 1994; Byerlee, 1998; Chambers et al., 1989; Ashby, 1990; Farrington, 1998; Ravnborg and Ashby, 1996; Collion and Rondot, 1998; Collion, 1995; Blauert, 1999; Gill and Carney, 1999; Guijt and Gaventa, 1998; Braun et al., 2000; Selener, 1997). In this area there has been an explosion in the number and variety of methods and tools, from the now more traditional Participatory Technology Development and Rapid Rural Appraisals, to the promotion of Local Farmers Research Committees and Farmer Field Schools, to participation of farmers and farmers organizations in the boards of the research and extension agencies, to the relatively more recent development of Competitive Agricultural Technology Funds.

These participatory, demand-led approaches have provided practical, effective and cost-efficient solutions to the very complex problem of how to make agricultural research, extension and development more relevant to the needs of poor farmers. On the other hand, they are not free of limitations. Pretty (1998), for example, estimates that in the mid-90's there were about 2 million farmers, in 20 countries, involved in projects promoting participatory sustainable agricultural technologies and processes, and yet he states that these are "small islands of success" and that "there remains a huge challenge to find ways to spread or scale up" these processes (p. 28). This is similar to the conclusion of Byerlee (2000) that many of these approaches have been most effective for local level adaptive research, but that they face greater difficulties when applied to national levels. Farmer participation does not always assures that the poor lead in influencing the agenda of these programs, as local rural elites tend to have more power in decision-making, as in the case of the Local Farmers Research Committees promoted by CIAT and others in Honduras, where illiterate farmers are underrepresented in local organizations (Humphries et al., 2000).

Finally, it must be said that these type of participatory methods are most appropriate when the purpose is to maximize direct effects of agricultural innovation on the participating individuals, households, or communities, but they are less relevant in contexts in which indirect effects are important.

5. DIFFERENTIAL STRATEGIES TO IMPACT ON RURAL POVERTY

In the previous pages we have argued that the net impact of agricultural innovation on poverty will be the result of:

(a) The livelihood strategies of the households, which in turn are conditioned by the interaction between their assets (capacities) and their contexts (incentives), and

(b) The relative size of the effects of agricultural innovation on the net income of farming families, food prices, and agricultural and non-agricultural employment

The interplay of both elements suggests that differential strategies are required to build situation-specific AKIS that are relevant to particular combinations of these factors (figure 1).

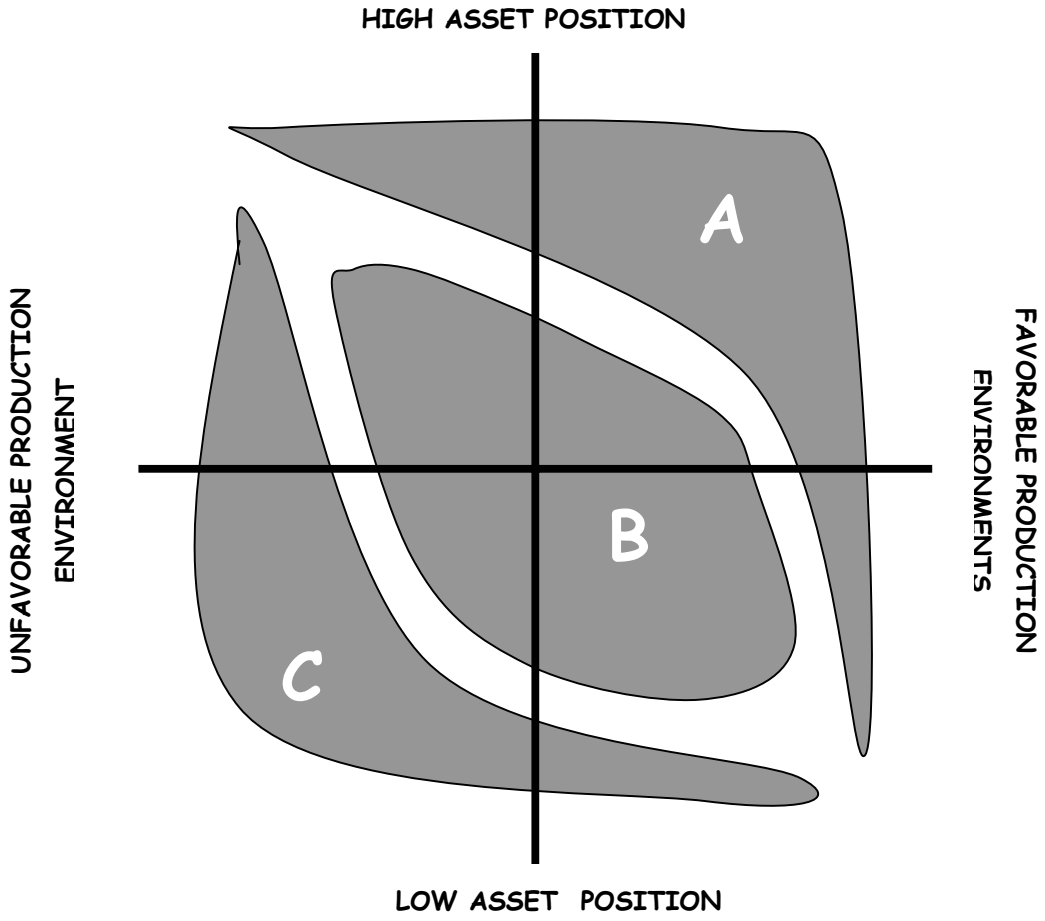

Figure 1. Differential strategies for the development of Agricultural Knowledge Systems (AKIS) and poverty reduction. (A) Market-driven AKIS that impact on poverty primarily through lower costs of food for the urban poor and for rural poor who are net buyers of food, through more and better employment opportunities, and through production, consumption and investment links that stimulate the nonfarm rural economy. (B) Market-oriented, asset constrained AKIS, that may impact on poverty through direct effects and indirect effects. (C) Context- and asset constrained AKIS, where innovation is driven by social capital, where agricultural innovation can make limited direct contributions to poverty reduction and where non-agricultural livelihood strategies predominate.

Market-driven AKIS

The first strategy is relevant to situations in which agricultural innovation is spurred by favorable contexts and asset positions. In sector A of figure 1, agriculture is a profitable and competitive enterprise. AKIS develop primarily due to the action of market forces, and specifically because of the profit opportunities found by commercial farmers and private firms and entrepreneurs in the services and agroindustrial sectors. The profit motive is the glue that drives the linkages and interactions between these actors. Research and extension find here near optimal conditions to display their capabilities. Private research naturally targets these type-A situations. Commercial farmers have the skills, education, networks, organizations, political power and capital required to mobilize and influence both public and private agricultural research and extension when and where necessary.

Direct effects are of little importance in this situation, as few of the farmers operating in these conditions will be poor to begin with. On the other hand, it is under these conditions that indirect effects are maximized: high adoption rates result in rapid improvements in productivity, that drive food prices down on a global scale. When intensive agricultural systems are the norm, thousands of jobs can be created, and these areas are characterized by large seasonal migration of farm workers from less favored regions, often across countries. By definition, these agricultural systems are linked in many ways with the nonfarm economy, as their requirements for transportation, supplies, professional services, marketing systems, and processing are very high. High income farmers and dynamic farms typically are also investment-linked with nonfarm enterprises.

Is there a role for public policies and interventions in developing countries directly related to agricultural innovation under this type of conditions?[1] The answer is a resounding yes. But these policies and interventions will tend to be of a horizontal nature, being those that

[1] It is outside the scope of this paper to detail the strong need for public action unrelated to agricultural research and extension, to insure that the growth and wealth generated in these areas are equitable distributed and that they contribute to the overall fight against poverty. Among others, these include fiscal, labor and environmental policies, development of public services for farm workers, land use planning to avoid the collapse of cities and services, etc.

in general create or strengthen institutional frameworks. These public policies and interventions should have the goal of exploiting the intersection between public goods and private interests, by means of:

- Developing clear regulatory frameworks and strengthening intellectual property rights
- Protecting these agricultural systems from unfair trade competition and non-trade tariffs and barriers to commerce, as well as promoting private-public cooperation for the purpose of opening new international markets
- Developing national science and technology policies that do not discriminate in favor of any one particular kind of research organization and that, on the contrary, promote diversity, specialization and competition, all of which will lead to cooperation when necessary, in particular if the private sector is provided additional incentives through such means as competitive science and technology funds or specific research contracts
- Supporting through direct public investment basic and strategic research in those fields of science and technology that are most relevant to those agricultural systems that enjoy an actual or potential competitive advantage
- Funding the specialized training of highly skilled young scientists
- Promoting the establishment of cooperation agreements between national universities and research institutes and their counterparts in other countries
- Stimulating linkages and cooperation for innovation between different actors in agroindustrial and marketing chains
- Investing in public but non-governmental organizations (such as foundations endowed with public and private funds) that manage venture capital to start new enterprises that bring new technologies into the country
- Adopting policies that create favorable conditions for foreign investments in R&E and in innovative for-profit enterprises

If the correct institutions and policies are in place to insure that the benefits of growth and innovation are broadly shared in a society, all of the above public policies and interventions

will lead to win-win scenarios for growth and poverty reduction. In addition, if successful in stimulating greater private investment in research and extension, these policies and instruments could free private resources for investment in other situations.

Market-oriented, asset constrained AKIS

Zone B in figure 1 depicts a situation in which small farmers are predominant, who may have the incentives to embark in market-oriented agricultural innovation processes, but lack the capacity to fully respond to that favorable context, either because their assets are too limited, the productivity of such assets is low, or because the transaction costs they face are too high. For reasons that will be discussed in the following paragraphs, it is likely that this group of small family farms represents the best opportunity (in economic, social and also political terms) for linking agricultural innovation and poverty reduction policies in developing countries.

Effective type-B policies and programs will yield both direct and indirect impacts on poverty. Many of the farmers in type-B situations are poor, and this opens space for direct effects on the net income of farming households. Second, all of the research on the nonfarm rural economy shows that it is in this type of situations that farm/nonfarm linkages develop best and have the largest effects on the welfare or rural communities. Third, small farmers in type-B situations produce a large share of the world's food products, as in the notable case of rice in Asia or vegetables for the domestic market in much of Latin America, or milk in Africa.

The market will not produce these results by itself, otherwise it would have already done so. But neither will they be achieved in the absence of clear and viable links to markets. Strategies for type-B conditions must have a clear and strong market-orientation, but this potential will not be achieved in the absence of pro-active public policies.

In type-B situations, one often finds the condition described by Röling and Jiggins (1998), that the AKIS has potential to develop, but lack of synergy among the many potentially

complementary contributions of different private and public agents to innovative performance constrains this potential.

Public policies and interventions under type-B conditions are needed to: (a) increase the assets available to small farmers, as well as their productivity; (b) lower transaction costs and diminish the institutional constraints and the market failures that hamper the productivity and innovation potentials of family farms, and; (c) promote the development of an effective AKIS by stimulating synergistic interaction between public and private agents, including farmers.

What types of agricultural innovation public policies and interventions can be successful in this context?[1]

- Supporting efficient and effective NARS, understanding that the concept must not be restricted to the conventional agricultural research agencies, but also universities, private R&D firms, NGOs, farmers' organizations, foundations, etc. Promoting institutional diversity and competition to deliver better service to small farmers, is of the essence. While action at the demand side (e.g., competitive funds targeted at small scale farmers, as the PRONATTA Fund in Colombia; Gill and Carney, 1999) is of great importance, there is also a need for policies and interventions that more directly target the development of capabilities at the supply side of the equation, by investing in the training of the staff of NARS, their equipment and infrastructure, their management systems, and their methods and tools. Demand-driven approaches do not work well in the face of weak suppliers of agricultural research and extension services.

[1] As in the previous case, for reasons of focus and of space, we refrain from discussing public policies and actions that, although not directly related to agricultural research and extension, would have obvious effects favorable to agricultural innovation in type-B situations. These include, among others: development of roads, electricity, irrigation and telecommunications infrastructure in these rural areas, improved education, regulatory frameworks and specific policies that stimulate the development of small and medium rural enterprises, improving the access of small farmers to land and financial markets, removing biases in agricultural policies that favor large scale farming at the expense of small scale landholders, etc. It must be said that these types of policies and interventions are of fundamental and irreplaceable importance for the success and consolidation of viable family farms in developing countries.

- Revitalizing extension and farm advisory services. In today's world, this means changing their outlook from primary production to a market orientation, empowering users so that they exert ownership over the extension services, decoupling public financing from private service delivery, decentralizing decision-making and involving local governments, investing in the development of new skills and know how, and imposing management and incentive systems that reward delivery of well-defined results. Fortunately, there are now dozens of examples for inspiration and orientation.
- To the extent that it is feasible at any given time and place, give priority attention to non-food staples (e.g., cash crops, boutique and niche products, nontraditional exports, crops that can be produced under contract with agroindustries, as well as rural farm-based enterprises that generate new types of goods and services demanded by the growing urban sectors, such as agrotourism and the management of rural areas for recreational purposes). Of course, large-scale emphasis of non-food staples will be practical and feasible only when the country has the foreign exchange required to purchase basic food staples in the world market, and when the infrastructure and the marketing and processing sectors are developed to the extent needed for the services-intensive production of these kinds of agricultural products. Yet, in many cases and in the long run, the small-scale production of food staples will be a poverty trap, as most of them can be produced more efficiently by farmers in type-A situations, and because most type-B regions will not enjoy the kind of de facto protection offered by remoteness and high transportation costs.
- Framing agricultural innovation within broader policies and programs aimed at the broad-based development of local rural economies. In particular, agricultural research and extension should strive to build their side of the bridge that links small scale farming with the nonfarm economy, by prioritizing those enterprises, processes and production and postharvest technologies that: (a) are more intensely linked with rural services and industries, (b) save labor from on farm work so that it can be invested in nonfarm self- or wage employment, wherever these opportunities exist.

- Promote small farmers' economic organizations as institutional platforms for collective action to confront problems of barriers to market access, economies of scale, and transaction costs (Berdegué, 2000).

Table 3 contains comparable data from 16 developing countries from Africa, Asia and Latin America, that give evidence of the significant shares and numbers of small farms with enough access to land to allow the development of livelihood strategies in which agriculture could play a significant role. While the data in table 3 provides only indirect and partial evidence of the potential of family farms in a number of countries - since, as we have discussed earlier, many other factors condition this potential aside from the size of the landholding – it does suggest that in the developing world, there are tens of millions of small farms that could participate productively in a comprehensive effort to consolidate a viable sector of family farms. There is a need for further research to identify, quantify and describe the importance and characteristics of those farms that could participate in type-B strategies of agricultural innovation to reduce poverty.

The work of Fan et al. (2000b) which provides evidence on the relatively high marginal returns to investment in technology in the less favored areas of India, also shows that the five most productive zones (rainfed and irrigated), contain 141 million poor rural people, with poverty incidence between 28 and 49%. This number is close to three times larger than the number of poor people living in the nine rural regions with lower land productivity, where poverty incidence ranges between 22 and 48%.

Renkow (2000) reviews the evidence from other studies (Kelley and Parthasarathy Rao, 1995, for India; Byerlee and Morris, 1993, for the wheat zones of South Asia; Heisey and Edmeades, 1999, for maize growing regions of the world, and; UNEP/GRID, 1997, for West Africa), and reaches two conclusions: (a) the evidence tends to show that poor rural people are not exclusively concentrated in marginal production environments, and that, on the contrary, there are very large number of them in more favored regions in the developing countries; (b) the geographic distribution of poverty varies considerably from country to

country, and hence it would be wrong to try to establish a general rule for targeting poverty through geographic variables.

Table 3. Importance of small farms with sufficient land potential for operating on a commercial basis

Country	Year	Strata (ha)	Number of total landholdings in strata x 1000	Percentage of total landholdings in the country	Percentage of total land
D. R. of Congo	1990	1-2	468	10.4	23
Ethiopia	1992	1-2	453	7	35
Lesotho	1990	1-2	67	29	n.a
Burkina Faso	1993	1-2	173	19	7
Guinea	1989	1-2	107	25	21
Uganda	1991	1-2	412	24	16
India	1986	1-5	34,000	35	46
India	1986	2-5	16,000	17	30
Nepal	1992	1-5	786	29	56
Nepal	1992	2-5	257	9	28
Pakistan	1989	1-2	1,000	20	8
Pakistan	1989	2-5	1,700	33	28
Philippines	1991	1-2	1,300	29	16
Philippines	1991	2-5	1,200	26	33
Thailand	1988	1-2	1,300	28	16
Thailand	1988	2-5	2,000	42	37
Brazil	1985	5-10	771	18	2
Paraguay	1991	5-10	67	22	2
Peru	1994	5-10	262	14	5
Colombia	1988	5-10	232	15	4
Honduras	1993	5-10	53	16	7

Source: FAO, 1997

Context- and asset constrained AKIS

Sector C in figure 1 shows the condition in which households lack most types of assets aside from unskilled labor and, sometimes, very little land (e.g., less than 1 ha), and, at the same time, operate in unfavorable environments. In short, the potential for agricultural development that results in sustainable reduction of poverty levels, is very limited or non-existent. While agricultural development projects can create artificial systems of incentives for a certain period and for a limited fraction of these millions of households, the fact remains that often these regions lack growth engines (i.e., regular and dynamic sources of demand either for labor, services or products) that can provide the stimuli needed for long term poverty reduction.

As discussed in previous sections, those type-C households that have access to land, often engage in subsistence farming because: (a) they lack better employment options; (b) they have developed diversified livelihood strategies in which agricultural production complements other sources of income, often as unskilled agricultural labor, from remittances and subsidies, or from what Reardon et al. (forthcoming) call refuge rural non-farm activities; and (c) transaction costs are so high as to effectively bar them from operating in the market as sellers and/or as buyers of most agricultural products.

In type-C situations, poverty reduction policies and programs must be even more broad-based than in the previous case. Given the very limited endowment of agricultural assets, even significant long term increments in agricultural productivity will usually have a very small impact on total household income. Farming systems under these conditions are very often in a state of finely-tuned equilibrium within their very constraining contexts, which means that unless the constraints are removed or at least significantly reduced by means of broad-based development policies, there is little room for improvement.

Broad-based development policies aimed at type-C situations, will normally include interventions aimed at trying to move these households towards a type-B condition, by enhancing their asset position (e.g., land distribution, access to credit, training, education , and health programs, strengthening of community organizations), and/or by improving the context in which they operate (e.g., roads, irrigation, improving the capacity of local governments, supporting more efficient markets). In the absence of such changes, the potential for agriculture-based development will remain very low.

Does this mean that agricultural research and development cannot play a role under type-C conditions? Of course not. But successful efforts will tend to be those that understand that under type-C conditions, self-employment in agriculture will usually be only one element – many times not even the most important one – of diversified household livelihood strategies.

There are many who call for targeting a greater share of agricultural R&D resources on regions characterized by marginal environments for agricultural production. The arguments include considerations of public vs private roles and of efficiency of public investments. The private vs private sector argument states that if the private sector can largely take care of type-A areas and farmers, then that should free resources for investment in agricultural R&D in areas, crops, problems and populations that are not being served by private agricultural technology companies (Altieri and Waters-Bayers, 2000).

Recent work by Fan et al. (2000b) shows that under some conditions there can be cost-efficient effects of publicly-funded research and infrastructure on production growth and rural poverty. They studied 14 agroecological zones of India, that differed in land productivity (a proxy for production potential of the environment) and in the incidence of poverty. They found that while in the past most impacts of agricultural research on rural poverty and production was achieved in the more favored environments, in the future it is likely that marginal returns to this investment could be greater in some of the less favored zones (but not the least favored).

The equity argument is based the notion that the vast majority of the rural poor are located in marginal areas and, conversely, that there are few rural poor people in the more favored agricultural environments. We have already discussed in the previous section that while this is true in the sense that most poor rural people do live in marginal areas, there is also a very significant number of them who live in favorable environments.

While these arguments show that there is certainly some room for agricultural innovation to contribute through direct effects to reducing income poverty, they do not dispel the findings of many other studies that conclude that the poorest of the poor, in the worse of the worse environments, almost always develop diversified livelihood strategies to try to improve their well-being and their income.

What are the types of agricultural innovation policies and interventions that can maximize the contribution – whatever its magnitude – of agriculture to poverty reduction in type-C situations? Most research in the past decade shows that successful experiences are always driven by the development of social capital. These households and communities often are well endowed with social capital. However, recent research has shown that while these networks do play important insurance and solidarity functions, they can promote significant movement towards reducing poverty and improving well-being, only when they cut across traditional family, clan, tribal or local community groups and link to outside networks (Narayan, undated). In other words, successful innovation in type-C situations depends on building local institutions, networks and organizations that help mobilize the very scarce resources of these communities, and link them to external networks.

The strategies that have shown the greatest potential for spurring institutional innovation for agricultural development under type-C conditions include participatory technology development, on-farm adaptive research by NGOs and local organizations, and farmer-to-farmer extension systems. In Peru and Bolivia, the International Fund for Agricultural Development (IFAD) has experimented with programs that transfer cash to local organizations that are empowered to hire technical assistance services as needed, and with minimal external intervention; these local organizations often enter into risk- and profit-

sharing agreements with their advisors to develop new market-oriented enterprises. Also in the Andean region of Latin America, many municipalities with high proportions of indigenous populations and with active NGOs, have seen the rise of "Mesas de Concertación" (Concerted Action Round Tables), which are institutional arrangements for developing private-public medium-term action plans for local development, in which agriculture and natural resource management projects often play a very important role. The biggest challenge - yet unsolved – is to find a way in which these local experiences can be upscaled so that their impacts are commensurate with the magnitude of 1 billion poor rural people.

Cash transfers programs are receiving increasing attention from international policy-makers, as a low-transaction cost and well targeted mechanism to reach the very poor. However, Sadoulet et al. (1999) have shown that the pioneer PROCAMPO program in Mexico has higher income multiplier effects for households with medium and large farms, non-indigenous backgrounds, access to irrigated land, and technical assistance.

In Type-C situations, formal research and extension organizations would probably be well served if they operate through agreements with local organizations and NGOs which can play the role of facilitating local level innovation processes, while the research organization plays a technical and methodological backstopping role, as CIAT (International Center for Tropical Agriculture) has done in Colombia and Central America (Braun et al., 2000; Humphries et al., 2000).

6. CONCLUSIONS

1. Poverty is multi-dimensional. Its causes are diverse, its manifestations and meanings are contextual, and it is not only a state of deprivation but also a dynamic set of processes. Because of this, poverty is a highly heterogeneous phenomenon. Too often in the past, the failure to recognize this fact, or to put it into practice when designing and implementing public policies and interventions, has led to a succession of fads of simplistic 'one size fits all' approaches. While some of them may have been better then others, our most basic disagreement is not so much with their specific content, but with the very notion that there can be a standardized strategy of agricultural innovation that can fit the determinants and conditions of all forms of poverty. If we want to improve the performance of agricultural knowledge and information systems vis-à-vis poverty, it is time that we learn to deal with diversity by means of customized approaches.

2. Part of the problem lies with the extended notion that agricultural research and extension equals agricultural innovation. The concept of 'Agricultural Knowledge and Information Systems' recognizes that agricultural innovation is a socially constructed process, in which a multitude of direct agents and stakeholders interact, each of them responding to particular interests and objectives, that are often in conflict with each other. If agricultural research and extension are important to agricultural innovation, so are markets, systems of government, social norms, and, in general, a host of factors that create the incentives for a farmer to decide to change the way in which he or she works, and that reward or frustrate his or her decisions. This is equally true whether we are talking about a commercial farmer who wants to export high value crops, or a subsistence indigenous rural community that needs to stabilize its production from year to year.

3. When the goal is poverty reduction, agricultural innovation policies and programs cannot start from agricultural research and extension towards poverty. This can only lead to standardized, 'one size fits all' solutions. The starting point has to be the analysis of the

different types of poverty (rural and urban), their determinants, the contexts in which they occur, and the livelihood strategies that the poor implement to respond to their condition. From there we can then move back to determine possible strategies for agricultural innovation, and only then can we look at the potential role of agricultural research and extension within each strategy. The more we move into conditions of poverty, deprivation, and unfavorable environments, the greater the need for these types of broad-based approaches. If this is done, then it will be seen that agricultural innovation will have to play widely different roles, depending on the specific poverty situation it wants to confront. The question is not one of research or extension per se, but one of innovation for poverty reduction. Only in certain circumstances will research and extension find themselves in the driver's seat. But even then, for research and extension to impact on poverty, they will have to be framed in the context of broad-based development policies, the broader as the potential for poverty reduction becomes narrower. Agricultural research and extension will fail if they try to tackle this issue in isolation.

4. Given the heterogeneity in the assets and contexts of the poor, and of the determinants of poverty, it is no surprise that rural households pursue a number of different livelihood strategies. Agricultural production can be a major element in those strategies, or it may play no role at all. The notion that all rural households are agriculturalists, or that agriculture is the best avenue for reducing income poverty for all rural households, are concepts that must be discarded as untrue and unrealistic. The agricultural path out of income poverty is relevant only for a share of the rural poor: those who have access to sufficient land and other assets relevant to agricultural production, and who operate in contexts that provide the incentives for those assets to be sufficiently productive over long enough periods of time, to leverage the household out of poverty. While participation in a development project can for a time create a favorable environment for those who are direct participants, it is only market integration that can provide the long term "engine" or incentives required for sustained development out of poverty once a project ends, and for the vast majority who never have a chance to participate in a development project in the first place.

5. Agricultural innovation has direct and indirect effects on the income and employment opportunities of the poor. Considering the magnitude of the challenge of poverty reduction, it would be unwise to chose one type of effect at the expense of the other, at least because of the following two reasons: (a) no single type of effect can adequately deal with and support the many and highly differentiated livelihood strategies chosen by the poor to escape poverty; rather than seeking to find a standardized policy and strategy for poverty-reducing agricultural innovation, "customized" solutions will be required to deal with different needs and circumstances; (b) the appropriate strategy can only be defined and designed at the national and sub-national level.

6. Under the increasingly prevalent condition of liberalized agricultural markets, those farmers who are early adopters of new technologies and who can keep the pace of continuous innovation, stand to gain from the direct effects of technological change. In the long run, many poor farmers in developing countries will only be able to benefit from the direct effects of agricultural innovation if they operate under conditions of *de facto* or *de jure* protection from international trade, or if public policies are put in place to allow them to significantly increase their productivity and/or to diversify into production systems in which they can have a competitive advantage.

7. Indirect effects of agricultural innovation through lower food prices, are a fundamental contribution to increasing the welfare of the 300 million urban people who live in absolute poverty and that spend very large proportions of their meager income on food, and also to a vast proportion of the rural poor (perhaps as many as 400 to 500 million people), who are net buyers of food either because they are landless, or because the amount of land that they have access to is so small that it is insufficient to provide all the food necessary to meet household needs. There is little hope for progress in the fight against poverty on a global scale, if agricultural research and extension diminish their overall support to those regions and farmers that can create this type of indirect effect. However, the rise of privately-funded R&D in developing countries offers a new set of conditions for defining the contribution of the public sector to agricultural innovation that seeks this type of indirect effects on poverty. There are now much greater opportunities for the public sector to reduce

its direct involvement in the implementation of research and the delivery of extension, while at the same time enhancing its capacity to stimulate and support private efforts, and to take care of those objectives that are outside the scope of private (i.e., commercial) interests.

8. An additional indirect effect of agricultural innovation that needs to receive much greater attention than in the past, is the growth of the rural non-farm economies. All the recent evidence shows conclusively that a growing number of rural households are deriving an increasing share of their total income from this source. Non-farm income is of particular importance to the rural poor, including to many agriculturalist households. Some traditional concepts need to be sharply revised, such as that which states that pro-poor agricultural technologies must be labor-intensive, as if the poor do not have other employment opportunities that can be better remunerated. Agricultural research should actively seek and exploit opportunities for developing and strengthening production, expenditure and investment linkages with the non-farm economy. Again, framing agricultural research and extensions priorities within the context of the broader livelihood strategies of rural households, should help in achieving this objective.

9. During the last two decades of the past century, the AKIS of developing countries have undergone significant institutional changes. To begin with, the magnitude of the public sector contribution to agricultural R&D has decreased in absolute and relative importance. The budgets of the traditional governmental research and extension agencies have tended to decrease. Unfortunately, this 'downsizing' has often been accompanied by a more general weakening of the capacities of these public organizations. At the same time, a positive development has taken place in many countries, that have seen the growth of a number of private, quasi-private, non-for-profit, and community-based organizations, that have taken over many of the tasks and services that used to be under the domain of governmental entities. Many of the new organizations are primarily or exclusively dedicated to working with poor rural communities, and on issues of direct relevance to them. These organizations have equipped themselves with new approaches and methodologies that are more responsive to the demands and the direct participation of the rural poor, who previously had

no voice under the status quo. In order to improve the effectiveness of these institutional complex vis-à-vis the rural poor, the public sector should: (a) put in place incentives and mechanisms so that the interests of the poor are not lost when public organizations are privatized or go commercial; (b) support the institutional strengthening and empowerment of rural communities and farmers' organizations so that they can play a greater decision-making role in this new institutional complex, and, in the last analysis, so they can exert a growing degree of ownership over many R&D services; (c) carry out programs to improve the quality and efficiency of many of the new organizations, in particular those working with the rural poor; (d) stimulate the coordination and interaction of these multiple agents, moving in the direction of true knowledge and information systems; (e) dismantle all those rules and mechanisms that discourage institutional plurality and, on the contrary, put in place policies and programs that foster institutional innovation at all levels; and (f) for all of the above to make sense, develop medium and long term science and technology policies that give consistency to the initiatives of the individual actors.

10. Differentiated policies for agricultural innovation must be designed to fit the needs and possibilities of different situations, such as the three described in this paper. Given the range of situations, it make little sense to commit to any option. The calls to place all the effort on working with the poorest of the poor in marginal environments, are as wrong as those that call for placing all bets on the indirect effects of high growth and productivity in the more favorable regions of the developing world. In general terms, one can recognize three different strategies to develop AKIS in support of poverty reduction: (a) strategies to support poverty reduction effects (mostly indirect) of innovation in dynamic, market-integrated, competitive agricultural systems; (b) strategies to support poverty reduction effects (both direct and indirect) of innovation by small farmers who may have the incentives and relatively favorable environments, but that lack the assets to respond to these opportunities to their highest potential, and; (c) strategies to support poverty reduction effects (mostly direct) of innovation by very poor rural people in marginal areas that offer few positive incentives and plenty of constraints.

11. Specific strategies need to be developed to respond to situations in which agricultural innovation is spurred by favorable contexts and asset positions, where agriculture is a profitable and competitive enterprise. Here, AKIS develop primarily due to the action of market forces, and specifically because of the profit opportunities found by commercial farmers and private firms and entrepreneurs in the services and agroindustrial sectors. Direct effects are of little importance in this situation, as few of the farmers operating in these conditions will be poor to begin with. On the other hand, it is under these conditions that indirect effects are maximized. Public policies and interventions should have the goal of exploiting the intersect between public goods and private interests, by means of: developing clear regulatory frameworks and strengthening intellectual property rights; protecting these agricultural systems from unfair trade competition and non-trade tariffs and barriers to commerce, as well as promoting private-public cooperation for the purpose of opening new international markets; developing national science and technology policies that do not discriminate in favor of any one particular kind of research organization; supporting basic and strategic research; funding the training of young scientists; promoting the establishment of cooperation agreements between national universities and research institutes and their counterparts in other countries; stimulating stronger linkages and more explicit cooperation for innovation between different actors within agroindustrial and marketing chains; investing in public but non-governmental organizations for R&D; adopting policies that create favorable conditions for foreign investments in R&D and in innovative for-profit enterprises.

12. There are millions of small farmers in developing countries that have the incentives to embark in market-oriented agricultural innovation processes, but lack the capacity to fully respond to that favorable context, either because their assets are too limited, the productivity of such assets is low, or because the transaction costs they face are too high. This group of small family farms represents the best opportunity for linking agricultural innovation and poverty reduction policies in developing countries, and as such they should be the primary target of national and international efforts. Many of them are poor, and this opens space for direct effects on the net income of rural households. Also, it is in this type of situations that farm/nonfarm linkages develop best and have the largest effects on the

welfare or rural communities. Small farmers produce an important share of the developing world's food products. Developing the full potential of these small farmers and their communities requires pro-active public policies that are market-oriented. These public policies should aim at increasing the assets available to small farmers, as well as their productivity; lowering transaction costs and diminishing the institutional constraints and the market failures that hamper the productivity and innovation potentials of family farms, and; promoting the development of an effective AKIS by stimulating synergistic interaction between public and private agents.

13. Finally, there is a need for differentiated strategies for rural households that lack most types of assets aside from unskilled labor and sometimes very little land, and that at the same time operate in unfavorable environments. Yet, those households in this condition that have access to some land, engage in subsistence farming as part of diversified livelihood strategies. Subsistence farming is also stimulated by high transaction costs that prevent these households from operating in the market as sellers and/or as buyers of agricultural products. Under these conditions, poverty reduction policies and programs must be even more broad-based than in the previous case, and will normally include interventions aimed at trying to move these households towards a better condition, by enhancing their asset position, and/or by improving the context in which they operate. In the absence of such changes, the potential for agriculture-based development will remain very low. Agricultural R&D policies and programs that are relevant to these rural communities must understand that self-employment in agriculture will usually be only one element of diversified household livelihood strategies. Most research in the past decade shows that successful experiences are always driven by the development of social capital. Successful innovation in these conditions depends on building local institutions, networks and organizations that help mobilize the very scarce resources of these communities, and link them to external networks. The strategies that have shown the greatest potential for spurring institutional innovation for agricultural development under these conditions, include participatory technology development, on-farm adaptive research by NGOs and local organizations, and farmer-to-farmer extension systems. The biggest challenge - yet unsolved – is to find a way in which these local experiences can be upscaled so that their

impacts are commensurate with the magnitude of 1 billion poor rural people. Formal research organizations would probably be well served if they operate through agreements with local organizations and NGOs which can play the role of facilitating local level innovation processes.

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