**Oxfam America**
Research Backgrounders

# Making Investments in Poor Farmers Pay:

## A review of evidence and sample of options for marginal areas

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Oxfam
America

# Oxfam America's Research Backgrounders

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Backgrounders available:

1. "Making Investments in Poor Farmers Pay: A review of evidence and sample of options for marginal areas," by Melinda Smale and Emily Alpert

2. "Turning the Tables: Global trends in public agricultural investments," by Melinda Smale, Kelly Hauser, and Nienke Beintema, with Emily Alpert

Forthcoming:

3. "A Compendium of Data on US Official Development Assistance to Agriculture" (working title), by Kelly Hauser

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# Abstract

This research paper is one of several prepared as background to an Oxfam International briefing paper on public investments in agriculture, written to support the agricultural campaign of Oxfam International and affiliates. The paper is motivated by the concern that despite growth in agricultural productivity over the past century, many of the developing world's farmers continue to live in poverty, particularly in areas that are marginal in terms of either agricultural potential, access to markets, or both. For decades, economists have debated whether or not more should be invested in agricultural research and development in marginal areas. The paper begins by summarizing this debate, concluding that it is narrow and off-center of Oxfam's campaign. Rates of return to investments in agricultural research are good enough in marginal areas, although they may be higher in other sectors such as infrastructure, and they are lower than in more favored areas. The economic reason for investing in agricultural research and development for marginal areas is that doing so reduces poverty, contributes to sustaining the environment, and benefits not only these farmers but the rest of the world—in a number of ways. There are also moral arguments, well-known to Oxfam.
The paper then locates marginalized farmers on the globe, backed by statistical data and analysis, reported in an appendix prepared by Kate Sebastian. About 20% of farmers in low and middle income countries are "neglected by man and nature," and an additional 10% are neglected by nature but not by man. "Man" refers to market infrastructure, and "nature" to a terrain and/or length of growing period. Thirty-four percent are neglected by man but not by nature. Adequate public investments in markets, and the institutions that enable farmers to participate in them effectively, could lead this third group out of poverty relatively quickly. The first group faces the biggest challenges. By describing who these farmers are, the paper then illustrates why we should invest in them and indicates how.
A sample of promising agricultural options are discussed, including low-external input technologies, local seed systems, and value chains for neglected and underutilized crops. Risk mitigation and transfer options are highlighted. Supporting annexes are provided that discuss institutional considerations related to the organization and funding of research and extension in marginal areas, and the methodology for defining marginal areas. However, although investing in agricultural research and development for these farmers is necessary, it is probably not sufficient to lead them out of poverty. They will need other livelihood pathways, and some may lead them out of agriculture.

# 1. The not-so-“green” revolution

Technical change in Asia’s Green Revolutions generated welfare benefits for farmers and consumers beyond the enhanced crop yields of adopting farmers in high-productivity environments,[1] but many of the world’s smallholder farmers have not yet benefited sufficiently from agricultural growth to cross the poverty line. Where are they, who are they, and which investments are likely to reach them? Why should we invest in these farmers? We address these questions here.

Despite renewed interest in creating a Green Revolution for Africa, replicating the same model will not meet the needs of all farmers in Africa or elsewhere, and particularly those of poor farmers in marginal areas. To generate agricultural growth and income among poor farmers in marginal areas, additional prototypes are needed, for several reasons.

The first reflects the characteristics of farmers and farming in marginal areas. It is worth remembering that the productivity gains of the first Green Revolution occurred in a narrow range of crops and technologies, and technical change was publicly financed by commodity-oriented, supply-driven, national and international research programs (Annex 1). Farmers who do not yet grow modern varieties of the major cereal crops in which the largest productivity gains have been made (rice and wheat, and to a far lesser extent, maize) reside primarily in diverse agro-ecologies and remote locations where a one-size-fits-all technology that depends on purchased inputs makes little sense. Other farmers grow crops that have received less research funding from either private or public sources (sometimes called “orphan” crops). For these farmers, there may be few technologies “on the shelf.” A second reason is institutional. The situation of these farmers has been aggravated by market liberalization policies that have made it harder for them to compete in markets. Input supply channels to deliver new technologies, once developed, are weak. A third is that many more people live in marginal areas today than during the Green Revolution, exacerbating environmental problems that must be addressed, especially as climates change.

Two interrelated background papers with annexes and technical appendices have been drafted by Oxfam America to support Oxfam International’s briefing paper on public investments in agriculture. One summarizes the arguments for investing in agriculture as a pro-poor growth strategy, and explores sector allocations at national and regional scales. The technical appendix of that paper examines Official Development Assistance to agriculture in greater detail. This

1. Mitch Renkow and Prabhu Pingali. “Agricultural Intensification and Environmental Degradation” (unpublished manuscript, FAO, Rome, 2003).

paper, which explores options for engaging farmers in marginal areas, focuses more on program options at a sub-national scale. The technical appendix presents the definitions, methods, and data used to characterize marginal areas and estimate the numbers of farmers living in these areas.

In the following section, we review the debate over the pros and cons of investing in developing agricultural technologies (agricultural R&D) for marginal areas. This debate, based on economics rather than moral arguments, has played an influential role in setting priorities for agricultural research investments. In the third section, we describe the characteristics of marginal areas and the farmers who live there—in order to better understand the needed scope of investments. Section IV highlights a sampling of options that we advance as particularly promising for marginal areas, given Oxfam's interests. These emphasize investments in agricultural research to develop suitable technologies, but also refer to investments in agriculture and outside of agriculture. This section is not intended to be exhaustive, but to suggest areas that may be of specific interest to Oxfam. We then draw some general conclusions for Oxfam policy.

# 2. To target or not to target: The economics of investing in marginal areas

## Economic decision rule

Any decision regarding the allocation of public investments hinges on national policy goals. If these are growth and poverty reduction, for example, economics suggests that governments should invest until the marginal social returns are equal between the two or a loss with respect to one is compensated by a gain in the other. Similarly, from the perspective of an investor in agricultural R&D, economics dictates that the amount invested in agricultural areas with lower potential productivity should depend on returns relative to investing in areas with higher potential. A policy trade-off is expected when two goals are pursued simultaneously; win-win solutions are uncommon.[2] Concern about establishing the nature and magnitude of this trade-off is the crux of the debate that has simmered over the past 20 years or so among experts on agricultural research policy.

## The economic argument for investing more in areas with greater productivity potential

The economic argument for investing in areas with greater productivity potential is as follows: Productivity gains from adopting agricultural technologies in areas of the world with better resource endowments are expected to be larger and cost less to achieve. The synergies of good soils, adequate moisture, and more homogeneous growing environments result in higher output/input ratios; developing successful packages of seeds, fertilizer, and other inputs for such environments takes less time, costs less, and diffuses more rapidly. Stronger linkages to factor and product markets then translate into higher rates of

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2. This is not true in cases where new funding streams emerge that address long neglected priorities, such as climate change adaptation and mitigation. Also, it is conceivable that addressing these market failures could catalyze changes in relative returns because investments in degraded lands (common in marginal lands) offer particular opportunities, such as carbon sequestration.

agricultural growth to more economic growth. Demand for labor pushes up wages while food prices decline—attracting people from the less productive regions who send migrant remittances back home, increasing the incomes of those left behind. Eventually, fewer people live in the poorer environments, reducing population pressure on the more fragile resource base.[3] Additionally, the diversity of altitude, rainfall, and soil conditions that characterizes marginal areas implies that technology "spillovers" from investments geared to more favored areas are likely to be greater—boosting the benefit-cost advantage of investing in high potential zones.[4]

## Evidence on relative returns to investment

To a large extent, this stylized story did play out in the rice and wheat-based green revolutions of Asia in the 1970s (Box 1). Initially targeted to the irrigated areas, public investments led to "a quantum leap in crop yields, but neglected rainfed and marginal lands."[5] Still, high-yielding varieties diffused more gradually across rainfed environments, and the benefits of increased demand for labor and lower food prices were broadly transmitted through markets.

By the 1990s, however, evidence was accumulating in Asia that the impacts of technical change were uneven across agroecologies and the poor outside irrigated areas had remained poor. Meanwhile, better off farmers in the irrigated areas were beset by stagnating yields,[6] the adverse effects of unsafe chemical use on human health,[7] and environmental problems,[8] such as salinity and waterlogging.

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3. Shenggan Fan, Peter Hazell, and T. Haque, "Targeting Public Investments by Agro-Ecological Zone to Achieve Growth and Poverty Alleviation Goals in Rural India," *Food Policy* 25 (2000): 411–428; Shenggan Fan and Peter Hazell, "Returns to Public Investments in the Less-Favored Areas of India and China," *American Journal of Agricultural Economics*, 83(5) (2001): 1217–1222; Renkow and Pingali, "Agricultural Intensification and Environmental Degradation;" Paul Heisey and Mitch Renkow, "Agricultural R&D, Resources, and Productivity," Ch. 19 in *Biophysical Processes and Economic Choices at Local, Regional and Global Levels*, edited by K. Wiebe (Cheltenham, UK: Edward Elgar, 2003); Arie Kuyvenhoven, "Creating an Enabling Environment: Policy Conditions for Less-Favored Areas," *Food Policy* 29(4) (2004): 407–430.

4. "Spillovers" from investing in agricultural R&D refer to the fact that technologies developed for one farming environment can also be adopted in other environments. See Melinda Smale, Kelly Hauser, Nienke Beintema, and Emily Alpert, "Turning the Tables: Global trends in public agriculture investments," Oxfam America Research Backgrounder number 2 (Washington, D.C: Oxfam America, 2009) for additional discussion of this topic.

5. Suresh Pal and Derek Byerlee, "India: The Funding and Organization of Agricultural R&D—Evolution and Emerging Policy Issues," Chapter 7 in Pardey, Alston, and Piggott (eds.), *Agricultural R&D in the Developing World* (Washington, DC: IFPRI, 2005): 177.

6. Prabhu Pingali, Mahbub Hossain, and Roberta V. Gerpacio, *Asian Rice Bowls: The Returning Crisis?* (Wallingford, UK: CAB International, 2007); Roderick Rejesus, Paul W. Heisey, and Melinda Smale, *Sources of Productivity Growth in Wheat: A Review of Recent Performance and Medium- to Long-Term Prospects*, CIMMYT Economics Paper 99–05 (Mexico D.F.: CIMMYT, 1999).

7. John Antle and Prabhu Pingali, "Pesticides, Productivity, and Farmer Health: A Philippine Case Study," *American Journal of Agricultural Economics* 76 (3, 1994): 418–430.

In response to the concern that public investments in wheat research had been biased toward high potential areas, several authors argued that the balance of investments between favored and marginal areas had not been distorted and the share allocated to marginal areas should not have been increased. Byerlee and Morris found no global evidence that investments in wheat research were lower in marginal areas than was justified by efficiency criteria (value of production, modified by sustainability and equity criteria).[9] Traxler and Byerlee found that rainfed and hill environments produced only 12 percent of India's wheat but received 30 percent of resources—more than would be justified based on efficiency criteria.[10] Renkow developed and applied a multi-market model of seed technological change for wheat in Pakistan in order to examine this point. Tracing the income impacts of technological change through factor and product markets across regions, his analysis demonstrated that the re-allocation of wheat research funds away from the irrigated sector to the rainfed areas would have been inferior in terms of income growth and could not be justified on equity grounds. He cautioned that his results were specific to Pakistan.[11]

A body of research led by Peter Hazell and Shenggen Fan in India and China countered with evidence indicating that, by the 1990s, rates of return to investment in agricultural productivity had declined in irrigated areas, and most investments (HYVs, roads, education, electricity) in the rainfed areas (including low-potential areas) led to higher payoffs in both growth and poverty reduction.[12] This work was then critiqued on methodological grounds. For example, Palmer-Jones emphasized a "fallacy of ecological composition" related to the definition of the units of analysis in the underlying data (that what is true of an aggregate is true for all its members).[13] This difficulty does not invalidate the estimated returns for the region or agroecological zone as a unit, but simply implies that investments need to be spatially targeted within these zones to give the best returns. Renkow argues that this body of research did not take the costs of research and development into account. He notes that since the high-yielding seed varieties were developed for favorable production areas to begin with, the

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8. Mubarik Ali and Derek Byerlee, "Productivity Growth and Resource Degradation in Pakistan's Punjab" in *Response to Land Degradation,* eds. E.M. Bridges and others (Enfield, NH: Science Publishers, 2001): 186–199.

9. Derek Byerlee and Michael Morris, "Have We Underinvested in Research for Marginal Environments?" *Food Policy* 18 (1993): 381–393.

10. Greg Traxler and Derek Byerlee, "Linking Technical Change to Research Effort: An Examination of Aggregation and Spillovers Effects," *Agricultural Economics* 24 (2001): 235–246.

11. Mitch Renkow, "Poverty, Productivity, and Production Environment: A Review of the Evidence," *Food Policy* 25 (2000): 463–478.

12. Shenggen Fan and Peter Hazell, "Returns to Public Investments in the Less-Favored Areas of India and China," *American Journal of Agricultural Economics* 83 (5, 2001): 1217–1222.

13. Richard Palmer-Jones, "Agricultural Growth, Poverty Reduction and Agroecological Zones in India: An Ecological Fallacy?" *Food Policy* 28 (2003): 423–431.

benefits measured in less favorable areas may have been largely spillover effects.[14]

Reviewing the evidence of a decade of research, Heisey and Renkow concluded that the chances of success, the rates of success, and the direct impacts on productivity tend to be greater in favored production environments. "Consideration of the indirect effects operating through commodity prices and factor markets only accentuates this finding." At the same time, "substantial re-targeting of R&D toward marginal production environments does not emerge as justifiable on distribution grounds in any of these studies."[15]

Most recently, Pandey and Pal concluded that rainfed environments (including 54 percent of India's rice area in lowlands, deepwater, and uplands) in India remain under-invested in rice research.[16] Rather than an econometric approach, they used a measure of congruence that compared full-time equivalent scientific research time adjusted for cost to actual production share.

Relatively few comparative analyses are available for crops other than rice or wheat, or regions other than Asia. Adapting the Renkow approach in Kenya, Karanja et al. found that improved maize technologies developed for the higher potential regions were more likely to have a greater impact on maize production and reduce demand for imports (under controlled prices) or maize prices (if prices are flexible). Unlike the case of wheat in Pakistan, in Kenya, the greater positive impacts of seed technical change in the high potential zone were offset by a worsening of income inequality compared to marginal regions.[17]

Evenson and Gollin's assessment of the global evidence clearly shows that the impacts of agricultural research investments in seed-based technical change have been uneven by crop. The greatest contributions of crop genetic improvement to growth from 1960–2000 were realized in the quintessential Green Revolution crops (rice and wheat); although the contributions of maize have also been important, those in crops such as beans and cassava—also staple crops of the poor—were low.[18]

14. Renkow, "Poverty, Productivity, and Production Environment," 463–478.

15. Heisey and Renkow, "Agricultural R&D, Resources, and Productivity," 410–412.

16. Sant Kumar Pandey and Suresh Pal, "Are Less-Favored Environments Over-Invested? The Case of Rice Research in India," *Food Policy* 32 (2007): 606–623.

17. Mitch Renkow, "Differential Technology Adoption and Income Distribution in Pakistan: Implications for Research Resource Allocation," *American Journal of Agricultural Economics* 74 (1993): 33–43; Daniel Karanja, Mitch Renkow and Eric Crawford, "Welfare Effects of Maize Technologies in Marginal and High Potential Regions of Kenya," *Agricultural Economics* 29 (2003): 331–341.

18. Robert Evenson and Douglas Gollin, *Crop Variety Improvement and Its Effect on Productivity: The Impact of International Agricultural Research* (Wallingford, UK: FAO and CABI Publishing, 2003).

Regional disparities were also marked. Research systems in sub-Saharan Africa were not supplying "modern varieties that merited adoption during the 1960s and 1970s"[19] and "it was not until the 1990s that sub-Saharan African farmers realized modest growth from crop genetic improvement programs." Estimated internal rates of return to crop genetic improvement by national agricultural research systems from 1960 to 2000 were 33 percent for Asia, nearly as high in Latin America (32 percent), but a mere 9 percent for sub-Saharan Africa.[20]

## Caveats and conclusions

In retrospect, this body of research documents a debate that is viewed from a relatively narrow perspective and has limited applicability today. Much of the evidence cited was generated from the viewpoint of an agricultural research investor who seeks to allocate a given budget, rather than a national policy maker who can choose among sector investment options to address multiple public priorities other than rates of return, such as poverty reduction, climate change mitigation and adaptation. With a few exceptions, the work focused geographically on the hotspots of the Green Revolution in Asia, and the agricultural technology referred largely to seed-based technical change, often with a package approach.

Some consensus has emerged with respect to several policy points. First, a strategy exclusively emphasizing agricultural R&D investments in favored areas is ill-advised, particularly in countries with limited high-potential land. Agricultural research targeting difficult marginal environments may be one of the most pro-poor of public investments, especially in areas where the share of income from agriculture is high among poorer people, agronomic circumstances have restricted the use of technologies developed for other, more favorable production environments, and there are still prospects for research success.[21] That said, investing in research and development of agricultural technology is not the sole and may not be the best means to reduce poverty and sustain livelihoods in marginal areas. Alston et al. state that "agricultural research is a blunt instrument for the pursuit of objectives other than economic efficiency.[22] Investments in support of agriculture, such as investments in infrastructure and

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19. There are some noteworthy exceptions, such as maize in Kenya, Zimbabwe, and South Africa. See Melinda Smale and Thomas Jayne, "Maize in Eastern and Southern Africa: 'Seeds' of Success in Retrospect" in S. Haggblade and P. Hazell (eds.), *Successes in African Agriculture: Lessons for the Future* (Baltimore: Johns Hopkins University Press, forthcoming).

20. Evenson and Gollin, *Crop Variety Improvement*, 471.

21. Renkow, "Poverty, Productivity, and Production Environment," 463–478.

22. Julian Alston, George Norton and Philip Pardey, *Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting* (Ithaca, NY: Cornell University Press, 1995): 80–93.

institutional reform may well yield significantly larger and more rapid benefits to poor people in marginal areas than will investments in agricultural research targeted to those areas."[23] Furthermore, by investing more in rural infrastructure and human capital, governments can help create the conditions under which investments in agricultural R&D will give higher returns.

A postscript involves informational constraints. As can be expected, inconsistent definitions of "marginal" underlie at least part of the debate. Heisey and Renkow note that the dichotomy between high potential and marginal, regardless of the terminology employed, is overly simplistic. For any single resource constraint, a continuum of values applies; in many agricultural areas, multiple constraints have varying effects on crop production.[24] The next section presents our characterization of marginal areas and "marginalized" farmers, which builds on earlier work.

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23. Renkow, "Poverty, Productivity, and Production Environment," 476.

24. Heisey and Renkow, "Agricultural R&D, Resources, and Productivity."

# 3. Who and where are the world's "marginalized" farmers

## Location and poverty

Globally, geographical location has a lot to do with poverty. IFAD's 2002 World Poverty Report concluded that the majority of the world's poor are rural, and are expected to remain so for the next few decades; the incidence and severity of rural poverty almost everywhere exceeds urban poverty, with the exception of South America, where intensive urbanization has meant that most of the poor live in urban areas. According to IFAD, the poorest of the rural poor live in remote areas, even in East and Southern Africa, where many of the rural poor live in densely populated areas close to capital cities, such as Nairobi, Harare, or Lusaka.[25]

The relationships among the productivity potential of agricultural resources in a region, remoteness, and the poverty of its farmers has long been recognized by development specialists,[26] but has been difficult to quantify in terms that can be used to guide policymakers—in part because of the nature of the data required to draw reliable conclusions.

In one of the earlier data-based efforts reported in the literature, Leonard et al. estimated that 46% of the world's poorest 20% lived in marginal areas of the developing world, with a similar percentage in Asia, Latin America, and Africa when aggregated at the regional scale. Among the remaining poorest 20%, 36% resided in areas that were more favorable for agriculture and 17% lived in urban areas.[27] Hazell and Garrett estimated that as many as 500 million people lived in marginal areas, including the upper watersheds of the Andes and the Himalayas, the East African highlands, and the Sahel. They calculated that the largest numbers of these people, 263 million, lived in Asia; 160 million lived in sub-Saharan Africa; another 40 million lived in Central and South America; and 11

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25. International Fund for Agricultural Development (IFAD), "The Rural Poor," Chapter 2 in *World Poverty Report* (Rome: IFAD, 2002).

26. A recent article by Stifel and Minten examines these relationships rigorously in Madagascar. An example of other economics studies that confirm the significance of geography at regional, national, and sub-national scales is William Masters, "Chapter 8: Climate, agriculture and economic development" in *Land Quality, Agricultural Productivity, and Food Security*, ed. K. Wiebe (Cheltenham, UK: Edward Elgar, 2003).

27. H. Jeffrey Leonard, ed., *Environment and the Poor: Development Strategies for a Common Agenda*, No. 11 of series US-Third World Policy Perspectives (New Brunswick, USA: Transactions Books, 1989).

million in Western Asia and Northern Africa. Worldwide, they estimated that these represented 36% of the world's rural poor.[28]

Contrasting pictures emerge when data are examined by cropping system, at a smaller scale of analysis, or with varying indicators. Zones classified by the International Maize and Wheat Improvement Center (CIMMYT) as having lower productivity potential for wheat often had lower rather than higher poverty rates—such as those located in West Asia and North Africa.[29] Defining marginal environments in India in terms of crop output value, Kelley and Rao found fewer numbers of the poor in marginal areas, with no evidence of increasing proportions of the poor in these areas over time.[30] Also in India, Fan, Hazell and Haque compared irrigated, high- and low-potential rainfed areas from 1972 to 1993. Data indicated that poverty was consistently higher in terms of the density (persons/1000 ha) and share (percent of poor in total population) in the high-potential rainfed areas, but that the absolute numbers of poor are equal between the high and low potential areas and are always lower in the irrigated areas.[31]

The estimated share of the developing world's rural poor living in marginal areas is sensitive to definitions, recently compared by Hazell et al.[32] Originally, Pender and Hazell coined the term "less favored areas" to describe "lands neglected by man and nature," proposing a two-way classification by market infrastructure and agricultural potential. They included three of the four classes that resulted in the less favored category: remote areas with good agricultural potential, areas with good access to infrastructure and poor agricultural potential, and those with neither good access nor good production potential.[33] Drawing on the CGIAR's analysis of resource use regimes, an assessment of poverty incidence in tropical farming systems and expert judgments, Hazell et al. identified the predominant farming systems in less favored areas, clustering them into uplands and drylands (Table 1). Associating this information with demographic and ecosystems data developed by Wood et al. in 1999, they estimated that less favored areas account for 40% of the agricultural land and

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28. Peter Hazell and James Garrett, "Reducing Poverty and Protecting the Environment: The Overlooked Potential of Less-Favored Lands," International Food Policy Research Institute (IFPRI) 2020 Brief 39 (1996).

29. Byerlee and Morris, "Have We Underinvested," 381–393.

30. T.G. Kelley and P. Parthasarathy Rao, "Marginal Environments and the Poor: Evidence from India," *Economic and Political Weekly* 30 (4, 1995): 2494–2495.

31. Fan, Hazell and Haque, "Targeting Public Investments," 411–428.

32. Peter Hazell, Ruerd Ruben, Arie Kuyvenhoven and Hans Jansen, "Development Strategies for Less-Favored Areas" in E. Bult and R. Ruben (eds.), *Development Economics between Markets and Institutions: Incentives for Growth, Food Security and Sustainable Use of the Environment*, Volume 4 of series *Mansholt Publication Series* (The Netherlands: Wageningen Academic Publishers, 2008).

33. John Pender and Peter Hazell (eds.), "Promoting Sustainable Development in Less-Favored Areas," *IFPRI 2020 Vision Focus* 4 (2000).

42% of the rural poor in the developing world—most residing in Asia and Africa.[34]

Hazell et al. found that when spatially referenced data are employed to overlay agro-ecological data (irrigation, moisture, and temperature) with data on market access (time taken to reach nearest market town), the estimated number of people living in less favored areas was similar (40%) but as much as 70 percent of world agricultural area falls into less favored areas.[35] The difference in estimates appears to have resulted from the inclusion of grazing and forest areas that are omitted from the farming systems approach and are located far from markets.

### Table 1. Major farming systems in less-favored areas

| Agro-ecological cluster | Production system | Share of developing countries' rural population (%) | Share of developing countries' agricultural land (%) | Main locations |
|---|---|---|---|---|
| Highlands / upland areas | Perennial / tree crops | 3 | 2 | East African highlands, Central America, Andean hillsides, Asian uplands |
| | Shifting cultivation | 2 | 5 | East and Central Africa, Southeast Asia |
| | Mixed upland systems | 24 | 9 | Semi-humid highlands of Southern Africa, Southeast Asia and Central America |
| Drylands / arid areas | Migratory herders | 6 | 12 | Arid areas of sub-Saharan Africa, Middle East and North Africa, Southeast Asia |
| | Agro-pastoral | 4 | 8 | Semi-arid areas of sub-Saharan Africa, Middle East and North Africa, Southeast Asia |
| | Mixed rainfed | 3 | 4 | Central and Southern Africa, South Asia, coastal North Africa, Northeast Brazil and Yucatan peninsula in Mexico |
| **TOTAL** | | **42** | **40** | |

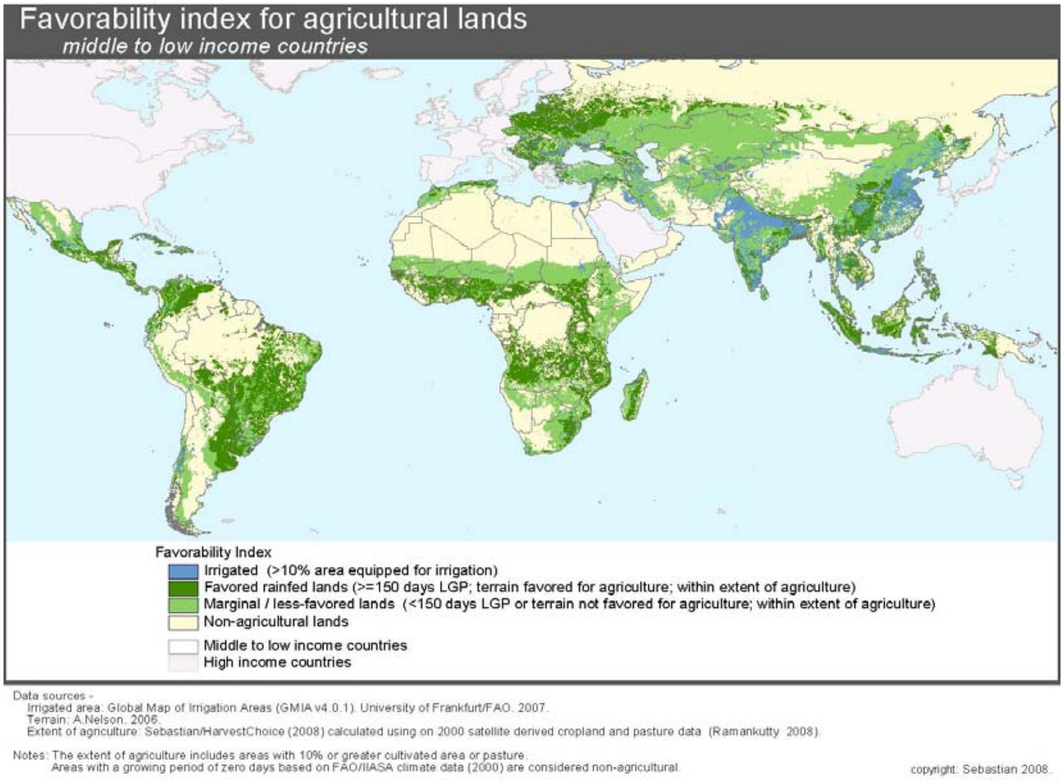
34. Hazell et al., "Development Strategies for Less-Favored Areas."

35. Ibid.

For Oxfam, Sebastian (Technical Appendix) began by developing criteria that rest solely on agroecological factors, which we consider to be "exogenous" and not directly mutable through policy. Her map (shown in Figure 1) reflects the following definitions. Among low and middle income countries, on agricultural lands, less favored areas have a growing period of less than 150 days (arid and semi-arid) or terrain less suitable for cultivation. Favored areas have both a longer growing period and suitable terrain. Irrigated lands, which have at least ten percent of area equipped for irrigation, are classified separately. Terrain more suitable for cultivation includes plains, lowlands, and low to mid-altitude plateaus and mountains; terrain less suitable for cultivation includes high altitude plains, hills and rugged lowlands, and high altitude plateaus or mountains. We chose the "terrain" criterion over slope, which would define all steep areas as unfavorable. The terrain criterion is based on the notion of "roughness" or relief of the area. Rules were applied to 10x10 km cells. Additional details and sources are provided in the Technical Appendix by Sebastian, including estimates of population and area by distance to market.[36]

36. We were unable to incorporate soil quality into the definition because the soil data that are available are at the global scale and not very reliable. It is also difficult to identity one quality variable that would serve as a global indicator of favorability. Since we did this work, FAO has released an updated and much improved soil database (the Harmonized World Soil Database) but the fertility constraints algorithms have not yet been applied to the data and they are not available for analysis. Soil fertility is highly correlated with the variables we use.

**Figure 1. Favorability index for agricultural lands in low and middle income countries**




Based on these definitions, rural populations and land in less favored areas are shown in Table 2 by regional aggregate. The number of people living in irrigated areas of Asia is on the order of one hundred times as great as it is in sub-Saharan Africa or Latin America and the Caribbean, and these represent 50 percent of the rural farm population in that region but only 25 percent of the agricultural land. A similar share of the land in the Middle East-North African region is irrigated, and over two-thirds (67%) of the agricultural land in that region is less favored. In our classification, sub-Saharan Africa and the Latin America-Caribbean region have similar distributions of rural populations by land favorability for agriculture, but the share of less favorable agricultural land is much greater in sub-Saharan Africa (54%) compared to Latin America and the Caribbean (40%). The greatest numbers of farmers working land that is less favorable for agriculture are found in Asia (504 million), followed by sub-Saharan Africa (157 million).

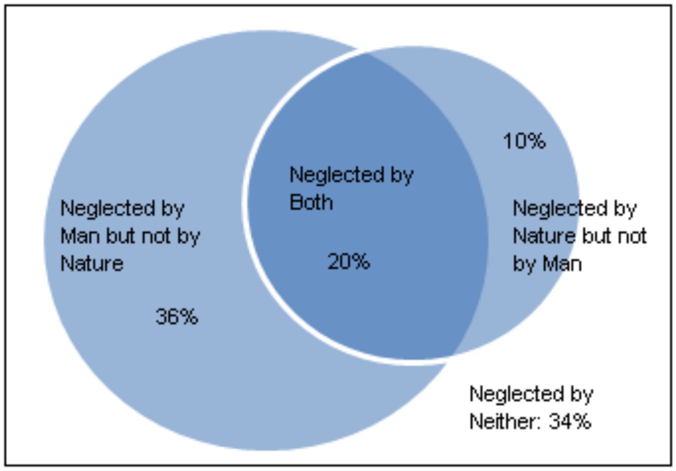
**Table 2. Rural population and land in less favored areas by national income and regional aggregate**

| Developing region | Not in agriculture | Irrigated | Favored | Less favored | Total | Irrigated | Favored | Less favored | Total |
|---|---|---|---|---|---|---|---|---|---|
| | population (millions of persons) | | | | | share of agricultural rural population (%) | | | |
| sub-Saharan Africa | 110 | 9 | 176 | 157 | **451** | 2.6 | 51.5 | 45.9 | **100.0** |
| Latin America/ Caribbean | 29 | 14 | 64 | 57 | **164** | 10.1 | 47.4 | 42.5 | **100.0** |
| Asia | 162 | 1106 | 389 | 505 | **2161** | 55.3 | 19.4 | 25.3 | **100.0** |
| CIS/Eastern Europe/Central Asia | 22 | 24 | 53 | 63 | **160** | 17.0 | 37.9 | 45.1 | **100.0** |
| Middle East/ North Africa | 35 | 26 | 11 | 51 | **123** | 29.7 | 12.6 | 57.7 | **100.0** |
| **Total** | **357** | **1178** | **692** | **832** | **3060** | **43.6** | **25.6** | **30.8** | **100.0** |
| | area (millions of square kilometers) | | | | | share of agricultural land (%) | | | |
| sub-Saharan Africa | 11 | 0 | 5 | 7 | **24** | 1.4 | 44.2 | 54.4 | **100.0** |
| Latin America/ Caribbean | 10 | 0 | 6 | 4 | **20** | 4.7 | 55.7 | 39.6 | **100.0** |
| Asia | 7 | 4 | 3 | 7 | **21** | 27.6 | 22.2 | 50.2 | **100.0** |
| CIS/Eastern Europe/Central Asia | 14 | 1 | 2 | 6 | **23** | 6.1 | 26.1 | 67.8 | **100.0** |
| Middle East/ North Africa | 7 | 1 | 0 | 2 | **9** | 23.7 | 9.2 | 67.1 | **100.0** |
| **Total** | **49** | **6** | **17** | **25** | **97** | **11.7** | **35.3** | **52.9** | **100.0** |

Overall, according to our definition and Sebastian's data, 20 percent of farmers in low and middle income countries (including Eastern Europe, the Commonwealth of Independent States, and Central Asia) are located in areas that are too dry or rough in terrain to be favored for agriculture and do not have good access to market infrastructure (Figure 2). These farmers are "neglected by both man and nature."[37] Another 10 percent are "neglected by nature" but not by "man." In the remainder of the paper, for consistency, we will refer to this 30 percent of farmers in low and middle income countries as "marginalized" and to their environments as "marginal areas." Transitional economies contribute 1 percent of rural people and 3 percent of land to these areas, but investment options for these farmers are not discussed here.

37. We defined "neglected by man" as an estimated time to market of 2–4 hours by car—medium to remote access, as compared to high access. This is a "generous" definition, but in many instances motorized transport is not available. We also argue that for farmers to make the most of market opportunities, high access is needed. Sebastian's paper details how the market access variable was constructed.

**Figure 2. Distribution of farm population in low and middle income countries**




Data: Sebastian 2009 (Technical Appendix)

Public policy can help farmers in these areas cope with difficult agroecological conditions, better manage their resources, and influence the extent to which the behavior of citizens in richer countries affect these environments detrimentally or positively. Agriculture alone will probably offer few pathways out of poverty for these farmers. Some will lay down their hoes.

Sebastian's data show that an additional 33% of farmers are neglected by "man" (market infrastructure) but not by nature. They have good conditions for farming, but not the good access to economic resources they need to pull themselves out of poverty. Adequate public investments in market infrastructure can offer them a pathway out of poverty, and they are more likely to replace their hoes with oxen and tractors. These two groups, representing two-thirds of the farmers in low and middle income countries and a total of 1.7 billion farmers, are particularly important for Oxfam programs and policy.

## Vocation and poverty[38]

Vocation also has a lot to do with poverty. In each geographical region of the world, smallholder farmers or farmers in rainfed areas are among the poorest socio-economic groups,[39] and their poverty may be intensified by further discrimination due to displacement, caste or tribe, or gender.[40]

Farmers in marginal areas are often socially disadvantaged, including landless farmers who depend on contracts, leases, and seasonal employment, and indigenous people who have lost traditional land rights due to encroachment of migrants into forest areas.

Farmers in marginal areas face certain constraints in common. First, they grapple with an easily degraded, fragile endowment of agricultural resources. The incidence and severity of soil erosion by water and wind is expected to be substantially higher in the drylands and sloping highlands of Africa, Asia, and Latin America than for these continents as a whole. In an effort to secure their livelihoods with unproductive lands, farmers often expand crop area by reducing fallows, clearing new land, and adding livestock to overburdened pastures; "soil mining is endemic," but inorganic fertilizer is typically uneconomic in these isolated communities.[41]

The harsh physical conditions of drylands and uplands often coincide with a second constraint—limited coverage of road and transport infrastructure. Elimination of public delivery systems with blanket market reforms has often aggravated a precarious situation for these farmers. Value chains for inputs and products are poorly integrated or may be monopsonistic, with high margins charged by itinerant traders who often bear substantial risks themselves for a clientele whose market participation is irregular and unreliable. Local labor, input, and product markets are characterized by high costs of transactions—both in terms of "hard" (road, vehicles, stores) and "soft" (product and price information) infrastructure.

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38. The characteristics of farmers in marginal areas are described in detail by Ruerd Ruben, John Pender, and Arie Kuyvenhoven, "Sustainable Poverty Reduction in Less-Favoured Areas: Problems, Options and Strategies" in *Sustainable Poverty Reduction in Less-Favoured Areas,* edited by the same authors (Boston: Cambridge University Press, 2007), based on a combination of primary and secondary research undertaken over a number of years in a range of empirical contexts. These are highlighted here, supplemented by other references.

39. Other poor socio-economic groups in rural areas include wage laborers and landless, artisanal fishermen, pastoralists and displaced people (IFAD, "The Rural Poor").

40. IFAD, "The Rural Poor."

41. Hazell et al., "Development Strategies for Less-Favored Areas."

While rural non-farm activities and off-farm employment are very important components of household income in rural areas of most developing countries,[42] these opportunities are limited where market infrastructure is poor and there is little demand for goods and services. Farmers in marginal areas are less able to become engaged in higher remunerated off-farm activities due to entry barriers and difficulty of financing lumpy investments.[43] Local non-farm enterprises are often poorly developed, and family members often have little to offer but unskilled wage labor.[44] Hence, these farmers often depend on food or cash for work, employment generation or assistance schemes, and on long-distance migration (Box 1).

Population dynamics reflect these fundamental constraints. Due to the "push" and "pull" that leads to migration of family members in search of additional income, farming communities in marginal areas often have unbalanced population structures. "Push" factors include diminishing land productivity and limited rural nonfarm opportunities; "pull" factors are urban industry, cheap food policies, an urban bias in provision of public goods, and higher returns to education in urban areas.[45] The young and able-bodied migrate (often, but not always, men), while small children and the elderly remain on the farm, reducing the pressure on meager food supplies from one harvest to the next. Rather than "push," Barrett et al. calls this migration "desperation-led."[46] Migrants may travel to a regional urban center, capital city, or another country, seasonal or quasi-permanent. Migrants are also a vector of disease (such as AIDS) transmission from urban areas to an already undernourished, weakened population.

Women may be left as de facto heads of household but with no means to engage in anything but low yielding, low value food production. In agricultural production, cultural taboos may preclude women's involvement in certain activities. Lacking rights to land and burdened with multiple responsibilities, women left behind have difficulty engaging productively in agriculture.

As a consequence of these multiple constraints, "the character of rural poverty" in marginal areas "is different."[47] Poverty is more "prevalent" (spatially

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42. Steven Haggblade, Peter Hazell, and Thomas Reardon (eds.), *Transforming the Rural Nonfarm Economy: Opportunities and Threats in the Developing World* (Baltimore: Johns Hopkins University Press, 2007).

43. Ruerd Ruben, and John Pender, "Rural Diversity and Heterogeneity in Less-Favored Areas: The Quest for Policy Targeting," *Food Policy* 29 (4, 2004): 303–320.

44. Chris Barrett, Thomas Reardon, and Patrick Webb, "Nonfarm Income Diversification and Livelihoods in Rural Africa: Concepts, Dynamics and Policy Implications," *Food Policy* 26 (4, 2001): 315–331.

45. Renkow and Pingali, "Agricultural Intensification and Environmental Degradation."

46. Barrett et al., "Nonfarm Income Diversification and Livelihoods."

47. Ruben and Pender, "Rural Diversity and Heterogeneity in Less-Favored Areas," 26.

widespread) in marginal areas.[48] Chronic poverty is frequent, and these areas are often politically excluded and low on the policy agenda.[49]

48. Ruben, Pender, and Kuyvenhoven, "Sustainable Poverty Reduction in Less-Favored Areas."

49. Chronic Poverty Research Centre, *Escaping Chronic Poverty through Economic Growth*, Policy Brief No. 8 (Manchester: Chronic Poverty Research Centre, July 2008).

In terms of their farming activities, perhaps the single overriding characteristic of farmers in marginal areas is their heterogeneity, which reflects the diversity of agroecologies in which they farm. Table 1 reports population shares in predominant farming systems. Systems based on perennials and tree crops, shifting cultivation, and mixed cropping are found in the highlands cluster, which represents as much as 24% of the rural population in developing countries. Here, population densities are high. Population shares are relatively small in the drylands cluster. Migratory herding represents a relatively large land share but has been omitted from our discussion below because it is not based on cropping and investments to support herders are distinct. Of the drylands, we focus on options for agro-pastoral and mixed rainfed systems.

**Box 1. Diversifying income through non-farm rural employment[50]**

Non-farm income is important to most farmers in the world, regardless of farm size—accounting for an average of 42% of rural income in Africa, 52% in Asia, and 47% in Latin America. But the composition of non-farm activities differs considerably as a result of wide variations in natural resource endowments, labor supply, location, and history.

Most rural nonfarm employment comprises services, commerce, and transport. Manufacturing, construction, utilities, and mining make up lower shares of the total. When weighted by population, women represent more than a third of rural nonfarm employment in both Africa and Latin America. Women's share is about a quarter in Asia and only 11 percent in West Asia/North Africa. They also participate extensively in part-time rural nonfarm activity, such as trading in weekly markets and home-based processing, manufacturing, and services.

Richer and more educated households dominate white-collar employment and the most lucrative business niches, while poor households remain relegated to labor-intensive, low-return activities. Women typically dominate in activities that require minimal capital investment and yield correspondingly low returns. The overall impact on income distribution is therefore mixed. Poor households can participate in the growing non-farm economy in two ways: as entrepreneurs in growing supply chains or as employees in growing segments of the labor market.

Thus, nonfarm employment growth can be "good news or bad." In stagnating rural economies, it is a symptom of landlessness and is constituted primarily of low-paying, manual jobs; in expanding rural economies, it is a means of spreading income gains and generating broader-based, demand-led growth. The micro determinants of farmer

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50. This box is based on the introductory chapter of Haggblade, Hazell and Reardon, *Transforming the Rural Nonfarm Economy;* and the summary article of Benjamin Davis, Paul Winters, Thomas Reardon, and Kostas Stamoulis, "Rural Nonfarm Employment and Farming: Household-Level Linkages," *Agricultural Economics* 40 (March 2009), 119–124.

participation in rural nonfarm employment are a combination of "push" factors, such as offsetting production risk, coping with poor harvests, and compensating for structural problems such as insufficient land to meet subsistence needs. "Pull" factors are lower risk and higher returns in the nonfarm sector. The capacity for farm family members to take advantage of these opportunities depends on their asset endowments, as well as meso scale factors such as "hard" (road) and "soft" (services) infrastructure.

Much of the literature has emphasized the growth linkages between agricultural and rural nonfarm employment. Some studies have confirmed the positive investment effects of rural nonfarm earnings on farming, especially in the absence of viable credit markets. Fewer studies have explored the effects of rural nonfarm employment on the choice of farming technology, the mix of farm activity.

The collection summarized by Davis et al. reconfirms the importance of income from rural nonfarm employment in a number of developing countries. In all cases, however, the upper income strata earned disproportionately higher shares and amounts of income from rural nonfarm employment than the lower strata. This outcome is explained mostly by differences in education, social status, access to infrastructure, and transactions costs. Unfortunately, "inequality in access to rural nonfarm employment dogs the steps of a wider impact of this process."[51]

Effects of rural nonfarm employment on farm purchased inputs and capital investments were positive and large, in most cases. Liquidity from nonfarm employment substituted for credit, which was largely unavailable. In cases where there was no effect, nonfarm employment represented an alternative, rather than a means, to agricultural intensification. The recommendations of the authors are to: 1) find policy and program paths that increase the equity of access to remunerative nonfarm employment in rural communities;[52] 2) search for instruments that can relax the credit constraints of poor families; 3) promote commercialization and diversification of smallholder farming in order to provide an alternative income-generating path when there are barriers to entry in remunerative nonfarm employment.

51. Davis et al., "Rural Nonfarm Employment and Farming," 122.

52. See Haggblade, Hazell, and Reardon, *Transforming the Nonfarm Rural Economy*, for more discussion.

# 4. Why invest in marginalized farmers?

Why are these farmers so important for global public investments in agriculture? First, with respect to research and development, the agricultural technologies needed to enhance their capacity to meet production goals are not likely to be produced and supplied by the increasingly privatized, corporate-financed research systems of richer countries.[53]

Second, they produce goods that are not only valuable to them but have public value. For example, what they harvest contributes directly to the food security of their families and non-farming families in local communities, many of whom are hard to reach by road and inadequately supplied by markets. Often the crops and varieties they manage, and conserve de facto, possess unique, adaptive traits that constitute part of the world's bounty of valuable genetic resources. In addition to the farmers who maintain these resources, plant breeding programs depend on them to meet future biotic and abiotic challenges.[54] Some of these crops have unique product attributes, such as nutritional or medicinal ingredients that are demanded by consumers in richer regions and countries. Quinoa, teff, and finger millet are recognized for their nutritional quality; bitter gourd and fenugreek are recommended for improving the body's ability to respond to insulin.[55]

They also manage some of the most fragile soils in the world, on the borders of deserts or on the margins of forests and watersheds. In some of these environments, large amounts of carbon are sequestered above and below ground. Most of the global and local environmental benefits of these systems are not yet valued in markets.[56] On a global scale, the expansion of agricultural lands has reached its limit; "at this point in history, virtually all agronomically favored farmland that remains available in developing countries …is under cultivation."[57] Thus, any expansion of cultivation will occur on fragile lands by

53. Melinda Smale, Kelly Hauser, Nienke Beintema, and Emily Alpert, "Turning the Tables: Global trends in public agriculture investments," Oxfam America Research Backgrounder number 2 (Washington, D.C: Oxfam America, 2009)

54. For examples, see case studies: Melinda Smale (ed.), *Valuing Crop Biodiversity: On-Farm Genetic Resources and Economic Change* (Wallingford, UK: CABI Publishing, 2006).

55. Alessandra Giuliani, *Developing Markets for Agrobiodiversity: Securing Livelihoods in Dryland Areas* (London: Earthscan Publications, 2007): 10.

56. Ruben, Pender, and Kuyvenhoven, "Sustainable Poverty Reduction in Less-Favored Areas."

57. Renkow and Pingali, "Agricultural Intensification and Environmental Degradation," 3.

poor farmers who have few choices for good husbandry—putting these assets at risk.

Most of the global and local environmental benefits of these systems are not yet valued in markets.[58] Such soils are often degraded due to overexploitation and/or insufficient use of restorative land management practices. If carbon is sequestered by planting trees or other woody biomass, then such lands can sequester carbon both above and below ground.[59] Where this is the case, these soils could provide large net gains in sequestration (i.e., removal from the atmosphere by conversion to physical form) of atmospheric carbon, since they are currently far below their carbon saturation potential. Growing interest in ecosystem service markets means that it may only be a matter of time before farmers and other rural people are compensated for valuable ecosystem services their lands provide, such as carbon sequestration, biodiversity conservation, and watershed effects.

Other public benefits of investing in these communities include avoiding human insecurity, such as famine, refugees, and conflict over resources. To enhance the food security of marginalized communities and protect globally valuable resources, mechanisms must be found to support the private investments and costs borne by poor farmers with cost-effective public investments, including the creation of incentives for novel forms of investment by other actors. For example, recognition of this fundamental point has led to efforts to stimulate carbon and biodiversity markets.

Some researchers have argued that with the increasing importance of off-farm incomes, exhaustion of technological opportunities, and tight public budgets, among other factors, it would be better for many of the farmers in marginal areas to lay down their hoes.[60] De Janvry and Sadoulet have described four types of pathways leading from rural poverty: households may "exit" agriculture through migration or the development of rural employment opportunities; some may follow an "agricultural path" that connects them with agricultural markets; others can follow a "pluriactive path" that combines off-farm income with subsistence farming; and finally some households must be provided an "assistance path" through income or food transfers that allows immediate survival and eventual opportunities to follow other paths.[61] "Strategies for

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58. Ruben, Pender, and Kuyvenhoven, "Sustainable Poverty Reduction in Less-Favored Areas."

59. Rattan Lal, *The Potential for Soil Carbon Sequestration*, IFPRI Vision Brief 5 (Washington, D.C.: IFPRI, 2009).

60. Simon Maxwell, Ian Urey, and Cathrine Ashley, *Emerging Issues in Rural Development: An Issues Paper* (London: Overseas Development Institute, 2001).

61. Alain de Janvry and Elizabeth Sadoulet, "Rural Poverty in Latin America: Determinants and Exit Paths," *Food Policy* 25 (4, 2000): 389–405.

poverty alleviation should not be generalized";[62] the variation in the distribution of poverty within marginal areas requires "targeted poverty alleviation efforts";[63] no "one-size-fits-all" strategy will work.[64]

Yet, nonagricultural options in marginal areas are often overrated (see Box 1). Hazell et al. assemble agricultural options for marginal areas under "four pillars." The first is agricultural technology, which must be grounded on natural resource management approaches. Major new scientific breakthroughs are still needed if degradation is to be reversed and livelihoods significantly improved. Second, since the technologies are location-specific, they require long-term commitments by farmers, and because they often entail public goods, local communities must drive technology adaptation and diffusion, supported by strong community associations. Third, the public sector must create an enabling environment by providing long-term property rights, investing in building farmer skills, participatory agricultural research and rural infrastructure. Combinations of public and private investments will likely be needed to combat weather and price risk, including information systems, insurance, savings and credit schemes, which cannot be coordinated locally. Fourth, they recommend the establishment of mechanisms, such as payments for environmental services, to overcome environmental degradation.[65] A fifth "pillar," not raised by Hazell et al., is productive safety programs designed to link social protection with agricultural development through building assets.[66]

The following sections highlight a sample of investment options within these main approaches.

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62. Renkow, "Poverty, Productivity, and Production Environment," 466.

63. Shenggen Fan and Connie Chan-Kang, "Returns to Investment in Less-Favored Areas in Developing Countries: A Synthesis of Evidence and Implications for Africa," *Food Policy* 29 (4, 2004): 434.

64. Ruben, Pender, and Kuyvenhoven, "Sustainable Poverty Reduction in Less-Favoured Areas," 1.

65. Hazell et al., "Development Strategies for Less-Favored Areas."

66. In this paper, we refer to environmental issues briefly, and only as drivers and outcomes of farmers' decision-making. References to research on environmental policy in investment options in poor countries, such as payments for environmental services, include Ramon López, "The Economics of Agriculture in Developing Countries: The Role of the Environment," Chapter 22 in B. Gardner and G. Rausser (eds.), *Handbook of Agricultural Economics, Volume 2A: Agriculture and Its External Linkages* (Amsterdam: North-Holland, 2002); and Food and Agriculture Organization of the United Nations (FAO), *The State of Food and Agriculture: Paying Farmers for Environmental Services*, FAO Agriculture Series 38 (Rome: FAO, 2007). Oxfam's work on climate change addresses environmental issues more directly.

# Low-external input technologies (LEIT) for agriculture

## Characteristics of LEIT[67]

Low-external input technologies (LEIT) have been recommended for farmers in remote, less productive areas precisely as a consequence of the challenges they face. Many of these innovative practices have emerged largely from the experience and experimentation of farmers themselves.[68] The distinguishing characteristic of the approach is its focus on the equity and environmental dimensions of dependence on external inputs.[69] There is a strong concurrent theme about empowering local communities to take charge and direct the use of their own biological, human and social resources.[70]

Tripp defines low-external input technologies (LEIT) specifically as those that "complement or substitute for external inputs (and hence, may be more accessible to farmers), provide significant environmental benefits, and usually require local adaptation." He explains that the dichotomy between local and introduced is not easy to maintain, and the functional classifications are hard to make because LEIT perform multiple functions, often in the context of farming systems that are undergoing a process of change.[71] Most proponents agree that despite a lessening dependence on external inputs, the search for technologies to improve the productivity and stability of smallholder farming must be as wide as possible.[72]

LEIT, and the broader "agroecology" approach in which it is sometimes embedded, have been recommended for both favored and marginal areas, and for farmers in rich as well as poor countries. Because of the continent's weathered soils and the predominance of rainfed agriculture, the InterAcademy Council has recommended a production ecological approach to diagnose

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67. Four reviews provide much of the evidence reported in this section: Hazell et al., "Development Strategies for Less-favored Areas"; Robert Tripp, *Self-Sufficient Agriculture: Labour and Knowledge in Small-Scale Farming* (London: Earthscan, 2006); John Pender, "Agricultural Technology Choices for Poor Farmers in Less-favoured Areas of South and East Asia," *Occasional Papers* 5 (2008); Norman Uphoff, *Agroecological Innovations: Increasing Food Production with Participatory Development* (London: Earthscan Publications, 2002).

68. Uphoff, *Agroecological Innovations*, 13.

69. Tripp, *Self-sufficient Agriculture*, 10.

70. Tripp (*Self-sufficient Agriculture*, 8–9) refers to approaches such as organic agriculture, agro-ecology, and permaculture, as "variations on the theme." Organic agriculture eliminates mineral fertilizers and synthetic pesticides, and when formalized, follows a strict certification system geared to consumers who are willing to pay a price premium. The agro-ecology approach he describes as a comprehensive view of production systems that is less concerned with particular technologies or the productivity of single crops than with stability and resilience (see Uphoff, *Agricultural Innovations*, and work by Altieri). Permaculture is an even more holistic approach.

71. Tripp, *Self-sufficient Agriculture*.

72. Jules Pretty, *Agri-Culture: Reconnecting People, Land and Nature* (London: Earthscan, 2002); Uphoff, *Agricultural Innovations*.

problems and find solutions in Africa, even in the four most promising farming systems.[73] In Asia, Pender concludes that some of the most promising innovations—zero tillage and IPM—have their greatest potential in irrigated environments where agricultural production is highly intensive and the returns to adoption are correspondingly high.[74]

LEIT, which are numerous and varied, have no single prototype. "The heterogeneity of agro-climatic conditions, the underlying natural resource base, and local population needs" mean that, unlike the Green Revolution prototype, "these systems are not broadly generalized and easily scaled upward; many successful examples of technologies and practices address location-specific 'niche'-type constraints."[75]

A consequence of the location-specificity of LEIT is that the benefit and cost structures of these technologies differ markedly from the Green Revolution prototype. The more heterogeneous the growing environment with respect to soils, elevation, and moisture, the greater the need for decentralized science and other factors held constant, the higher the research costs relative to the benefits base. Evaluating the costs and benefits of LEIT, and the farmer participatory research it entails, is therefore difficult. Both involve valuing public goods—impacts on the environment and knowledge.

For Oxfam, the most obvious pros of LEIT are their focus on empowering poor farmers in remote areas and their potential in building resilience to climate change. What are the cons of LEIT? So far, the experience with their use has been mixed.[76] Perhaps the single most important criterion, so often overlooked by outsiders, is that investment opportunities must be profitable for farmers in the sense that "the rate of return exceeds farmers' rate of time preference."[77] This last point refers to slow payoff period for natural resource management technologies and practices—farmers' investment horizons differ. Some LEIT technologies, such as seed improved through participatory approaches, some soil and water conservation techniques, and integrated pest management, can benefit farmers in each season—some seasons more than others. Other soil and water conservation

73. The IAC identified four farming systems that show the most promise for increasing African food security, using as indicators, the extent of malnutrition among children and the economic value of agricultural production: 1) the maize-mixed system, including cotton, cattle, goats, poultry and off-farm work; 2) the cereal/root crop-mixed system, based on maize, sorghum, millet, cassava, yams, legumes and cattle; 3) the irrigated system, based primarily on rice, cotton, vegetables, rainfed crops, cattle, and poultry; and 4) the tree crop-based system, based primarily on cocoa, coffee, oil palm, rubber, yams, maize, and off-farm work.

74. Pender, "Agricultural Technology Choices."

75. David R. Lee, "Agricultural Sustainability and Technology Adoption: Issues and Policies for Developing Countries," *American Journal of Agricultural Economics 87* (2005): 1325–1334.

76. Hazell et al. "Development Strategies for Less-Favored Areas."

77. Ruben and Pender, "Rural Diversity."

practices benefit farmers only over the longer term, and realizing these benefits requires secure long-term property rights over resources. Larger-scale terraces and watershed management need to be undertaken cooperatively by organized groups of farmers and communities. Moreover, what makes economic sense for farmers must be evaluated by farmers themselves following a process of learning and experimentation. In most of these settings, the economic value of their time and other input costs is not adequately reflected in market prices. In other words, economic calculations are "socially-mediated."[78]

Some improved natural resource management practices simply may not offer sufficient productivity gains in either the short term or the long term to make the investment worthwhile for farmers, and this depends on the agroenvironment and economic context, which affects the opportunity cost of labor. Pender reports that although soil and water management practices have been promoted in the humid uplands of several Asian countries for decades, they have met with limited success. Constraints to their use have included high labor costs, costs in terms of diverting farmland from one use to another, and poor adaptation of introduced species. More labor-demanding approaches appear to have greater potential in less-intensive farming systems, where the opportunity costs of labor are lower in other on-farm activities. He also suggests that soil and water conservation measures may be much more profitable in the near term in low-rainfall areas, since they can have an immediate productivity impact by conserving scarce soil moisture.[79] Such measures are also especially significant for increasing the resilience to climate change of marginal communities, which are particularly vulnerable to climate change impacts such as increasingly variable rainfall or more frequent and intense droughts and floods. Such appears to have been the case in the Sahel.[80]

Certainly the availability of labor is a critical decision-making criterion for many farmers in marginal areas, and those who are wealthier, and can hire labor, are more likely to adopt and benefit from adoption. Evidence suggests that, as in the case of other technologies, farmers with better access to market infrastructure, including well-developed labor markets, are more likely to adopt first. At the same time, better access to market infrastructure generally implies greater non-farm opportunities for poor households to sell their labor. Promoting these methods where the pull of migration is greatest, and those left behind, such as women and an aging population, are unable to participate due to other demands

78. Tripp, *Self-Sufficient Agriculture*, 44.

79. Pender, "Agricultural Technology Choices."

80. Chris Reij and David Steeds, "Success Stories in Africa's Drylands: Supporting Advocates and Answering Skeptics," paper commissioned by the Global Mechanism of the Convention to Combat Desertification (Amsterdam: Vrie Universiteit and Centre for International Cooperation, 2003).

on their time, should be considered carefully. Natural resource management practices are also knowledge intensive. Farmers, and especially women left behind by migrants, may not have access to appropriate agricultural extension or training. Such constraints, however, can be overcome by program design.

Focusing in his review on the equity implications of LEIT, Tripp stated that the "limited literature available provides more examples in which LEIT adoption favors relatively wealthier farmers than those in which poorer households have at least equivalent access to the innovations."[81] But he also points out that this would be the case with any technology, especially where it is divisible and adopted by individuals (as compared to the community, as in the case of larger-scale conservation bunds and terraces).

LEIT should not necessarily be expected to reduce rural inequality within adopting communities any more than conventional technologies. Financial barriers to adoption of LEIT may be less, but other barriers, such as differential access to information and knowledge, remain. One consequence of introducing any new technology into a poor rural area is typically to widen rather than narrow the gap between the haves and the have-nots. However, LEIT technologies may be of benefit to the poor in farming communities. For example, in Western Kenya, Place et al. found that agroforestry interventions, including improved fallows and biomass transfer systems, were attractive to the poor because they are low in cost and yield-enhancing. While fertilizer use depends on income, lower and higher income farmers in the villages they studied used these practices in similar ways.[82] Swinton and Quiroz found that fallowing was practiced by poor farmers and rotational grazing, which reduces overgrazing, is neutral to farm size in the impoverished Peruvian altiplano. They conclude that relative improvements can be made in natural resource stewardship even among the very poor: "awareness of sustainability problems and low-cost steps to address them, combined with closely knit community structures are the key factors that support good stewardship in such a setting."[83]

While they may contribute to poverty reduction, even the most promising, low-external input technologies are not likely to boost farm income so much that they enable the chronically poor to pull themselves out of poverty. The study by Place et al., like others, concluded that because frequent adverse shocks almost always deplete the already limited assets of poor farmers, poverty reduction will require

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81. Tripp, *Self-Sufficient Agriculture*, 71.

82. Frank Place, Michelle Adato, Paul Hebinck, and Mary Omosa. *The Impact of Agroforestry-Based Soil Fertility Replenishment Practices on the Poor in Western Kenya*, IFPRI Research Report 142 (2005).

83. Scott Swinton and Roberto Quiroz, "Is Poverty to Blame for Soil, Pasture and Forest Degradation in Peru's Altiplano?" World Development 31 (11, 2003): 1903–19.

sets of interventions that are sequenced and integrated.[84] In addition to LEIT, investments in other farm and non-farm livelihood options are recommended. Several outstanding examples of LEIT are described briefly below.

### *Reducing soil erosion*

Most common in the more humid uplands, soil and water management technologies reduce soil erosion and water runoff. These include: physical structures such as hillside terraces; contour planting or ridges; vegetative or live barriers; conservation tillage, including mulches and cover crops. Soil fertility management practices aim more specifically to complement or replace the use of mineral fertilizers with manures, composts, and biomass transfers from leguminous species planted as alley crops or green manure.

There is documented evidence that mulches and cover crops increase net returns to land and labor on the hillsides of southern Mexico[85] and Central America. For example, *mucuna pruriens* (velvet bean) is considered a success story in this region. Velvet bean is valued primarily as a soil amendment in Central America, where farmers refer to it as the "fertilizer bean."[86] Tripp describes how *mucuna* is managed in the maize-based systems on the north coast of Honduras. Farmers plant maize in two seasons. In the second, they establish *mucuna* by planting it into a maize field and allowing it to mature after the maize harvest. The field is left during the summer season as a short fallow, where it matures, senesces and reseeds. The field is prepared in the next winter season by slashing the *mucuna* to the ground and planting maize into the mulch. Only a little weeding and little to no fertilizer is required, and the system can be continuously cropped.

Bunch reported that average smallholder maize yields were several times higher after a period of 10–22 years relying on cover crops and velvet bean.[87] Richards and Suazo document the enduring use of *mucuna* from the 1980s–1990s through 2003 in central Honduras, where more than 90 percent of the region is on hillsides, soils are thin and of poor quality. One in four farmers still used velvet bean with maize over 20 years later.[88]

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84. Place et al., Soil Fertility Replenishment Practices.

85. Olaf Erenstein, *Evaluating the Potential of Conservation Tillage in Maize-Based Farming Systems in the Mexican Tropics*, NRG Reprint Series 96–01 (Mexico, DF: CIMMYT, 1999).

86. Tripp, *Self-Sufficient Agriculture*, 30.

87. Roland Bunch, "Changing Productivity through Agroecological Approaches in Central America: Experiences from Hillside Agriculture" in N. Uphoff (ed.), *Agroecological Innovations* (London, Earthscan, 2002).

88. Michael Richards and Laura Suazo. "Learning from Success: Revisiting Experiences of LEIT Adoption by Hillside Farmers in Central Honduras" in Tripp (ed.), *Self-Sufficient Farming: Labour and Knowledge in Small-Scale Farming* (London: Earthscan, 2006).

Buckles documented the history of *mucuna* and its adoption in Central America. Velvetbean is of Asian origin and was introduced into Central America as a forage crop by the United Fruit Company during the 1920s to feed mules on its plantations. Picked up by indigenous Guatemalans from the highlands who worked on the plantations, velvetbean diffused spontaneously from farmer to farmer during the 1980s. *Mucuna* became part of the hillside maize management strategies of a large proportion of small-scale farmers in some areas, and was then promoted in development projects by NGOs.[89]

Richards and Suazo find that spontaneous diffusion was not as great as expected; instead, they recommend that more formal extension models be used to complement farmer-to-farmer dissemination.[90] A study by Neill and Lee raises questions about reliance on spontaneous diffusions and underscores the importance of farmers educating each other. Witnessing some abandonment of the practice, they recommend a farmer-to-farmer model of extension with a trained "farmer educator" who lives in the community and "who not only promotes new techniques but also situates them within an agronomic context that farmers can understand." They conclude that spontaneous diffusion does not necessarily provide farmers with the understanding they need about agronomic principles, soil health and preservation, and the importance of reseeding.[91]

### *Water harvesting and crop establishment*

Water harvesting in the drylands involves concentrating rainfall runoff from a larger area into a smaller catchment area. Practices include the construction of small pits or basins for direct planting, sometimes with the addition of organic matter, as in the "zai" or "tassa" of the Sahel. Small-scale, farmer-controlled irrigation programs that use simple and low-cost cost methods to divert or lift water from shallow rivers or seasonally filled depressions are also common.

Water harvesting has been practiced for thousands of years in semi-arid and arid areas of China and India, and current efforts, numerous in India and large-scale, are reported to be successful in terms of farm incomes and reduction of land degradation. In the Sahelian countries, simple pits, bunds, and dikes that retain soil nutrients and reduce erosion can lead to higher (and more stable) yields and income. Indigenous practices, these have been enhanced through farmer

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89. Daniel Buckles, "Velvetbean: A "New" Plant with a History," *Economic Botany* 49 (1, 1995): 13–25; Daniel Buckles, Bernard Triomphe, and Gustavo Sain, *Cover Crops in Hillside Agriculture: Farmer Innovation and with Mucuna* (Ottawa and Mexico, DF: IDRC/CIMMYT, 1998).

90. Richards and Suazo, "Learning from Success."

91. Sean Neill and David Lee, "Explaining the Adoption and Disadoption of Sustainable Agriculture: The Case of Cover Crops in Northern Honduras," *Economic Development and Cultural Change* 49 (July 2001): 814.

experimentation and low-cost technical assistance. A widely documented example occurred in the environmentally degraded, northern Central Plateau of Burkina Faso. In response to the droughts of the 1970s and 1980s, farmers dug planting pits, aligned stone bunds on the contours of their fields, and built permeable stone dikes to rehabilitate gullies across tens of thousands of hectares. Adoption of water-retention technology improved sorghum and millet yields, enabled the reclamation of barren land, contributed to natural regeneration of vegetation, and in some cases, raised water tables.[92] The techniques were diffused from the Dogon Plateau in Mali to the Central Plateau of Burkina Faso to villages in Niger by lead farmers and farmer movements, both spontaneously and in visits organized by NGOs and donors.[93]

To refute the claim that investing in drylands made little economic sense, Reij and Steeds compiled longitudinal success stories from the Central Plateau of Burkina Faso (1980–2002), Machakos District in Kenya (1930–1990), Maradi Department in Niger, Kano Region in Nigeria, Diourbel Region in Senegal, and a number of other projects and programs across Africa. They found economic rates of return of 20–40% on soil and water conservation investments in Niger, Mali, and northern Nigeria.[94]

Clearly, technologies such as stone bunds, terraces, and planting pits demand a great deal of initial and recurrent labor to maintain their structure. Nonetheless, crop production budgets for planting pits show a 15% return to labor.[95] While poor farmers may be less likely to take advantage of planting pits because they are more labor-constrained, other techniques, such as dams or bunds across a larger area produce benefits for both rich and poor farmers. The extent of adoption depends to some extent on soil type.

### *Pest management*

Cover crops, alley crops, and mulches promoted primarily as soil fertility amendments also suppress weeds—one reason cited for their adoption by farmers. A major motivation for LEIT technologies in more humid or wet areas has been the unsafe use of synthetic insecticides, fungicides, and other chemicals to control insect pests and other plant diseases, which has led to environmental

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92. Chris Reij, Gray Tappan, and Adama Belemvire, "Changing Land Management Practices and Vegetation in the Central Plateau of Burkina Faso (1968–2002)," *Journal of Arid Environments* 63 (November 2004): 642–659.

93. Daniel Kaboré and Chris Reij, *The Emergence and Spreading of an Improved Traditional Soil and Water Conservation Practice in Burkina Faso*, EPTD Discussion Paper 114 (Washington, DC: International Food Policy Research Institute (IFPRI), 2004); Melinda Smale and Vernan Ruttan, "How Social Capital Can Enable Technical Change: The Groupements Naams of Burkina Faso" in C. Clague (ed.), *Institutions and Economic Development: Growth and Governance in Less-Developed and Post-Socialist Countries* (Baltimore: Johns Hopkins University Press, 1997).

94. Reij and Steeds, "Africa's Drylands."

95. Kaboré and Reij, *Soil and Water Conservation Practice*.

damage and health problems. Referred to as integrated pest management (IPM), methods include intercropping and crop rotation, the use of traps, bio-pesticides and pest-resistant cultivars, and plants that repel or attract pests. A common denominator of these approaches is their rejection of pest management that depends entirely on synthetic pesticides, often applied following a fixed schedule. Most seek to maintain pest damage below an economic threshold. Farmers learn about the principles and develop adaptive responses to pest pressures in the context of their own farming system. "Few of them represent the simple substitution of one practice for another and most require farmers to continually update their skills and their knowledge of new techniques and to be ready to adapt to changing conditions.[96] Where pest pressures are high year-to-year, these strategies can generate immediate, palpable benefits for farmers; where pest outbreaks can cause important losses but do not occur every year, benefits streams are episodic. Compared to soil and water management practices, and water-harvesting, however, farmers can earn benefits from IPM in a single season and whether or not they own the land they farm.

The most successful examples of IPM came from the irrigated rice fields of the post-Green Revolution—in Indonesia, where the early experience began. IPM has since been widely adopted in intensive rice cultivation in the Southeast Asia and Pacific region. Newer examples in other crops and environments have met with variable success. A critical determinant of success is the incidence, severity and persistence of the pest pressures the measures are designed to offset. This pressure is great in very humid, intensified agricultural systems such as irrigated rice—which we have classified here as "favored." Even so, there are successful cases cited for many areas of the world, such as for head borer of pearl millet in the Sahel. Dryland cotton and small-scale vegetables are other examples.

Recognition of the importance of human capital in IPM, since the 1980s, led to the widespread promotion of these practices by FAO through Farmer Field Schools (FFS). FFS are an adult education method developed and widely promoted in Asia to teach integrated pest management practices to groups of farmers. While there is considerable variation in form and content, the basic approach involves teaching farmers how to solve problems, set priorities, and conduct experimental research through facilitated, hands-on sessions in fields allocated by the farming community for study.

The impacts of FFS are a subject of lively debate. Critical reviews of the evidence, most related to IPM, suggest that they have not translated into changes beyond local communities, they tend to favor more privileged farmers within those

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96. Tripp, *Self-Sufficient Agriculture*, 36.

communities,[97] and they provide an unlikely basis for sustained, group activity.[98] Tripp, Wijeratne and Piyadasa express concern that the assessment of FFS has been "insufficient."[99] Van der Berg and Jiggins explain that the methodology for evaluating the impacts of farmer field schools is still under development, and is characterized by a tension between statistical rigor, which implies a narrow focus, and comprehensiveness, which leads to a diversity of impact indicators and definitions of impact. While most reports have been positive, most reporting is probably biased (p. 665); measurement of medium-term and longer-term impacts has been particularly weak (p. 679). Only one study in Indonesia is known to have examined impacts econometrically with design that included both control vs. treatment groups, with before-and-after comparison to account for initial differences between the groups.[100] Feder, Murgai, and Quizon found that the training had no statistically significant impact on the yields or the pesticide use among the participants or others in the same communities, although a related study found that the participants had superior knowledge of pest control methods and those who had more knowledge used less pesticides.[101] Pender rejoins that this contradiction "strains credibility," and may be a consequence of low statistical power or data problems in the impact analysis.[102]

### Institutional implications of LEIT

Tripp finds that LEIT projects are innovative with respect to methods of extending knowledge and practices.[103] LEIT is more farmer-centered and focused on local flows of information than are traditional extension activities. Often, Uphoff says, these agricultural innovations are farmer-led.[104] This means that building the human and social capital of farmers is of great importance to their success.

Micro-studies about the adoption of Green Revolution technologies by smallholder farmers have generally proven that development of human capital through formal education has played a role. There is scant evidence, however,

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97. Kristen Davis, "Commentary: Farmer Field Schools: A Boon or Bust for Extension in Africa?" *Journal of International Agricultural and Extension Education* 13 (1, 2006): 91–96.

98. Robert Tripp, Mahinda Wijeratne and V. Hiroshini Piyadasa, "What Should We Expect from Farmer Field Schools? A Sri Lanka Case Study," *World Development* 33 (10, 2005): 1705–1720.

99. Ibid.,1718.

100. Henk Van den Berg and Janice Jiggins, "Investing in Farmers—The Impacts of Farmer Field Schools in Relation to Integrated Pest Management," *World Development* 35 (4, 2007): 665–679.

101. Gershon Feder, Rinku Murgai, and Jaime Quizon, "Sending Farmers Back to School: The Impact of Farmer Field Schools in Indonesia," *Review of Agricultural Economics* 26 (2004a): 45–62.

102. Pender, "Agricultural Technology Choices."

103. Tripp, *Self-Sufficient Agriculture*.

104. Uphoff, *Agroecological Innovations*.

that formal education has a direct influence on the success of LEIT projects, although basic numeracy and literary may be indispensable skills. For successful development and adoption of these more demand-driven sets of practices and technologies, Tripp suggests that the type of education needed for LEIT is more likely to be on the side of "principles" rather than "recipes."[105]

While group methods were also used to promote Green Revolution technical packages, the group approach may be more relevant to LEIT because often these are not divisible and scale-neutral. Most require collective action to implement key components, such as arranging for fields for experimentation and organizing labor. They depend for success on the development of human and social capital in farming communities. They often emphasize social learning, which enables farmers to learn from each other in a semi-formal context. Adaptation of principles and technologies to local context requires participatory research methods.

Social capital substitutes not only for formal extension systems where these are lacking or ineffective but for human capital. Social networks are a "structural" manifestation of social capital which is observable and extrinsic.[106] These can be leveraged in extension schemes, but are more complex than "model farmer" approaches, which rely on a single actor as the focal point. Matuschke argues that social networks may play a particularly important role for poor farmers, who tend to rely to a greater extent on informal as compared to formal sources of information, as well as to women farmers and other excluded groups, whose information needs are often not addressed by formal extension services or whose participation may be socially proscribed.[107] Recent empirical research has demonstrated that social networks do influence the adoption decisions of individual farmers.[108] They act as conduits for financial transfers that may relax the farmer's credit constraints, information about a new technology or practice, and they can facilitate cooperation to overcome a collective action dilemma, such as those posed by LEIT technologies that involve environmental externalities.[109]

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105. Tripp, *Self-Sufficient Agriculture*.

106. Enid Katungi, *Social Capital and Technology Adoption on Small Farms: A Case of Banana Production Technology in Uganda* (Pretoria: University of Pretoria, 2006).

107. Ira Matuschke, Evaluating the Impact of Social Networks in Rural Innovation Systems, IFPRI Discussion Paper 816 (2008).

108. Timothy Conley and Christopher Udry, "Social Learning through Networks: The Adoption of New Agricultural Technologies in Ghana," *American Journal of Agricultural Economics*, 83 (2001): 668–732; Jonathan Isham, "The Effect of Social Capital on Fertiliser Adoption: Evidence from Rural Tanzania," *Journal of African Economies* 11 (1, 2002): 39–60; Katungi, "Social Capital"; Ira Matuschke, Ritesh Mishra, and Matin Qaim, "Adoption and Impact of Hybrid Wheat in India," *World Development* 35 (8, 2007): 1422–1435.

109. Heidi Hogset and Christopher Barrett, Imperfect Social Learning among Kenyan Smallholders (discussion paper, Cornell University, Dept. of Applied Economics and Management, 2007).

How groups are composed, who participates in them, and which cultural norms they reflect, has a lot to do with the success of LEIT in terms of performance and its equity impacts. In the banana-based production systems of Uganda's highlands, Katungi, Machethe, and Smale found that social capital is not universal; wealth, education, and age were important determinants of participation in organizations, as was the extent of ethnic and social fragmentation in the community. Interestingly, membership in agricultural-based organizations was wealth-neutral—but most of these were brought about by NGOs or actors based outside the village.[110] Gender disparities were also revealed in this research.[111] Consistent with existing literature, female heads of households appear to be disadvantaged in their access to information related to recommended soil fertility management practices. Male and female heads of households also diverge in their access to different types of social capital.

So far, the evidence that LEIT has empowered farmers through strengthening human and social capital appears to remain weak—but establishing the causality of this effect is probably fraught with methodological difficulties that are difficult to overcome.[112] In their study of hillside farmers in Central Honduras, Richards and Suazo found that farmer-to-farmer dissemination was in fact limited, implying that complementary, formal extension methods were still needed. Social and human capital had no significant influence on adoption, which they ascribe to the relative simplicity of the technologies extended and their rapid payback.[113] In Western Kenya, Longley et al. found that "the link between the Catchment Approach of Kenya's National Soil and Water Conservation Programme and strengthened social capital was tenuous." They noted that no effort was made to sustain the networks established between extension agents and farmers by the project itself, citing the short-lived, project-based funding as a constraint.[114]

Some of the more intensive LEIT activities, which are costly to scale up, involve extension agents working alongside farmer-leaders who work as catalysts to encourage new communities to initiate their own activities. Clearly, on-station research still plays a role in the testing of new approaches, but research products

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110. Enid Katungi, Charles Machethe, and Melinda Smale, "Determinants of Social Capital Formation in Rural Uganda: Implications for Group-Based Agricultural Extension Approaches," *African Journal of Agricultural and Resource Economics* 1 (2, 2007): 166–190.

111. Enid Katungi, Svetlana Edmeades, and Melinda Smale, "Gender, Social Capital and Information Exchange in Rural Uganda," *Journal of International Development* 20 (1, 2008): 35–52.

112. Tripp, *Self-Sufficient Agriculture*.

113. Richards and Suazo, "Learning from Success."

114. Catherine Longley, Nelson Mango, Wilson Nindo, and Caleb Mango, "Conservation by Committee: The Catchment Approach to Soil and Water Conservation in Nyanza Province, Western Kenya" in R. Tripp (ed.), *Self-Sufficient Farming: Labour and Knowledge in Small-Scale Farming* (London, Earthscan, 2007), 125.

need to move quickly to farms and extension needs to take a more facilitative rather than directive role. Decentralization of research and extension is necessary with LEIT. The effectiveness of extension in reaching poor farmers has long been a subject of controversy. Some alternative models are discussed in Annex 2, with reference to experiences in sub-Saharan Africa. Some options for the institutional organization of investing in agricultural research with scarce public funds are summarized in Annex 3.

Although LEIT should be a driving paradigm for developing agricultural research and development in marginal areas, gradual improvement in the quality of the land and plant growing conditions can create an environment in which the improved seed combined with modest amounts of mineral fertilizer will boost productivity and justify their cost. As a consequence of farmer and public investments in small-scale water harvesting and farmer-managed natural regeneration, some intensification has occurred, for example, in parts of the Sahel over the past 20 years.[115]

## Improving seed and local seed markets

### Improved seed

To address binding constraints in difficult growing environments particularly as climates change, long-term strategic investments are needed in plant breeding to augment nutrient use, tolerance to drought, flooding, and temperature extremes. For example, in the Sahel, where there is high spatial and temporal variability of rainfall, dry spells can occur anytime during the cropping season but are most likely to occur during seedling establishment and grain maturation. While there is little scope at present to improve drought tolerance at seedling establishment for pearl millet, there are good prospects for improvement of drought adaptation through enhancing water use efficiency.[116] Low phosphorus in soils is a major constraint to improving yields in this region. According to Payne, this can be addressed not only through fertilizers and crop management practices but also through exploiting crop genetic variability and heritability for phosphorus uptake through plant breeding.

In addition to this strategic research, continuous investments in plant breeding to enhance genetic resistance to evolving pests and disease are fundamental to combat annual yield losses and forestall plant disease epidemics. Often called

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115. Reij, Tappan, and Belemvire, "Changing Land Management Practices"; Gray Tappan and Michael McGahuey, "Tracking Environmental Dynamics and Agricultural Intensification in Southern Mali," *Agricultural Systems* 94 (2007): 38–51.

116. William Payne, personal communication with authors, January 12, 2009.

“maintenance research,” this type of crop improvement aims to protect yields rather than enhance yield potential, and is an ongoing part of any plant breeding program.

There are examples of where public investments in plant breeding for marginal environments have paid off financially and have generated profits for farmers—though perhaps not as dramatically as in more well-watered, uniform growing environments. In some marginal areas, breeding to enhance grain quality or fodder of staple crops can generate income in local markets that is large enough to pay for the cost of the seed through price premia. In the rainfed and mountainous areas of northern Pakistan, Byerlee, Iqbal, and Fisher found that fodder accounted for between one-third and one-half the total value of the maize crop.[117] Improved durum wheat varieties with preferred grain quality have generated profits for farmers in the more marginal drylands of North Africa and West Asia.

But other models are often needed to improve seed in marginal areas. Seed can be “improved” through on-farm mass selection by farmers, as was the case until well into this century in industrialized agricultural nations of the world and is still the case for the majority of farmers elsewhere. Crop improvement in the Green Revolution was “supply-driven” (Annex 1), with considerably more attention paid to optimal production packages than to what is economically optimal for semi-commercial smallholders or subsistence growers in difficult growing environments. Dissatisfaction with the capacity of public or private sector breeding to meet the needs of local adaptation in stress-prone environments led scientists to propose the establishment of local-level breeding or improvement systems, since advocated by NGOs and also undertaken by some public research institutions. There is now a widespread consensus that farmers and end-users need to be more involved in setting priorities, screening and selecting materials earlier on in the scientific process, in order to ensure the relevance of the research to the traits they need and the constraints they face. Participatory plant breeding (PPB) refers to a range of approaches that link breeders and farmers more closely in order to address these needs.

In the Sahel, for example, the tremendous micro-variation in climate, soils, and production systems means that the degree of plant stress is not only high but also highly variable across locations. Diakité et al., Bazile, and Weltzien et al. recommend greater involvement of farmer and community organizations in testing and evaluating improved varieties, coupled with decentralized seed production, to reduce the time lag between development and adoption of

117. Derek Byerlee, Muzaffar Iqbal, and K.S. Fischer, “Quantifying and Valuing the Joint Production of Grain and Fodder from Maize Fields: Evidence from Northern Pakistan,” *Experimental Agriculture* 25 (1989): 435–445.

improved sorghum and millet seed.[118] A dramatic success story in maize in participatory plant breeding is the adoption of improved open-pollinated varieties in east and southern Africa with tolerance to drought and low nitrogen fertility. First, CIMMYT worked with the national agricultural research systems in the region to identify breeding priorities that were well-aligned with farmers' production environments. Large numbers of genotypes were screened for drought and low nitrogen tolerance and final selections made. Then, participatory methods were applied to evaluate a limited set of new varieties across a wide range of environments, using farmers' selection criteria. Engaging farmers in the process of making selections ensures that the very best are chosen and establishes a demand for particular varieties, creating incentives for seed producers and distributors.[119]

Generally speaking, farmers and communities are purposively selected for participatory plant breeding and research. In estimating impacts of such efforts, there is known bias due to the method of participant selection and program placement, high cost per farmer, and difficulty in scaling up to more farmers. Just how many farmers are in fact needed to develop and maintain good local materials remains unclear—and these may be few.

It is likely that such efforts have impacts on variety use and information accumulation beyond the lifetime of the project, and that without at least some participatory research component, breeding work in marginal environments with semi-subsistence farmers is not likely to succeed. In some instances, the counterfactual to participatory plant breeding is no use of introduced materials or practices at all. In reality, "participatory research is often tried or used when conventional approaches for developing improved crop varieties or natural resource management practices fail."[120]

### Local seed systems

Farmers in marginal areas generally rely on themselves and each other for seed. Principal seed sources are on-farm seed saving, farmer-to-farmer exchanges

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118. Lamissa Diakité, Amadou Sidibé, and S. Diakité, *Enquête pour l'identification des paysans semenciers dans les zones et villages propices à la production semencièr* (Bamako: Services d'Experts pour les Ressorces Naturelles et l'Environnement au Sahel, 2005); Didier Bazile, *State-Farmer Partnerships for Seed Diversity in Mali*, Gatekeeper Series 127 (London: International Institute for Environment and Development, 2006); Eva Weltzien, Anja Christinck, Aboubacar Touré, Fred Rattunde, Mamadou Diarra, Abdullaye Sangaré, and Mamadou Coulibaly, "Enhancing Farmers' Access to Sorghum Varieties through Scaling-up Participatory Plant Breeding in Mali, West Africa" in C. Almekinders and J. Hardon (eds.), *AgroSpecial 5: Bringing Farmers Back into Breeding: Experiences with Participatory Plant Breeding and Challenges for Institutionalisation* (Wageningen: Agromisa Foundation, 2006).

119. Marianne Bänzinger and Mark Cooper, "Breeding for Low Input Conditions and Consequences for Participatory Plant Breeding: Examples from Tropical Maize and Wheat," *Euphytica* 122 (2002): 503–519.

120. Nina Lilja and Mauricio Bellon, Analysis of Participatory Research Projects in the International Maize and Wheat Improvement Center (Mexico, D.F.: CIMMYT, 2006).

through social networks, and unregulated sales in village markets. Open-air markets or "fairs" are typically convened in villages on a weekly basis, where farmers trade their produce, conduct other market and non-market business, and occasionally, sell their own seed or purchase seed from other farmers or traders.

Marginalized farmers often grow crops for which well adapted, high-yielding varieties have not yet been developed or are not widely adopted. Low adoption rates often reflect a combination of seed supply bottlenecks, lack of farmer interest because the seed is not necessarily superior to their own, and farmer inability to afford seed on a regular basis. For example, the quality of certified seed may not be assured, little information about the variety and its characteristics may be provided by the seller, or the costs of obtaining it at distant outlets from unknown sources may be prohibitive. Environments are often so heterogeneous that farmers have difficulty observing yield advantages of modern varieties; for subsistence food crops, it may not make economic sense for cash-constrained farmers to purchase seed. Even where promising new varieties have been bred for and introduced successfully into these cropping systems, farmers often choose to grow variety portfolios in order to satisfy a range of consumption needs and buffer production risk.

Though little is documented in quantitative terms about the informal seed trade, emerging evidence suggests that it can be crucial as a source of well-adapted local and improved (non-hybrid) seed marginal areas. A recent set of studies coordinated by FAO confirmed that village grain markets are an important part of local seed systems in drylands and recommended policy reform to strengthen their capacity to provide farmers access to seeds.[121] Recommended actions include: 1) mobilizing seed/input fairs in local communities to improve seed availability; 2) encouraging the supply of improved varieties in small seed packs through traders in exchange for vouchers to improve yields; 3) linking local markets and their vendors to seed sources, such as existing seed programs and seed producer groups, to improve supplies of well-adapted, quality seed types; 4) educating traders and farmers about the benefits of differentiating seed and grain, and supporting this through the introduction of locally-implemented seed quality standards; and 5) improving the supply of foundation seed from research organizations to local seed producers, and involving local seed producers more closely in variety release and quality control. In the long run, it is important to strengthen local market infrastructure and vendor capacity through improved roads, facilities, and information on prices and varieties. The potential for credit provision to traders or farmers also needs to be examined.

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121. Food and Agriculture Organization of the United Nations (FAO), "Seeds, Diversity and Development," http://www.fao.org/economic/esa/seed2d/projects2/marketsseedsdiversity/projectteam/en/ (accessed April 19, 2009).

There are a number of hurdles to overcome, however. The process of seed certification can be long and costly—tending to exclude many of the minor crops grown by marginalized farmers. Some nations such as Mali and Kenya prohibit the trade of seed unless it is officially certified, barring commercial sales of farmers' varieties. Seed of local varieties is thus sold as grain, without a label. A premium to reflect quality differences may or may not be charged. The FAO studies suggest that markets could function more effectively if countries would permit the trade of local varieties. For example, guarantees could come from accredited seed inspectors or developing local seed brands, with information on the variety and its origin.

There are potential opportunities that remain unexploited in marginal areas, including new paradigms for supplying quality seed. For example, seed markets can be developed through innovative public-private partnerships and through research-producer association partnerships. The Initiative Service Conseil (ISC), an agro-dealer and input shop in Niger, partners closely with INRAN, the national research institute, on seed multiplication. Seed multiplied by ISC is certified as truthfully labeled and sold through agro-dealers' own social networks, farmers' radio clubs and competitions, at field demonstrations, public meetings, and displays in local markets. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) also found that direct seed sales were the most effective mechanism in terms of farmer knowledge of the variety and origin.[122]

Farmer organizations are proving to be vital partners in development of the formal seed system for sorghum and millet in Burkina Faso, Niger, and Mali. Working with ICRISAT cereal breeders and national program scientists, organization members conduct and evaluate trials to identify varieties that increase and stabilize yields on their farms. Mooriben, a farmer organization in Niger, was trained to produce quality millet seed, which was then widely distributed by selling small seed packs (1 to 5 kg) through local input shops, their offices, or at general meetings. Farmer organizations in Burkina Faso and Mali were trained to market certified seed, and then began to sell sorghum seed directly to input traders and emerging seed companies keen on building an input distribution network. Two other farmer organizations in Burkina Faso produce foundation seed and certified seed with close supervision of researchers, and this

122. Catherine Longley, L. Nagarajan, T. Boye, I. Maizama, A. Boubacar, A. Y. Aboubacar, and I. Kassari, *Enhancing Seed Systems and Dissemination of New Varieties in Niger*, Draft manuscript (Nairobi: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), 2009).

seed is distributed to other organization members for production of certified seed.[123]

## Enhancing the value of neglected and underutilized plant species[124]

There is no commonly recognized definition of neglected and underutilized plant species (NUS). NUS are unique in that they possess three characteristics simultaneously: 1) they are locally, but not globally abundant; 2) they are known practically by users but largely unknown by scientists; and 3) their use is limited relative to their economic potential. Based on the second property, they are sometimes referred to as "orphan" crops, since neither private not public research institutions have invested much in their improvement.

Neglected and underutilized species are also referred to as "minor" because they are less important than other crops in terms of global trade or value of production. They persist because they are valued by local people. Some occupy special niches in the agro-ecology, demonstrate an agronomic advantage on marginal lands, or contribute to land restoration; others are a source of food, dietary diversity, micronutrients, or herbal remedies. Typically, traditional knowledge is associated with their use, while scientific information about them is limited. Thus, many of these plants have use value for some of the world's more vulnerable populations but their potential value is largely unknown. They can also be viewed as "emergency assets" on which local communities depend during difficult periods, such as droughts.

While there are various options for investing in NUS, include participatory plant breeding, some NUS have the potential to contribute to the livelihood security of poor people in marginal areas through markets. For example, in Syrian drylands, Guiliani applied a value chain analysis and livelihoods approach to document the role of selected wild and cultivated NUS species (fig, jujube, laurel, caper, purslane, mallow) and pinpoint constraints. Her data confirmed that while minor to the national economy, the income share from NUS activities represented 10–23% of annual household income from rural households engaged

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123. ICRISAT, "Farmers Lead New Cereal Seed System," *SA Trends 94* (September 2008). http://www.icrisat.org/satrends/september2008.htm.

124. This section is excerpted from Guillame Gruère, Alessandra Giuliani, and Melinda Smale, "Marketing Underutilized Plant Species for the Poor: A Conceptual Framework" in A. Kontoleon, U. Pascual, and M. Smale (eds.), *Agrobiodiversity, Conservation, and Economic Development,* Explorations in Environmental Economics Series (Abingdon, UK: Routledge, 2008).

in these activities.[125] The high proportions of the product sold (64–95%, according to the species), underscored that market development is crucial. Human and social capital were the main assets on which NUS producers depended. Collectors emerged as the most vulnerable actors in the value chains—mostly illiterate, with a high proportion of women and children.

What explains why these crops have a potential economic value that surpasses their current value? Plant species are underutilized as a consequence of various types of market imperfections or market failures. There are three necessary conditions for the successful commercialization of underutilized plant species for the poor: 1) demand expansion; 2) increased efficiency of supply and marketing channel; and 3) supply control mechanism or capacity to differentiate the product from close substitutes. Figure 2, in Annex 3, represents the three conditions in the context of partial equilibrium.

### Expansion of demand

An underutilized plant species cannot be successfully commercialized without a well-articulated, strong demand for its products. The existence of potential value implies the existence of potential demand. To expand demand, it is necessary to assess demand opportunities by identifying observed and potential buyers, the potential products that would be demanded, and the scope of the demand.

There is some evidence that there are market opportunities for underutilized plant species that could be exploited as consumer incomes rise. First, there is an increasing global demand for an array of natural (and exotic) products, different qualities of products or product attributes, and a range of related niche markets (some based on eco labeling schemes) in both developed and developing countries. Related to that, many countries are experiencing a consumption trend towards traditional food products and regional or national cultural assets. At the same time, there is an increased interest in products that support healthy living, such as natural medicinal or cosmetic products. Secondly, grassroots organizations, local non-governmental organizations, and several international organizations, supported by fora such as the Convention on Biological Diversity, have stimulated public awareness of the value of plant diversity for the environment and in the livelihoods and knowledge systems of local (including indigenous) communities.

There are several types of actions that can help these species reach their market potential. One is to provide better information concerning the private and public benefits of the products. For example, product fairs and rural theaters have been used to promote local products and traditional or new recipes among consumers

125. Giuliani, "Markets for Agrobiodiversity."

in rural areas. In Syria, poets worked together with extension agents and local project staff to write songs which were used during local festivals to draw attention to products.[126] Nepalese writers created rural roadside dramas (*Gramin Sadak Natak*) based on village accounts, highlighting the value of in situ conservation with local examples.[127]

Another means of supporting consumer demand is product differentiation. Product differentiation may open other market opportunities through labeling (e.g., ecolabels or "fair trade" schemes), certification and branding. Public programs can be used to support a stable local or national demand as a complement to other approaches, at least during the initial phase of market development. For example, the M.S. Swaminathan Research Foundation, which leads the market development effort for minor millets in India, has advocated the use of minor millets in public child feeding programs, citing their nutritional qualities compared to other grains. Including underutilized grains in hospital meals or military rations could also support demand.

### Increase efficiency of marketing

Any successful marketing chain must be able to bring a product of satisfactory quality onto the market at a reasonable price. There may be an endogenous constraint, such as the lack of organizational structure, leading to weak information, risk and vulnerability for primary producers. In addition, production may be restricted exogenously by fixed costs, absence of credit markets, or inadequate infrastructure.

The transmission of information may require basic communication tools. The organization of producer groups or cooperatives, as well as vertical integration, should be considered in order to allow for a more effective or equitable distribution of margins. Producer groups or cooperatives enable primary actors to share capital investments, gain bargaining power relative to middlemen, and enforce contracts. By organizing themselves vertically, farmers may benefit not only by cooperating but also by absorbing basic processing services in order to sell higher-valued products on the market.

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126. Ibid.

127. Bhuwon Sthapit, Anil Subedi, Deepak Rijal, Ram Rana, and Devra Jarvis, "Strengthening Community-Based, On-Farm Conservation of Agricultural Biodiversity: Experiences from Nepal" in *Conservation and Sustainable Use of Agricultural Biodiversity*, a sourcebook produced by CIP-UPWARD, in partnership with GTZ GmbH, IDRC of Canada, IPGRI, and SEARICE (2003).

### Maintaining a "niche" market

Strong consumer demand and a relatively efficient marketing chain do not guarantee that we achieve our objective of transmitting a share of the benefits to the poor over time. To avoid pressures toward commoditization and declining prices, indirect restriction of the quantity marketed is necessary to preserve minimum rents for the producers. An example of caper production in Northern Morocco illustrates this point. Encouraged by a growing demand from Europe, many farmers in the same area started to produce capers. The price decreased dramatically, leading to the abandonment of caper fields.[128]

Indirect restriction can be achieved by 1) specifying product characteristics or quality attributes, 2) specifying production process or method used, or 3) linking the product to its area of production (region of origin labeling). Practically, these three mechanisms are enforced if planting is restricted to certain geographical areas, regulations forbidding the cultivation or harvests above a particular scale, or private quality[129] brands and labels (region of origin, traditional process, fair trade, or eco label). Each of these different strategies depends on the support of well-developed institutions, including cooperative arrangements, joint-ventures (NGOs, public or private), legal requirements for distinctness, legal frameworks to ensure access to resources and property rights, grading schemes and quality standards. The institutional organization that maintains the niche market may be able to legally guarantee a share of the rent for primary producers.

These mechanisms and quality certification present certain challenges. Although private and public institutional arrangements of this type have been adopted in most if not all high income countries, they are still rare in low income countries because of their cost and the difficulty of implementing them where quality standards are largely absent. Public certification systems, such as geographical indications, are not always recognized by national law and may be difficult to protect in international trade. Quality certification may also be perceived as a pro-export strategy that does not correspond to the reality of subsistence farming and local markets.

Two types of underutilized plant species will likely require public intervention in addition to market development: 1) underutilized plant species with limited potential private value but very large public value, and 2), underutilized plant species with missing output markets. The first set may be better addressed with direct public intervention such as subsidies to support primary producers in order to avoid under-provision of the product. If there is a general lack of

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128. Giuliani, "Markets for Agrobiodiversity."

129. As compared to standards imposed through public regulations, private quality brands are imposed by chain actors. This often implies greater quality differentials or finer product distinctions.

markets that is not particular to the species, the second set calls for public investments in infrastructure before any specific marketing intervention is feasible.

### Other conditions

While these general conditions are necessary for successful development of NUS value chains, they are not sufficient. Based on a comparison of minor millets and other crops in the Kolli Hills region of Tamil Nadu, India, Gruère et al. show that success required collective action among local users (Box 2).[130] Similarly, in Peru, the International Potato Center (CIP) has advanced a Participatory Market Chain Approach (PMCA).[131] The approach has been applied in the Papa Andina project to identify market opportunities for landraces of native potatoes. The project facilitates contacts between small-scale potato farmers and processing companies. Farmers learn more about market demand with respect to specific traits, quality, quantity, and timing. Processors are able to exploit varieties not previously used. Hellin and Higman found that, in contrast to this approach for native potatoes, quinoa production and consumption in the Andes has been enhanced by government-sponsored initiatives that use quinoa in food-support programs.[132]

Successful supply and demand expansion can have undesirable environmental or health consequences if these are not taken into consideration by producer associations and advocates. A detailed study on quinoa in the Southern Bolivian Altiplano concludes that rapid commercialization based on strong international demand can result in declining local consumption to the detriment of diet quality in the primary producing area, and to environmentally extractive production practices. Located at 3600–4100 masl, the remote communities of the Southern Altiplano have poor soils and extreme temperatures in an arid environment. High rates of migration have led to the loss of capacity to engage in collective action, such as "lamp lighting campaigns" to trap insects and butterflies that lay eggs on quinoa plants. Instead, money from migrants is used to purchase chemical pesticides. While the average household income is higher than in other regions of Bolivia, the diet is deficient in calories, protein, fat, and carbohydrates. Quinoa is very nutritious relative to wheat, maize, and rice. Ironically, development of the value chain has led to increased utilization of

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130. Guillaume Gruère, Latha Nagarajan, and E.D.I. Oliver King, "The Role of Collective Action in the Marketing of Underutilized Plant Species: Lessons from a Case Study on Minor Millets in South India," *Food Policy* (November 2008), doi:10.1016/j.foodpol.2008.10.006.

131. Thomas Bernet, Graham Thiele, and Thomas Zschocke (eds), *Participatory Market Chain Approach (PMCA) User Guide* (Lima: CIP, 2006).

132. Jon Hellin and Sophie Higman, "Crop Diversity and Livelihood Security in the Andes," *Development in Practice* 15 (2, 2005): 165–174.

quinoa by urban communities elsewhere in the world, but to its replacement in the local diet. Quinoa has become a cash monocrop in these communities, with increased use of unsustainable practices such as chemical pesticides, tractors, and disc plows.[133]

**Box 2. Collection action and market linkages for minor millets in Kolli Hills**

Kolli Hills is a mountainous area with a temperate climate located on the eastern border of the Namakkal District in Tamil Nadu, India. Agricultural lands represent 52% of the estimated 28,000 ha, with the remainder heavily forested. Almost all of the estimated 50,000 inhabitants of Kolli Hills are tribals from the Malayali community. Agricultural lands are highly heterogeneous with respect to moisture and topography, comprising valley lands with springs where wetland crops are cultivated, dry or rainfed lands planted to minor millets and cassava, and land on the fringes of the valleys planted to pineapple, coffee, pepper, and other condiments. Kolli Hills is linked to the rest of the district by a single paved road, and many areas of the Hills are still accessible only by foot.

Traditionally the Kolli Hills is known for its genetic diversity in landraces of minor millets, including little millet (*Panicum sumatrence*), finger millet (*Eleucine corocona*), and foxtail millet (*Setaria italica)*. In 1994, the MS Swaminathan Research Foundation began its work in the Kolli Hills with a 3 year appraisal that identified several major issues, including the rapid decline in the production and consumption of minor millets, and the lack of a value chain for minor millets.

To provide market linkages for minor millets, MSSRF promoted self-help groups (SHGs), which are a common type of grassroots institution in India. Task-driven enterprise groups were then formed by local communities around millet marketing and processing, including those with men only, women only, and both men and women, at each node of the supply chain. The basic infrastructure for each enterprise was self-financed, supported via a loan from the MSSRF or linked to an existing government lending scheme. Participation is voluntary and the only condition for entry is that a farmer grows the targeted crop. The enterprises have been brought under a single federated system linked to the Tribal Cooperative Marketing Development Federation of India (TRIFED).

Developing a more effective supply chain involved working with millet productivity, procurement, dehusking and processing, and value addition and packaging before sending the products to retailers. Millet productivity was raised through farmer selection of superior lines of minor millets that were tested in their fields. Because men's selection criteria emphasized agronomic attributes and women's focused on taste and culinary aspects, criteria were pooled in the final selection process. Farmer's

133. Damiana Astudillo, "An Evaluation of the Role of Quinoa in the Livelihoods of the Households in the Southern Bolivian Altiplano: A Case Study in the Municipalities of Salinas and Colcha K" (unpublished manuscript, Bioversity International & Fundación PROINPA, Rome, 2007).

groups then undertook seed selection and multiplication for distribution to other farmers. A women's SHG bore primary responsibility for procuring minor millet harvests from farmers and transporting them in head loads from a radius of 5–6 km to a village assembly point where they were transported by a hired vehicle to the dehusking center for processing. Procurement groups obtained loans to build small storage facilities and drying facilities, improving grain quality. A men's group, responsible for dehusking and processing, obtained a small loan from MSSRF to acquire machinery, and after fulfilling the state government's regulatory requirements, obtained a larger loan to construct the building. The group maintains the capital investment through profits, net of loan repayments. On the supply side, an economic analysis comparing intervention and non-intervention areas has shown that collective efforts of producer groups had a positive impact on minor millet conservation and commerce.[134]

## Risk management

Marginalized farmers bear more risk than other farmers because of the natural environments in which they farm, the costs they incur when they attempt to engage in distant, unreliable markets, and other disadvantages related to their social and economic characteristics. Since many are net consumers, they also bear price risk as purchasers of farm products. Frequently, the weather risks that affect them affect many other farmers in their communities, so that social capital provides inadequate insurance.

Schneider groups and discusses strategies for reducing the negative effects of agricultural risk in terms of those that reduce risk directly and those that enhance farmers' ability to cope with risk. Those that reduce risk directly include those geared to production, such as the introduction of technologies or practices that change yield distributions. Examples of these include the seed and LEIT options discussed in the preceding sections. Mechanisms that directly reduce price risk include direct price controls, such as those imposed by marketing boards or producer cartels. Clearly, these are less pertinent in locations where farmers participate little in markets, or the product scope and turnover in local markets is thin. There, markets don't work well. Farmers and traders lack information or don't have the same information, and the costs of reaching and participating effectively in markets is high. One consequence of price risk among marginalized farmers is under-participation in markets. Producer associations and cooperatives are one way of offsetting the idiosyncratic price risk faced by individual farmers in local markets. Vertically integrated market chains, such as those of high-value export crops and perennials, spread the risk among actors in

134. Gruère, Nagarajan, and King, "Collective Action."

a more controlled fashion, but expose producers to the vicissitudes of international markets.[135]

By contrast, Schneider's second grouping of strategies includes those that enhance the farmers' ability to farm under risky conditions. These include improved ability to respond to risk by aligning cropping decisions to the season's rainfall and market conditions. For example, new information technologies that provide farmers in remote areas with better information on weather and prices improves their ability to capitalize on opportunities and invest optimally.[136] Farmers everywhere are generally on the search for new options. Providing better access to general information, literacy and numeracy, and reinforcing various forms of human and social capital embodied in local institutions, including "bridging capital" that enables linkages outside the community, are ways to enhance the success of their search.

Diversification is another way to enhance farmers' ability to farm under risky conditions. In marginal areas, crop and variety diversification (crop biodiversity), mixed and intercropping, sequential planting, agroforestry, and integrated crop and livestock production are the norm in the major farming systems of marginal areas, although often they are default as compared to optimal strategies. As mentioned above, because they are limited and often non-remunerative, nonfarm opportunities other than long-distance migration are less common in more remote marginalized areas. Public safety net programs that provide work opportunities in times of stress (such as road-building), can ameliorate this situation for households that have surplus, able-bodied labor.

Approaches for enhancing farmers' capacity to bear risk that are gaining increasing interest—productive safety nets to build assets and risk transfer through micro-insurance—are highlighted next.

### Bearing risk better through building assets

Positioning producers to be better able to bear risk generally occurs through savings, access to credit, or safety nets. Safety nets can prevent the onset of shocks, mitigate their impact, and enhance the resilience of farming households through asset-building strategies. Agriculture itself can be socially protecting, as recourse for low-wage laborers, part-time farmers and consumers.[137] Informal

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135. Schneider provides a more thorough discussion of the issues highlighted here. This section mentions those of particular relevance to marginal areas as we have defined them. For more, see Leander Schneider, *Risk and Risk Transfer in Agriculture: Facilitating Food Security and Small Farmer Participation* (internal background document, Oxfam America, Washington, D.C., July 2008).

136. Ibid.

137. Overseas Development Institute, *Linking Social Protection and the Productive Sectors*, ODI Briefing Paper 28 (London: Overseas Development Institute, 2007).

safety nets that involve transfers of cash and food, sharing of labor, and charitable gifts are found in most rural communities. These work best when risks are idiosyncratic (affecting specific households, such as illness or death of a household head) and are often inaccessible to socially excluded groups; they are also beset by the same problems faced by private, commercial insurers—difficulty in contract enforcement and moral hazard.[138]

Common forms of publicly-funded, social safety nets include cash transfers (conditional and unconditional) and public works, although these vary widely in form and objective. According to the World Bank, this variation reflects the fact that households may be exposed to a range of shocks and risks, be they temporary or permanent, idiosyncratic or covariate (affecting communities or countries, such as droughts or shifts in terms of trade), and these may need to be addressed through multiple instruments. In general, they are designed to address, but not fulfill, the needs of three different groups: a) the chronic poor; b) the transient poor; and c) those with special circumstances such as displaced people to people who suffer discrimination.[139]

There is extensive debate about cash vs. in-kind transfers, the pros and cons of different types of targeting,[140] and the relative effectiveness of conditional as compared to non-conditional transfers.[141] While "the argument is all but won for cash transfers," there are still situations and circumstances when food aid is appropriate—such as when markets function poorly.[142] Analyzing a World Bank database on cash transfer programs in Latin America, the Middle East and North Africa, sub-Saharan Africa and South Asia, Coady, Grosh, and Hoddinott found that random selection would have provided more benefits to the poor than the chosen method of targeting. Cash transfer programs were among the 10 best and 10 worst cases of targeting. The authors conclude that the way the program was implemented has a lot to do with whether it works or not.[143] Ellis illustrates the social divisiveness that targeted transfers can create by examining the circumstances of households in the bottom 50 to 60 percent of the consumption

138. Jonathan Morduch and Manohar Sharma, *Strengthening Public Safety Nets*, FCND Discussion Paper 122, Washington, DC: IFPRI, 2001).

139. World Bank, "Overview: What Are Safety Nets Programs?" http://go.worldbank.org/RJP1CF2CM0 (accessed April 4, 2009).

140. Manohar Sharma, "The Effectiveness of Community-Based Targeting and Longer-Term Impacts" (report submitted to World Vision, IFPRI, Washington, D.C, May 2008); David Coady, Margaret Grosh, and John Hoddinott, "Targeting Outcomes Redux," *World Bank Research Observer* 19 (2004a): 61–85.

141. For more, see Alan de Brauw and John Hoddinott, *Must Conditional Cash Transfer Programs Be Conditioned to be Effective?* IFPRI Discussion Paper 757 (Washington, DC: IFPRI, 2007); and John Maluccio and Raphael Flores, *Impact Evaluation of a Conditional Cash Transfer Program: The Nicaraguan Red de Protección Social,* Research Report 141 (Washington, D.C.: IFPRI, 2005).

142. Stephen Devereux, "Livelihood Insecurity and Social Protection: A Re-Emerging Issue in Rural Development," *Development Policy Review* 19 (4, 2001): 507–519.

143. Coady, Grosh, and Hoddinott, "Targeting Outcomes Redux."

distribution, who are very similar with respect to other indicators of well-being.[144]

Adato and Hoddinott conclude that while universal programs are expensive and a big share is destined for those who don't need them, targeted transfers do reach the poor. Deciding who to target and how poses a challenge. They recommend community-based committees, targeting by age or group, and self-selection approaches such as for public works. Program implementation also requires that citizens are made aware of the program, beneficiaries are correctly identified, and that there are effective monitoring and evaluation programs.[145]

Conditional cash transfer programs are most common in Latin America. Mexico's *Oportunidades* program provides transfers conditional on households investing in child nutrition, health, and education. The PROGRESA program in Mexico—intended to encourage greater school attendance by low-income children—provided cash transfers to parents every two months with proof that their children were both enrolled in school and maintained an 85% attendance rate. DeBrauw and Hoddinott found that the effect of conditionality depended on the grade level of the student, with the strongest impact on the enrollment of children making the transition to lower secondary school and no measurable impact on children continuing primary school. The effect was more pronounced among households with literate heads and those employed outside of agriculture.[146]

The Nicaraguan conditional cash transfer program appears to have been more effective. Intending to increase family spending on food, increase primary school enrollment, and improve the health and nutrition of children under 5, the Red de Proteccion Social program provided cash transfers to families whose beneficiaries attended health and education workshops, ensured children under five attended preventative health appointments, and maintained an 85% school attendance rate. According to Maluccio et al., the program decreased the percentage of beneficiaries living in extreme poverty by one-third down to 30%. Beneficiaries on average were able to increase their expenditures by 18% and 40% for the extremely poor. Enrollment for grades one through four increased 18% and overall school attendance increased by 23%. Other noticeable impacts included no evidence of a negative work incentive, decreased child labor by 5% and a dramatic decline in stunting for children under the age of 5. The success of the program is attributed to the classes that promoted longer-term changes in

144. Frank Ellis, "'We Are All Poor Here': Economic Difference, Social Divisiveness, and Targeting Cash Transfers in sub-Saharan Africa" (paper presented at *Social Protection for the Poorest in Africa: Learning from Experience*, Kampala, Uganda, September 8–12, 2008).

145. Michelle Adato and John Hoddinott, *Social Protection: Opportunities for Africa*, IFPRI Policy Brief 5 (September 2008).

146. DeBrauw and Hoddinott, "Conditional Cash Transfer Programs."

health and nutrition behavior and the ability to communicate effectively about the program to participants.[147]

Most reviews find little evidence that these programs have created long-term "productive" benefits, no matter the type of program or the method of targeting. Reviews of PROGRESA and Oportunidades in Mexico, Red de Protection Social in Nicaragua, NGERA in India, the PSNP in Ethiopia (examples of conditional and unconditional cash transfers and public works programs) as well as humanitarian responses after natural disasters in Ethiopia, Bangladesh and Malawi tell the same story—the programs are essential, but long-term "productive" benefits are not readily apparent. Beyond helping the poor to cope with immediate shocks (preventing them from selling off productive assets or reducing food consumption), it was not evident that those reached in these programs were "better" off in terms of income levels, asset endowments, or consumption levels after the initial shock wore off or after participating in the program over a period of time. Measuring these programs with other indicators produced positive results, particularly with respect to some of the conditional cash transfer programs on child and maternal health and school enrollment levels. In the short term, this suggests that these types of safety nets are critical in preventing the poor from getting poorer, but do they help the poor get richer?

Furthermore, the evidence that cash or food transfers reduce chronic poverty is inconclusive. It is even possible that many transfer programs, whether they are conditional or not, have no effect at all on chronic poverty because they cannot help people escape poverty traps. A new type of social protection—"productive" safety nets—seeks to resolve this dilemma. Considering that poor people can become chronically poor by suffering shocks that knock them into a poverty trap or by choosing low-return, risk averse livelihoods that likewise keep them poor indefinitely, social protection programs aim to help poorer farmers take on higher risk, higher return activities by enabling them to maintain or accumulate assets.[148]

While concrete impacts of this approach are not yet proven, several pilots are underway. For instance, DFID and the Government of Kenya are partnering to offer a combination of cash transfers and an insurance-based safety net among pastoralists that is expected to 1) slow further downward spirals into poverty after shocks occur; 2) promote asset accumulation in the face of catastrophic

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147. Maluccio and Flores, Nicaraguan Red de Protección Social.

148. Christopher Barrett, Michael Carter, and Munenobo Ikegami, "Poverty Traps and Social Protection" (working paper, University of Wisconsin, Madison, 2008); Devereux, "Livelihood Insecurity"; Michael Carter and Christopher Barrett, "Asset Thresholds and Social Protection: A 'Think-Piece,'" *IDS Bulletin* 38 (May 2007): 34–29; Stefan Dercon, "Comment on Poverty Traps and Social Protection Policy," *IDS Bulletin* 38 (May 2007): 39–42.

losses; and 3) create an attractive environment for private investors in hopes of generating future growth.[149]

Oxfam America and SwissRe (an multinational insurance company) are also working together to help communities most vulnerable to climate risks. HARITA (Horn of Africa Risk Transfer for Adaptation) is a weather-based crop insurance pilot project designed with and for farmers in the village of Adi Ha in Ethiopia who grow teff, Ethiopia's staple grain. Adi Ha is a drought-prone community that has expressed strong interest in incorporating crop insurance into its risk management strategy. The pilot will adopt a holistic approach to risk management, examining the suitability of weather insurance and risk reduction measures such as seasonal forecasting and improved agricultural practices. All efforts will be undertaken in close collaboration with the local farming community with the overall objective of alleviating poverty.

### Transferring risk

Micro-insurance schemes also serve to transfer the burden of bearing risk from households to financial or insurance markets rather than to poor governments, for whom safety nets are particularly costly.[150] Crop yield insurance is generally thought to be nonviable for farmers in marginal areas because it requires close monitoring, is prone to various types of problems related to self-selection of the insured, and yield risk is spatially covariate. Poor farmers are generally unable and unwilling to pay an actuarial fair premium. Index-based weather risk insurance is one product that has garnered considerable interest as a potentially suitable option for smallholder farmers in developing economies—particularly in semi-arid environments with unreliable rainfall.

The insurance contract is based on the notion that an index can be devised for weather conditions that is both observable and correlates closely with a representative farmer's yield. In return for a premium, the farmer is paid compensation when the weather (rainfall) indicates that crop loss is highly likely. As long as the weather-based index is a good enough proxy for yield, this mode of insurance does not require close monitoring and loss assessment assuming that the weather-index is a good enough proxy for yield levels. In addition, there is an international market where a local provider of weather insurance can re-insure itself.

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149. Christopher Barrett, Michael Carter, Sommarat Chantarat, John McPeak, and Andrew Mude, "Altering Poverty Dynamics with Index Insurance: Northern Kenya's HSNP," *BASIS Brief* (November 2008).

150. Schneider, "Risk and Risk Transfer in Agriculture."

Schneider and Barrett et al. caution that necessary conditions for its success may not be met in any particular context.[151] These include, for the case of rainfed areas: 1) good historical data on rainfall and crop yields; 2) good predictability of future patterns with historical patterns; 3) good correlation between yields and the weather index. The insurance is only as effective as this relationship. In addition, micro-level variability in weather-crop correlations would make a weather-index insurance product difficult to design. How representative is the representative index? Micro-level variation is common in areas with variable soils and altitudes. With respect to data, systems ranging from local weather stations with remote reading to satellite weather and vegetation data are under investigation, and as would be expected, each offers advantages and disadvantages. More importantly, weather-index insurance is not likely to be affordable for most farmers in marginal areas unless it is subsidized or is tied to a technology package that can lead to significant increases in farm income. The insurance protects the cost of improved seeds and fertilizers against important weather risks, and this unlocks credit for their purchase.

What is so attractive about index insurance? First, it is essentially a safety net that protects farmers in poor seasons—substituting for other types of safety nets and a means of providing at least a portion of a public good privately. If farmers prefer other available safety nets, they may have little incentive to purchase micro-insurance. Credit may be purchased more cheaply with insurance or obtained as a package. Barrett et al. suggest that insurance can facilitate greater access of farmers to credit on better terms. There may be substantial synergies between these approaches and efforts to improve input distribution systems for fertilizer and improved seed. Nevertheless, index-based insurance is "but one arrow in the quiver of risk management tools needed for addressing the multiple layers of risk faced by poor people in developing countries."[152]

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151. Schneider, "Risk and Risk Transfer in Agriculture"; Christopher Barrett, Barry Barnett, Michael Carter, Sommarat Chantarat, James Hansen, Andrew Mude, Daniel Osgood, Jerry Skees, Calcum Turvey, and M. Neil Ward, *Poverty Traps and Climate and Weather Risk: Limitations and Opportunities of Index-Based Risk Financing*, IRI Technical Report 07–02 (New York: Columbia University, 2007).

152. Barrett et al., "Limitations and Opportunities" 39.

# Conclusions and policy recommendations

It is a haunting reality that despite the progress of the past century, many of the world's rural people have not yet benefited sufficiently from agricultural growth to cross the poverty line. The interventions of the past—packaged approaches with high-yielding seed varieties, intensive input use and irrigation—are not likely to be useful to many poor farmers today, and particularly those in marginal areas. To engage the poor left behind, investments must include marginalized areas.

The economics debate about whether or not to invest more in marginal areas has been argued from the narrow perspective of a research decision-maker with a fixed budget, and focused on seed-based technical change in the hotspots of the Green Revolution. Although influential, this debate is not relevant for Oxfam. It is now clear that "smart" investments in marginal areas can generate reasonable benefit-cost ratios. More importantly for Oxfam, investing in marginal areas has the potential to benefit many very poor people, create environmental benefits through reducing deforestation and carbon emissions, save biodiversity, and combat land degradation.

Based on Sebastian's mapping, which is supported by comprehensive statistical data and analysis, we have identified through groups of farmers in low and middle income countries, of roughly equal size. One third have benefited from past productivity growth, with relatively good agricultural land and easy access to the opportunities that markets provide. These farmers are not the subject of this paper.

Another third are "neglected by man" but not by nature. These farmers have relatively good land but their ability to exploit its potential is constrained by inadequate access to markets. Public investments in the physical infrastructure of markets are fundamental to remove this constraint, but so are investments in institutions that enable these farmers to participate effectively in markets. Adequate public investment today has the potential to bring these farmers out of poverty relatively soon.

The last third, addressed in this paper, are "neglected by nature." Agricultural technologies that work for these farmers, and their diffusion, typically require substantial investments by farmers themselves. Perhaps the greatest impediment to wider adoption of LEIT technologies is the collective action and farmer knowledge on which their use depends. Public investments in building farmer capacity can support more widespread diffusion. Public investments should also be directed to ensuring that cutting-edge science is applied to solve the practical problems of these farmers.

However, investing in innovative agricultural technologies and decentralized research and extension approaches is probably not sufficient to lead these farmers out of poverty in the longer term. They will need various pathways out of poverty. As in the case of farmers "neglected by man" but not by nature, these pathways will be forged by substantial investments in both basic infrastructure and institutions. There is no single strategy for investing successfully in marginalized areas due to the diversity of their physical environments, the asset endowments of their populations, and in many cases, the social exclusion of certain groups. Only a few agricultural options, such as local seed system development, development of value chains for neglected and underutilized species, and risk mitigation and transfer have been mentioned here. Programs that support nonfarm enterprise development in rural areas and ease exit from agriculture are also needed for these farmers.

# Annex 1. What was the Green Revolution?

The plethora of definitions of the Green Revolution is as varied as the debate over its consequences is protracted. Only a few aspects are treated here.

The principal manifestation of the Green Revolution was the spread of short-strawed, fertilizer-responsive varieties of wheat and rice in the 1960s–70s that led to vast increases of food supplies in many Asian countries.[153] Playing out in ways that varied by country and crop, in the stylized Green Revolution model, carefully subsidized delivery of packages of appropriate, improved varieties of seed, fertilizers, pesticides, and practices augment production through higher yields rather than area expansion, so that scarce land could be put to other crops and uses. Agricultural growth in many Asian countries registered sharp increases as a consequence of widespread adoption of improved seeds, inputs and practices, and associated investments in irrigation, along with public investments in land reform and infrastructure. Without what is now referred to as the Green Revolution, it is generally acknowledged that there would be large food deficits in the world today.

Tripp recalls that the Green Revolution "met its first critics not from the environmentalists, but from those who detected a bias in its beneficiaries."[154] Concern for environmental and health consequences followed. Semi-dwarf rice and wheat varieties diffused rapidly in the irrigated areas to which the approach was initially targeted, and more slowly and incompletely among farmers in rainfed areas. According to Tripp, the farming systems movement was in part a response to recognition that farmers in diverse, risk-prone areas could not take advantage of standardized packages of practices.[155]

If the Green Revolution was more than a technical package, what was its institutional underpinning? The organizational approach to designing and implementing research during the Green Revolution is described by experts who participated as "top-down" and the research agenda "supply-driven." Byerlee and Echeverría explain that until the 1960s, research investment in developing

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153. Tripp, "Self-Sufficient Agriculture."

154. Tripp, "Self-Sufficient Agriculture"; An example is Michael Lipton with Richard Longhurst, *New Seeds and Poor People* (London: Unwin Hyman, 1989).

155. Tripp, "Self-Sufficient Agriculture."

countries was traditionally oriented to cash crops.[156] The Green Revolution gave the impetus for a dramatic expansion in public research systems for major food crops up through the 1980s. Many countries, especially those that had recently obtained independence, consolidated research activities into centralized, national research organizations that tended to be oriented to single commodities, including both food and export crops. National organizations also were backed by a publicly-funded system of international agricultural research centers (the IARCs, or the Consultative Group on International Agricultural Research) that began to be established from the 1960s with a mandate to promote food production in poor countries. Though comprehensive at the time, this institutional model is insufficient to tackle the challenges faced by farmers today—particularly in marginal environments. Participation of other actors, such as universities, for-profit or non-for-profit private organizations—and pointedly, farmers—is needed to design and implement research in these locations.

Djurfeldt et al. conceptualize Asia's Green Revolutions as a predominantly "state-driven, market-mediated and small-farmer based strategy to increase national self-sufficiency." The threat of famine, volatile world grain markets, and the vulnerability of countries to imports led governments who sought self-sufficiency to promote the development of a food-grain commodity chain. Though state-driven, Asian Green Revolutions were mediated by markets, in which private traders were instrumental.[157]

Government interventions are crucial to address market failures in the early phases of developing food staple agriculture from subsistent to market orientation. As conditions change, these interventions become outmoded, fiscally expensive and socially wasteful. The size of India's subsidies is often cited as a case in point; the bill for buffer stocking alone reached $1.6 billion in 2002.[158] In recent years, Asian governments have engaged in a progressive dismantling and reform of foodgrain parastatals to accommodate the economic realities of a more diversified agricultural economy, other sources of agricultural growth, and a burgeoning private sector. Nonetheless, the global food price crisis has caused them to rethink their strategies.

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156. Derek Byerlee and Ruben Echeverría, *Agricultural Research Policy in an Era of Privatization* (Wallingford, UK: CABI Publishing, 2002).

157. Goran Djurfeldt, Hans Holmén, Magnus Jirström, and Rolf Larsson, "African Food Crisis—The Relevance of Asian Experiences" in G. Djurfeldt, H. Holmén, M. Jirström, and R. Larsson (eds.), *The African Food Crisis: Lessons from the Asian Green Revolution* (Wallingford, UK: CABI Publishing, 2005): 3.

158. Shahidur Rashid, Ashok Gulati, and Ralph Cummings, Jr., *From Parastatals to Private Trade: Lessons from Asian Agriculture,* Issue Brief 50 (Washington, DC: IFPRI, 2008).

# Annex 2. Diversifying extension systems: a focus on sub-Saharan Africa

It is widely recognized that extension played an important role in launching the Green Revolution in Asia but provision of extension services still represented a heavy fiscal burden for governments. In spite of extensive literature showing the positive impact of extension on agricultural performance, national and international support for agricultural extension declined over the past few decades, spurred in part by structural adjustment policies of the 1980s and '90s. Once more, there is a shift in thinking about the role of agricultural extension in pro-poor development, but the new challenge is to adapt and diversify extension systems.

From early 1980 to the mid-1990s the Training and Visit (T&V) system was promoted in around 50 countries including some African countries. This was a rather uniform model of managing and providing agricultural extension. T&V was an expensive top-down approach that concentrated on the transfer of scientific agricultural knowledge and technology packages from research institutions to farmers. An important criticism to the system was that heterogeneity across agro-ecological zones was not taken into account, but lack of fiscal sustainability was the most probable reason for its decline. T&V contributed to a widespread perception that agricultural extension was ineffective and inefficient. Even though there have been efforts to replace T&V, the basic scheme still persists in the extension strategy of a number of countries.

Over the last 15 years, national and international support for agricultural extension has declined in sub-Saharan Africa. Under structural adjustment programs, African governments were under pressure to reduce public expenditure and withdraw from commercial activity. However, public extension is a classic public good for which public support is, in principle, justified. Furthermore, studies confirm the high rates of return to public investment in extension services. Second, the loss in confidence in the Training and Visit extension system left an intellectual vacuum. In the absence of a promising alternative model, interest in extension by national governments and donor agencies declined.

Being asked to do more with less contributed to the diversification of agricultural extension services during the 1990s, along with decentralization of public services, market liberalization, and democratization of political processes. Combined with reduced public funding for research and development and increasing inability of governments to fund extension, other pressures for change include broadening of the research agenda to emphasize non-traditional areas, increased requirements for accountability and priority setting processes, and the development of mass media technology.

Increasingly, countries are experimenting with privatization of extension activities and extension commercialization. Some authors argue that the traditional linear transfer of technology model failed and there was a need for a more efficient extension system. Higher quality and greater efficiency are usually considered to be the main advantages of including private participation in the extension system. This higher efficiency is the expected result of increasing incentives for information exchange in the technology generation and delivery. Adoption rates of new practices are expected to increase since farmers have a direct say in the subjects addressed. Another important advantage is the change in the relationship between extension agents and farmers. Cost sharing among clients increases accountability, empowerment, and ownership of the technology, project or activity.

Disadvantages cited for including private participation in the extension system include the fact that the sustainability of a number of cases reviewed for sub-Saharan Africa still depends on donor support. Introduction of financial participation or cost recovery activities does not necessarily translate into reduced extension costs. Private extension does not necessarily reduce the public role. Thus, paid extension does not guarantee fiscal sustainability. Further, paid extension is not an idea that can easily be sold to poor, risk-averse farmers. Literature on farmers' willingness and capacity to pay for extension services remains scant, and existing evidence suggests that it is limited. Companies, NGOs, and farmers' associations can provide or finance the extension service and a number of examples prove that such arrangements can work for African countries.

While the changes in the agricultural scenario have induced a diversification of the institutional arrangements to finance and provide extension or advisory services, private extension has been a rather small component of overall reform packages in sub-Saharan Africa. A few countries have advanced in reforming and introducing private components to the extension service. In 1998 in Uganda the directorate of extension at the ministry of agriculture was abolished. Support and backstopping of extension was transferred to the national agricultural research organization. Extension became a responsibility of the districts. The central government currently pays the salaries of existing extension staff and local governments pay new extension agents**.** Local governments also pay operational expenses. In the long term it is expected that the service providers will be private, and the local government will give service mandates to them. Since 1991 Mali has been engaged in privatizing, decentralizing and restructuring its agricultural services. In both cases a number of public-private partnerships including the participation of NGOs have developed.

In other African countries, some private components have been introduced in agricultural extension. In general, institutional arrangements that increase participation of farmers and farmers' associations in demanding or financing extension via contracts or other instruments (cases of Guinea, Kenya, Uganda, Central African Republic, etc.) empower actors as they learn to decide which extension services are important to them and to manage community funds. Still, the extension program needs to provide assistance in developing proposals since the communities may have difficulties in demanding good quality services from consultants (Madagascar, South Africa).

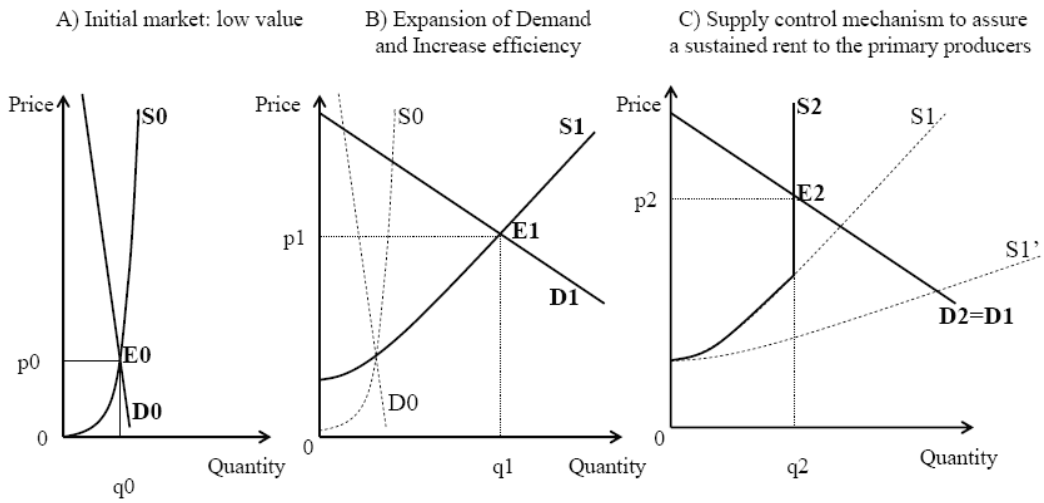
In countries where private participation or fee for service has been implemented, a common problem cited is the excludability of potential users who are unable to pay for the services. Cases in Zimbabwe and the Central African Republic show that providing services through farmer organizations has helped to address this issue. Another criticism of private participation is that extension services with ecological and social benefits could have lower demand. However, there are reported cases with contracting to promote environmental service (Madagascar). The public sector then has a role in addressing neglected populations and prioritizing social benefits over economic ones.

# Annex 3. Graphical depiction of three necessary conditions for market development of NUS

The present value of the crop can be defined by a market equilibrium with low quantity and price. Panel A in Figure 2 shows the initial market equilibrium E0 (p0, q0) at the intersection of the demand (D0) and supply (S0) curves. Panel B shows the result of two mechanisms (corresponding to necessary conditions 1 and 2). The first mechanism is demand expansion, which relates to increasing the market opportunity of the crops. The second is increased efficiency of production and marketing systems. These two steps lead to an outward rotation of the demand and supply curves, from D0 to D1 and S0 to S1. The market reaches a new equilibrium E1 with a higher price and quantity (p1, q1).

Increasing the value of the crop provides an incentive for the entry of large scale investments, which may drive a process of commoditization. Efficiency is greater with commoditization and prices are lower, but there are also lower margins and fewer incentives for the poor to produce. To generate a sustainable rent for the poor, some type of supply control is required. Panel C in Figure 2 shows the new supply curve S1 with a kink at the level of the supply control (q2). The price rises from p1 to p2. Supply control generates a rent to producers that largely exceeds that obtained through commoditization. In a commoditization process, the equilibrium is represented by the intersection of D2 with supply curve S1' (Panel C). Next, necessary conditions are explained in greater detail.

**Figure 2. Market development for underutilized species: three necessary conditions**




Source: Gruère, Giuliani, and Smale (2008).

# Annex 4. Organizing investments in marginal areas

How can these investment options be funded when public funds are scarce and corporate interests in marginal areas are limited? Many have advocated public-private partnerships as a solution, and farmer-funded research is also feasible under some circumstances. Some institutional arrangements are discussed in this section.

## Blending private and public investments

The balance sheet concerning partnerships between multinational companies and public sector research organizations has been mixed, however. While there is considered to be much potential, Byerlee and Echeverría concluded that these will be slow to emerge even in mature research systems and may depend on reform of the public sector to emphasize results and ensure flexibility. Potential is far less in marginal areas.[159]

Unfortunately, the cases reviewed by these authors also provide the "overall impression that public sector reform has not lived up to expectations in increasing budgets and institutional performance."[160] Commercializing of products to generate funds must be done in ways that do not distort public mission. Public leadership must be strong. Incentive systems for scientists must be restructured. Competitive funding mechanisms are recommended.

In Bangladesh, Ahmed and Karim report that one potentially beneficial innovation has been to extract the financing mechanism for agricultural research from the budgetary process, by establishing an autonomous foundation or trust fund. A trust fund of this type could depend on public resources, private resources, or some combination. Autonomy enables scientists "to pursue research activities according to a long-term research plan, avoiding the vicissitudes of annual budgetary allocations and cumbersome financial approvals required by current mechanisms."[161] Stimulating private investment was the objective of the creation of the Colombian Corporation for Agricultural

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159. Byerlee and Echeverría, *Agricultural Research Policy in an Era of Privatization*.

160. Ibid.

161. Raisuddin Ahmed and Zahurul Karim, "Bangladesh: Uncertain Prospects," Chapter 6 in P.G. Pardey, J.M. Alston, and R. R. Piggott (eds.), *Agricultural R&D in the Developing World: Too Little, Too Late?* (Washington, D.C.: IFPRI, 2006): 251.

Research (CORPOICA) in 1993, where the public agricultural research system underwent a major reform. CORPOICA's progress has been thwarted in large part by a deteriorating national situation.[162] The demand for private research innovations is growing primarily in higher-value agricultural products such as meats, fruits, and vegetables,[163] and, other than in maize, remains limited by low commodity prices in most major foodgrains. In general, governments can stimulate private investment through more effective intellectual property rights legislation, removal of unnecessary controls on direct foreign investment, greater transparency and stability in regulations that affect foreign investors, tax exemptions on research expenditures and venture capital, and more liberal policies on the importation of research equipment.[164]

Still, public funding of agricultural research will continue to be crucial to support research on certain public goods, and especially research oriented toward broader social objectives such as increasing smallholder productivity and protecting the environment.[165] Any expansion in the relative importance of private funding, or public-private partnerships in the provision of agricultural R&D, will be for technologies associated with inputs used in farming (such as chemicals, seeds, and machines), as has been the case in India, or with off-farm processes.[166]

Neglected and underutilized species, natural resource conservation, reduction of chronic poverty and mitigation of systemic (as compared to idiosyncratic risk) are examples of quintessentially public sector products. Reduction of chronic poverty and mitigation of systemic risk are goods with public attributes. Involvement of large private companies in marginal areas is unlikely given the scale and poverty of the client base and the crops grown, which will not in general be profitable for them.

Many countries are pursuing decentralized strategies to make public services more client-oriented. Pluralistic systems, involving universities, the private sector, farmer organizations, and non-governmental organizations can reduce costs and allow specific scientific research and extension skills to be tapped.

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162. Nienke Beintema, Luis Romano, and Philip Pardey, "Colombia: A Public-Private Partnership," Chapter 11 in P.G. Pardey, J.M. Alston, and R. R. Piggott (eds.), *Agricultural R&D in the Developing World: Too Little, Too Late?* (Washington, D.C.: IFPRI, 2006).

163. Carl Pray, "The Growing Role of the Private Sector in Agricultural Research," Chapter 2 in D. Byerlee and R. Echeverría (eds.), *Agricultural Research Policy in an Era of Privatization* (Wallingford, UK: CABI Publishing, 2002).

164. Philip Pardey, Julian Alston, and Roley Piggott (eds.), *Agricultural R&D in the Developing World: Too Little, Too Late?* (Washington, D.C.: IFPRI, 2006).

165. Byerlee, Alex, and Echeverría, *Agricultural Research Policy in an Era of Privatization*.

166. Philip Pardey, Julian Alston, and Roley Piggott (eds.), *Agricultural R&D in the Developing World: Too Little, Too Late?* (Washington, D.C.: IFPRI, 2006).

These types of systems make a lot sense for the location-specific, farmer-centered technologies discussed in this paper.

Governments can spearhead efforts to establish pluralistic research consortia, and support regional models that bolster national capacity and take advantage of similar constraints and common problems.[167] As the spillovers from rich-country agricultural research and development become less relevant to poor country needs, Pardey, Alston, and Piggott advocate that the IARCs return to the basic objective of supplying technologies to boost staple food, supporting international research spillovers among poorer nations, and contributing to the continued strengthening of agricultural research capacity. Finally, they say, "another role for poor-country governments and others who care will be to remind rich people in developed countries that they can and should do more to help poor people in developing countries feed themselves."[168]

## Private funding of research by farmers

Colonial companies and governments used taxes on export commodities to fund research. Today's examples of farmer-funded research are organized through producer associations who pay a levy proportional to production in return for a voice in establishing the research agenda. This institutional organization is viewed by some as a relatively equitable, client-oriented system which can empower farmers—including smallholders.[169] Compared to developed countries, developing countries make relatively less use of these approaches.[170]

Research on export crops in many East African countries has been financed by the producers themselves, although the mechanisms for collecting revenues and shares vary among countries and commodities. Significant shares of coffee, tea, cotton, tobacco, cashew, and sugarcane research are financed this way in Tanzania and Kenya, and to a lesser extent, Uganda, according to Beintema and Stads. Kangasniemi adds the case of Zimbabwe.[171]

Against the claim that these systems favor large farmers at the expense of small-holders, Kangasniemi argues that where the performance of the public sector is

167. Ibid.

168. Ibid.

169. Jaakko Kangasniemi, "Financing Agricultural Research by Producers' Organizations," Chapter 5 in D. Byerlee and R. Echeverría (eds.), *Agricultural Research Policy in an Era of Privatization* (Wallingford, UK: CABI Publishing, 2002).

170. Pardey, Alston, and Piggott, *Too Little, Too Late?*

171. Neinke Beintema and Jan-Gert Stads, *Agricultural R&D in Sub-Saharan Africa: An Era of Stagnation*, ASTI Background Report (Washington, D.C.: IFPRI, 2006); Kangasniemi, "Financing Agricultural Research by Producers' Organizations."

poor, constraints are similar for all producers. Historically, the public sector has often exhibited the same biases. Often, larger-scale players have a vested financial interest in ensuring that technologies reach smallholders and the industry as a whole is productive—and the implicit threat of government takeover can reinforce this situation.[172]

Other examples explored by Byerlee and Echeverría and Pardey, Alston, and Piggott include Colombia.[173] Colombia is an exception in Latin America, where general government revenues are still the predominant source of support for agricultural research.[174] In 2000, 12 nonprofit organizations accounted for about a quarter of the country's agricultural research investments—many linked to producer organizations and funded through levies. These include crops like rice and cereals, in addition to cocoa, flowers, and cotton.

Byerlee and Echeverría describe the principles and scope of the approach. First, it is most suitable for commodities that pass through a narrow, well-integrated market chain—such as traditional export commodities (tea, coffee, cotton) or horticultural crops. The approach is also feasible for staple food crops as long as the market channel is narrow and well-integrated, as in the case of some parastatal organizations such as those for maize in the high-potential areas of Kenya and wheat in India.[175] Private funding of research through a levy system is considered to be inappropriate for crops primarily consumed on farms (non-tradables) or marketed through many dispersed smallholder farmers in local markets, as is likely to be the case in most marginal areas where market infrastructure is sparse. This would be the case for food staple production in marginal areas where markets do not function well. In less-favored areas, the approach might be considered in the case of high-value specialty crops with a strong export market niche, such as quinoa.[176]

A levy of 0.4–0.5% of production value is common among the cases in the volume edited Byerlee and Echeverría. In richer countries, the government often makes a matching grant and has representation along with farmers on the board. Institutional models differ among the cases. Levies have been used to fund a commodity research station, as a private entity (Colombia, Zimbabwe) or parastatal, or to fund the national research institute (Uruguay).[177]

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172. Kangasniemi, "Financing Agricultural Research by Producers' Organizations."

173. Byerlee and Echeverría, *Agricultural Research Policy in an Era of Privatization*; Pardey, Alston, and Piggott, *Too Little, Too Late?*

174. Beintema, Romano, and Pardey, "Colombia: A Public-Private Partnership."

175. Derek Byerlee, personal communication with this paper's primary author, January 22, 2009.

176. Byerlee and Echeverría, *Agricultural Research Policy in an Era of Privatization*.

177. Ibid.

Authors of this collection of studies compare farmer financing and governance favorably with public research organizations, noting quicker response to new pest outbreaks, and better uptake of improved seed, IPM, and processing technology. These organizations suffer from social, political and economic disruptions as much as do public organizations, however. They draw the following lessons: 1) the success of the producer levy system depends on the strength and broad-based representation of the farmer's associations that govern it; 2) the levy should be backed by enabling legislation and dedicated to research and development so that it is not diverted to other uses, such as market promotion and political lobbying; 3) research organizations funded by levies need to have autonomy from government; 4) industry and/or government can lend valuable support in matching funds and especially in meeting initial start-up costs, which may be high; 5) government matching funds help ensure that broader social objectives are met, such as those related to equity and environmental protection.[178]

178. Ibid.

# Technical annex

## Mapping favorability for agriculture in low and middle income countries: technical report, maps and statistical tables

Kate Sebastian, 2009

### Introduction

Often agricultural investments are targeted based on national or sub-national units with little attention given to the biophysical characteristics of the area in question. While country groupings are important in understanding the context, both political and cultural, within which policies are implemented, they do not help researchers and policy makers understand the biophysical characteristics or constraints that may vary within these political units. Thus, to fully explore opportunities in agriculture, scientists and policy makers must move beyond analyses based solely on country groupings and towards a better understanding of agriculture-environmental linkages and the implications that these have on farmers and overall productivity.

To help understand this link between agriculture and the environment we have used spatially referenced data to define the extent of rainfed and irrigated croplands and pasture/grazing lands (Ramunkutty 2008). We have further divided the rainfed areas into favored and less favored (FA & LFA, respectively) areas based on climatic and terrain conditions. This process resulted in three categories of agricultural-environmental location:

- **Irrigated Agriculture (IA)** defined as cropland and managed pasture with 10% or greater area equipped for irrigation
- **Favored Areas (FA)** defined as rainfed cropland and pasture/grazing lands with a length of growing period (LGP) of 150 days or more per year and terrain favorable for agriculture

- **Less Favored Areas (LFA)** defined as rainfed cropland and pasture/grazing lands with an LGP of less than 150 days or terrain not favorable for agriculture.

With a focus primarily on poorer populations it was important to include an economic measure in our typology. To that end, the area was also divided by income level using the World Bank's income groupings from the 2008 World Development Report (WDR: World Bank 2008).

The resulting typology consisted of 15 distinct classes: 5 income groups intersected with 3 favorability classes. Details on these classes and how they were derived follow.

## Typology definition

### Income level characterization

The focus of the Oxfam work is primarily on poorer nations and thus it was important to differentiate countries in this manner. The World Bank's income groups were used to isolate middle to low income countries. A listing of the countries and their respective income groups is located in Appendix A. The classification of economies includes all World Bank member countries plus all other countries with populations of more than 30,000. As is evident from the list there are some countries, primarily small islands, which are not included in the World Bank's income groups due to their size in terms of population. In the tables these are included as a line item called "miscellaneous islands."

The countries are divided into income groups based on 2006 Gross National Income (GNI) per capita. The groups are:

| | |
|---|---|
| Low income | $905 or less |
| Lower middle income | $906 – $3,595 |
| Upper middle income | $3,596 – $11,115 |
| High income | $11,116 |

For many of the tables in this report a summary of the Low to Middle income groups was provided. Country level details are not provided for the High income group.

## Biophysical characterization

### *Defining favorability*

Agricultural areas were first identified as either irrigated or rainfed. The rainfed areas were subsequently divided in favored or less favored areas. Less Favored Areas (LFAs) are defined as those that have been less favored by humans as well as by nature (FAO 2002). They are areas where agriculture occurs but within the constraints of low potential for growth due to limited moisture and unsuitable terrains. Most LFAs are steep or mountainous regions or drier areas with short growing seasons.

FAO incorporates market accessibility into their definition of favorability in order to capture the effect that socioeconomic constraints can have on agricultural potential. For this study we use only biophysical factors and income levels to create the characterizing typology but report statistics on market accessibility and population (rural and urban) distribution to better understand the human element. We also report on land cover and total and agricultural land area within the specific income groups and favorability classes.

The final typology of favored versus less favored agricultural lands was based on four input data layers: the extent of agriculture, areas equipped for irrigation, the length of growing period (LGP), and terrain. These are defined in more detail below.

### *Extent of agriculture*

Since this research focuses on identifying where the world's poorer farmers are located, it is important that the area of study is limited to those areas that fall within the extent of farming and other agricultural activities (e.g. grazing). For this study, the extent of agriculture is defined using 10x10 kilometer satellite derived land cover data from the MODIS sensor for the year 2000 (Ramunkutty et al. 2008). Ramunkutty's cropland and grazing land surfaces report the area intensity of agriculture within each cell with the shares ranging from 0–1 (representing 0–100%) with 0 meaning no cropping or grazing and 1 meaning full cropping or grazing. Using these data we identified as agricultural any cell that has potential for plant growth *and* has 10% or greater cropland or grazing land. Areas with potential for growth are any area with a length of growing period (LGP) of greater than zero days (FAO/IIASA 2001). This eliminated desert areas that may be categorized as extensive grazing but do not have other agricultural potential. It is important to note that the extent is not a measure of suitability as there are many areas under cultivation that are not the most suitable and there are potentially other suitable areas in terms of productivity that fall in regions that do not fall within the extent of agriculture. This definition of the global extent of agriculture provided the outer boundaries of the region of focus in terms of biophysical characteristics.

### *Irrigated areas*

The area within the global extent of agriculture was then identified as either irrigated or rainfed. By default, all areas were considered rainfed and the Global Map of Irrigated Areas (GMIAv4.0.1: Siebert et al. 2007) was used to reclassify cells as irrigated. This dataset is available at a resolution of 0.0833dd (approximately 10x10 km at the equator). Any cells with 10% or greater areas equipped for irrigation were classified as irrigated.

The rainfed areas were further divided into Favored Areas (FA) and Less Favored Areas (LFA) using data on length of growing period and terrain.

### *Length of growing period*

The length of growing period is defined as the period of time during the year when average temperatures are conducive to crop growth (mean temperature >=5o C) and precipitation plus moisture stored in the soil exceed half the potential evapotranspiration (P > 0.5PET). A normal growing period is defined as one with a period when there is an excess of precipitation over PET (i.e. a humid period). Such a period meets the full evapotranspiration demands of crops and replenishes the moisture deficit of the soil profile (FAO 1978). For this study it was decided that a growing period of greater than or equal to 150 days provides a more favorable environment for crop growth. This includes all sub-humid and humid moisture zones and a portion of the semi-arid moisture zone. Any area with a growing period of zero days had previously been eliminated in defining the extent of agriculture. The length of growing period criteria was thus:

| | |
|---|---|
| 0 | area eliminated |
| <150 days | area less favored for agricultural production |
| >=150 days | area favored for agricultural production |

### *Terrain*

Slope is often considered a factor in deciding whether areas are suitable for agriculture, with steeper areas falling into the less favorable category. But this criteria is limiting as it identifies all steep areas as less favorable and flatter areas as favorable when it is known that there are steep areas where farmers are very productive and there are high altitude flatter areas where there is little or no agricultural activity. In lieu of slope, we thus chose to use a terrain surface to help define favorability. The terrain surface identifies classes based on relief and roughness. It was developed at a resolution of 0.0833dd (approximately 10x10km at the equator) and is based on both elevation and slope data (Nelson 2004) using an algorithm developed by Meybeck et al. (2001). For this study, terrain identified as more suitable for cultivation includes: plains, lowlands, and low to mid-altitude plateaus and mountains; terrain less suitable for cultivation includes high altitude plains, hills and rugged lowlands, and high altitude plateaus or mountains.

***Note on soil fertility***

Although soil fertility is highly correlated with terrain and length of growing period, we were unable to incorporate more precise information on soil quality into the definition. The soil data that is available at the global scale is not very reliable and it was too difficult to identify one quality variable that would serve as a global indicator of favorability. The indicators we use have the same implications globally. Since this work was completed, FAO has released an updated and much improved soil database, the HWSDv1.1 (harmonized world soil database). However, the algorithms related to fertility constraints in this database have not yet been applied to these data and are thus not yet available for analysis.

Figure 1 provides a map of the resulting Favorability Index. The data are at a resolution of 0.0833dd or approximately 10x10km$^2$.

## Overlays and statistical tables

For reporting purposes the favorability surface was combined with the income group surface to create a combined typology layer at a resolution of 10x10km. We overlaid this typology layer with a series of spatial datasets in order to generate reports on: land area, population distribution, market access, and land cover within typology classes. Below is a list of the resulting tables included as an addendum to this report. The list includes notes where necessary describing the input data and the overlay process.

***Table 1. Land Area by favorability index and income groups***

***Table 1a. Land area by favorability index and income groups—with country breakdown***

> Process: Favorability and income group typology classes (from here on referred to as "Typology classes") summarized using global land area data (CIESIN/IFPRI/CIAT 2004) at a resolution of 0.008333dd (approximately 1x1km). The area reported here is TOTAL land area with

a breakout by favorability class for the area within the extent of agriculture. The subsequent tables provide country level details for all low to middle income countries.

***Table 2. Total and rural population summarized by favorability index and income groups***

***Table 2a. Total population by favorability index and income groups—with country breakdown***

***Table 2b. Rural population by favorability index and income groups—with country breakdown***

***Table 2c. Urban population by favorability index and income groups—with country breakdown***

Process: Typology classes summarized using global rural & urban population data (CIESIN/IFPRI/CIAT 2004) at a resolution of 0.008333dd (approximately 1x1km). The total population is a sum of the results of the rural and urban population overlays. The first table provides a summary by income group for the total population and the rural population. Breakouts are provided by favorability class for the areas within the extent of agriculture. The subsequent tables provide country level details for all low to middle income countries.

***Table 3. Agricultural area by income group, favorability index & market accessibility***

Process: Typology classes combined with market access classes at a resolution of 0.0833dd (approximately 10x10km) and summarized using global land area data (CIESIN/IFPRI/CIAT 2004) at a resolution of 0.008333dd (approximately 1x1km).

### Market accessibility

The market accessibility data measures in hours the amount of time to the nearest market town. A cost distance function was used to measure the "cost" to the nearest market in minutes/hours for each 1km pixel based on a number of input variables. The input variables were: roads; markets/towns; elevation; slope; boundaries & landcover. Each of these (except the markets) was converted to a value representing the time it takes to travel 1km. For example good roads are given a value of 60km/hr and really bad roads 15km/hr with other values in between. Land cover was used to assign a rate of travel for urban areas and water bodies. Using elevation data all areas over 5000m were deemed inaccessible. Slope was reclassified into 3 groups (steep:>10 degrees; moderate: 6–10 degrees; flat: <6 degrees) and multiplied against roads to make travel over steep roads slower. Border crossings were given a wait time of 1 hour. Markets were defined as any human settlement with 50,000 or greater inhabitants. The dataset is global at a resolution of 0.00833dd or approximately 1x1km (Nelson 2008).

For the purposes of this study the market access data were classified as follows:

| | |
|---|---|
| High | 0–2 hours |
| Medium | 2–4 hours |
| Low | 4–8 hours |
| Remote | >8 hours |

*Note: It is recognized that this classification is a generalization applied to all regions of study and that if examined on a regional basis the thresholds for each class may vary. These cutoffs were developed primarily with Sub-Saharan Africa in mind (HarvestChoice 2009).*

***Table 4. Rural population by income group, favorability index & market accessibility***

Process: Typology classes combined with market access classes at a resolution of 0.0833dd (approximately 10x10km) and summarized using global rural population data (CIESIN/IFPRI/CIAT 2004) at a resolution of 0.008333dd (approximately 1x1km).

*Note: see above for details on market access data.*

***Table 5. Total land area by income group and land cover class***

Process: Income classes combined with aggregated land cover classes at a resolution of 0.0833dd (approximately 1x1km) and summarized using global land area data (CIESIN/IFPRI/CIAT 2004).

***Table 6. Distribution of agricultural areas by favorability and land cover class for low to middle income populations***

Process: Typology combined with aggregated land cover classes at a resolution of 0.0833dd (approximately 1x1km) and summarized using global land area data (CIESIN/IFPRI/CIAT 2004).

### Land cover data:

The land cover data are derived from classification of a MERIS FR time series satellite for the period December 2004 to June 2006 at a resolution of 0.00277dd (approximately 30x30m). The original data is presented with 22 land cover classes defined with the UN Land Cover Classification System (LCCS) (Bicheron et al. 2008). For the purposes of this study these 22 classes were aggregated into 13 classes placing less emphasis on the varieties of natural land cover and more emphasis on the agricultural classes. These classes and their relationship to the UN classes are outlined in Appendix B.

*Note: Because these data are based on data from different dates (2004–06 versus 2000), different satellites, and different classification processes than the MODIS data, employed by Ramunkutty to define cropping and grazing lands, it is difficult to compare the agricultural areas of the two. For this reason Table 5 represents* ***total*** *land area by income and land cover classes and does not break the income groups out into the agricultural favorability classes. On the other hand Table 6 looks only at the land cover class distribution* ***for the areas that fall within the extent of agriculture*** *as defined using the Ramunkutty data for the low to middle income groups. Again it is important to note the different methodologies and data sources used for the various land cover datasets and use the data in these tables with caution. It is for this reason that only the share distribution is reported in Table 6 and not the absolute area for each cell.*

# Appendix

## Table 1. Land area by favorability index & income groups

| Income group / country | Total land area | | | Area within the extent of agriculture by favorability index | | | Area distribution within the extent of agriculture by favorability index | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Grand total | Outside the extent of agriculture | Within the extent of agriculture | Irrigated areas | Favored areas | Less-favored areas | Irrigated areas | Favored areas | Less-favored areas | Grand total |
| | area - 000 square kilometers | | | | | | share of agricultural land (percent) | | | |
| **High income** | **33,558** | **22,565** | **10,993** | **1,409** | **3,587** | **5,997** | **12.8** | **32.6** | **54.5** | **100.0** |
| High income - OECD | 30,713 | 19,846 | 10,867 | 1,321 | 3,574 | 5,971 | 12.2 | 32.9 | 55.0 | 100.0 |
| High income - Other | 2,845 | 2,719 | 126 | 88 | 13 | 25 | 69.7 | 10.3 | 20.1 | 100.0 |
| **Low to middle income** | **96,879** | **49,371** | **47,508** | **5,578** | **16,789** | **25,141** | **11.7** | **35.3** | **52.9** | **100.0** |
| Low income | 21,997 | 10,901 | 11,096 | 868 | 4,309 | 5,919 | 7.8 | 38.8 | 53.3 | 100.0 |
| Lower middle income | 45,469 | 18,572 | 26,898 | 4,087 | 8,650 | 14,161 | 15.2 | 32.2 | 52.6 | 100.0 |
| Upper middle income | 29,413 | 19,899 | 9,515 | 623 | 3,830 | 5,062 | 6.6 | 40.3 | 53.2 | 100.0 |
| Misc island nations | 74 | 74 | 0 | 0 | - | - | | | | |
| **Total** | **130,512** | **72,010** | **58,502** | **6,987** | **20,377** | **31,138** | **11.9** | **34.8** | **53.2** | **100.0** |
| *Percent of total land* | *100.0* | *55.2* | *44.8* | *5.4* | *15.6* | *23.9* | | | | |

Source: Country groupings per World Bank data (World Bank 2008); extent of agriculture and favorability index land area (CIESIN/IFPRI/CIAT 2008) (Sebastian 2009);

## Table 1b. Land area by favorability index & country/income groups

| Income group / country | Total land area | | | Area within the extent of agriculture by favorability index | | | Area distribution within the extent of agriculture by favorability index | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Grand total | Outside the extent of agriculture | Within the extent of agriculture | Irrigated areas | Favored areas | Less-favored areas | Irrigated areas | Favored areas | Less-favored areas | Grand total |
| | area - 000 square kilometers | | | | | | share of agricultural land (percent) | | | |
| High income - OECD | 30,713 | 19,846 | 10,867 | 1,321 | 3,574 | 5,971 | 12.2 | 32.9 | 55.0 | 100.0 |
| High income - Other | 2,845 | 2,719 | 126 | 88 | 13 | 25 | 69.7 | 10.3 | 20.1 | 100.0 |
| **Low income** | **21,997** | **10,901** | **11,096** | **868** | **4,309** | **5,919** | **7.8** | **38.8** | **53.3** | **100.0** |
| Afghanistan | 635 | 161 | 475 | 81 | 2 | 392 | 17.0 | 0.3 | 82.6 | 100.0 |
| Bangladesh | 135 | 6 | 129 | 98 | 24 | 8 | 75.4 | 18.8 | 5.8 | 100.0 |
| Benin | 118 | 37 | 81 | 0 | 69 | 12 | 0.3 | 85.4 | 14.3 | 100.0 |
| Bhutan | 39 | 28 | 12 | 1 | 2 | 9 | 5.9 | 14.0 | 80.1 | 100.0 |
| Burkina Faso | 271 | 22 | 249 | 1 | 79 | 169 | 0.2 | 31.9 | 67.9 | 100.0 |
| Burundi | 25 | 5 | 20 | 1 | 18 | 2 | 2.5 | 89.8 | 7.6 | 100.0 |
| Cambodia | 178 | 56 | 122 | 9 | 81 | 32 | 7.3 | 66.5 | 26.2 | 100.0 |
| Central African Republic | 620 | 515 | 105 | 0 | 87 | 19 | 0.0 | 82.2 | 17.8 | 100.0 |
| Chad | 1,243 | 665 | 578 | 0 | 141 | 437 | 0.1 | 24.4 | 75.6 | 100.0 |
| Congo | 346 | 283 | 63 | 0 | 44 | 19 | 0.0 | 69.6 | 30.4 | 100.0 |
| Eritrea | 121 | 49 | 72 | 0 | 0 | 72 | 0.2 | 0.0 | 99.8 | 100.0 |
| Ethiopia | 1,122 | 446 | 676 | 8 | 136 | 531 | 1.2 | 20.1 | 78.6 | 100.0 |
| Gambia, The | 11 | 0 | 10 | 0 | 2 | 8 | 0.0 | 21.0 | 79.0 | 100.0 |
| Ghana | 226 | 35 | 191 | 0 | 150 | 41 | 0.1 | 78.3 | 21.6 | 100.0 |
| Guinea | 247 | 102 | 145 | 3 | 98 | 45 | 1.8 | 67.4 | 30.8 | 100.0 |
| Guinea-Bissau | 34 | 7 | 27 | 0 | 25 | 2 | 0.9 | 91.3 | 7.8 | 100.0 |
| Haiti | 27 | 0 | 27 | 3 | 8 | 15 | 10.1 | 31.8 | 58.1 | 100.0 |
| Ivory Coast | 321 | 75 | 246 | 1 | 203 | 42 | 0.6 | 82.5 | 16.9 | 100.0 |
| Kenya | 570 | 160 | 410 | 3 | 67 | 340 | 0.7 | 16.2 | 83.0 | 100.0 |
| Kyrgyzstan | 187 | 2 | 185 | 28 | 0 | 156 | 15.2 | 0.0 | 84.8 | 100.0 |
| Laos | 228 | 182 | 46 | 7 | 23 | 16 | 15.5 | 49.4 | 35.1 | 100.0 |

| Income group / country | Total land area: Grand total | Total land area: Outside the extent of agriculture | Total land area: Within the extent of agriculture | Area within the extent of agriculture by favorability index: Irrigated areas | Area within the extent of agriculture by favorability index: Favored areas | Area within the extent of agriculture by favorability index: Less-favored areas | Area distribution within the extent of agriculture by favorability index: Irrigated areas | Area distribution within the extent of agriculture by favorability index: Favored areas | Area distribution within the extent of agriculture by favorability index: Less-favored areas | Area distribution within the extent of agriculture by favorability index: Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | area - 000 square kilometers | | | | | | share of agricultural land (percent) | | | |
| Liberia | 96 | 87 | 9 | 0 | 8 | 1 | 0.0 | 89.3 | 10.7 | 100.0 |
| Madagascar | 593 | 145 | 447 | 25 | 226 | 196 | 5.6 | 50.5 | 43.9 | 100.0 |
| Malawi | 97 | 34 | 63 | 1 | 52 | 9 | 2.4 | 83.2 | 14.5 | 100.0 |
| Mali | 1,249 | 783 | 466 | 8 | 69 | 389 | 1.8 | 14.7 | 83.5 | 100.0 |
| Mauritania | 1,039 | 868 | 171 | 1 | 0 | 170 | 0.5 | 0.0 | 99.5 | 100.0 |
| Mozambique | 775 | 139 | 635 | 3 | 377 | 255 | 0.4 | 59.4 | 40.2 | 100.0 |
| Myanmar (Burma) | 671 | 386 | 286 | 58 | 119 | 108 | 20.3 | 41.8 | 37.9 | 100.0 |
| Nepal | 139 | 37 | 103 | 31 | 41 | 30 | 30.3 | 40.0 | 29.6 | 100.0 |
| Niger | 1,162 | 831 | 332 | 2 | 0 | 330 | 0.5 | 0.0 | 99.5 | 100.0 |
| Nigeria | 909 | 58 | 852 | 6 | 440 | 405 | 0.7 | 51.7 | 47.6 | 100.0 |
| North Korea | 124 | 51 | 72 | 41 | 11 | 21 | 56.3 | 15.3 | 28.4 | 100.0 |
| Pakistan | 854 | 475 | 379 | 242 | 9 | 128 | 63.9 | 2.3 | 33.7 | 100.0 |
| Papua New Guinea | 452 | 422 | 30 | 0 | 26 | 4 | 0.0 | 86.5 | 13.5 | 100.0 |
| Rwanda | 24 | 4 | 21 | 0 | 17 | 3 | 0.4 | 83.2 | 16.4 | 100.0 |
| Senegal | 197 | 28 | 169 | 3 | 34 | 131 | 1.7 | 20.4 | 77.8 | 100.0 |
| Sierra Leone | 73 | 54 | 19 | 0 | 13 | 6 | 0.5 | 69.9 | 29.7 | 100.0 |
| Solomon Islands | 27 | 27 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Somalia | 639 | 410 | 229 | 7 | 0 | 223 | 3.0 | 0.0 | 97.0 | 100.0 |
| Tajikistan | 131 | 39 | 93 | 16 | 0 | 77 | 17.3 | 0.0 | 82.7 | 100.0 |
| Tanzania, United Republic | 895 | 173 | 721 | 4 | 520 | 197 | 0.6 | 72.1 | 27.3 | 100.0 |
| Togo | 57 | 3 | 54 | 0 | 41 | 13 | 0.2 | 76.1 | 23.7 | 100.0 |
| Uganda | 207 | 42 | 165 | 0 | 154 | 11 | 0.2 | 93.4 | 6.4 | 100.0 |
| Uzbekistan | 417 | 98 | 320 | 83 | 0 | 237 | 26.1 | 0.0 | 73.9 | 100.0 |
| Vietnam | 331 | 153 | 178 | 73 | 47 | 59 | 40.9 | 26.1 | 33.0 | 100.0 |
| Western Sahara | 264 | 264 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Yemen | 422 | 401 | 21 | 12 | 0 | 9 | 55.2 | 0.0 | 44.8 | 100.0 |
| Zaire | 2,310 | 1,790 | 520 | 1 | 441 | 79 | 0.1 | 84.7 | 15.2 | 100.0 |
| Zambia | 751 | 173 | 578 | 3 | 357 | 218 | 0.5 | 61.8 | 37.7 | 100.0 |
| Zimbabwe | 386 | 90 | 296 | 4 | 50 | 243 | 1.3 | 16.8 | 82.0 | 100.0 |

| | Total land area | | | Area within the extent of agriculture by favorability index | | | Area distribution within the extent of agriculture by favorability index | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Income group / country** | **Grand total** | **Outside the extent of agriculture** | **Within the extent of agriculture** | **Irrigated areas** | **Favored areas** | **Less-favored areas** | **Irrigated areas** | **Favored areas** | **Less-favored areas** | **Grand total** |
| | area - 000 square kilometers | | | | | | share of agricultural land (percent) | | | |
| **Lower middle income** | **45,469** | **18,572** | **26,898** | **4,087** | **8,650** | **14,161** | **15.2** | **32.2** | **52.6** | **100.0** |
| Albania | 28 | 3 | 25 | 8 | 14 | 3 | 32.5 | 55.8 | 11.8 | 100.0 |
| Algeria | 2,297 | 2,119 | 178 | 15 | 47 | 116 | 8.2 | 26.4 | 65.4 | 100.0 |
| Angola | 1,252 | 285 | 967 | 2 | 713 | 251 | 0.3 | 73.7 | 26.0 | 100.0 |
| Armenia | 29 | 2 | 27 | 7 | 0 | 20 | 26.9 | 0.0 | 73.1 | 100.0 |
| Azerbaijan | 85 | 6 | 80 | 32 | 3 | 45 | 39.9 | 3.3 | 56.8 | 100.0 |
| Bolivia | 1,079 | 419 | 660 | 3 | 396 | 261 | 0.5 | 60.0 | 39.5 | 100.0 |
| Bosnia and Herzegovina | 49 | 8 | 42 | 0 | 27 | 15 | 0.2 | 65.0 | 34.8 | 100.0 |
| Brazil | 8,486 | 4,343 | 4,143 | 57 | 2,883 | 1,202 | 1.4 | 69.6 | 29.0 | 100.0 |
| Bulgaria | 113 | 10 | 102 | 23 | 30 | 49 | 22.5 | 29.6 | 47.9 | 100.0 |
| Cameroon | 465 | 278 | 187 | 1 | 129 | 57 | 0.5 | 69.2 | 30.4 | 100.0 |
| China | 9,220 | 3,161 | 6,059 | 1,550 | 1,030 | 3,479 | 25.6 | 17.0 | 57.4 | 100.0 |
| Colombia | 1,139 | 474 | 666 | 25 | 458 | 183 | 3.7 | 68.8 | 27.5 | 100.0 |
| Djibouti | 21 | 21 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dominican Republic | 48 | 1 | 46 | 8 | 17 | 21 | 17.4 | 37.2 | 45.3 | 100.0 |
| Ecuador | 248 | 84 | 164 | 24 | 50 | 90 | 14.7 | 30.4 | 54.9 | 100.0 |
| Egypt | 979 | 927 | 52 | 52 | 0 | 0 | 99.9 | 0.0 | 0.1 | 100.0 |
| El Salvador | 21 | 0 | 21 | 1 | 9 | 10 | 5.6 | 44.4 | 50.0 | 100.0 |
| French Guiana | 86 | 86 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Gaza Strip | 0 | 0 | 0 | 0 | 0 | 0 | 100.0 | 0.0 | 0.0 | 100.0 |
| Georgia | 69 | 16 | 53 | 7 | 24 | 22 | 12.8 | 45.8 | 41.3 | 100.0 |
| Guatemala | 110 | 21 | 89 | 5 | 54 | 30 | 5.3 | 61.1 | 33.7 | 100.0 |
| Guyana | 211 | 178 | 33 | 6 | 21 | 6 | 18.3 | 64.5 | 17.2 | 100.0 |
| Honduras | 112 | 35 | 77 | 2 | 60 | 15 | 2.3 | 77.7 | 19.9 | 100.0 |
| India | 3,111 | 379 | 2,732 | 1,311 | 412 | 1,009 | 48.0 | 15.1 | 36.9 | 100.0 |
| Indonesia | 1,907 | 409 | 1,499 | 117 | 912 | 469 | 7.8 | 60.9 | 31.3 | 100.0 |
| Iran | 1,598 | 672 | 926 | 208 | 5 | 713 | 22.5 | 0.6 | 77.0 | 100.0 |
| Iraq | 427 | 275 | 152 | 77 | 18 | 58 | 50.2 | 11.6 | 38.2 | 100.0 |
| Jordan | 88 | 80 | 9 | 2 | 0 | 6 | 29.3 | 2.6 | 68.1 | 100.0 |

| Income group / country | Total land area: Grand total | Total land area: Outside the extent of agriculture | Total land area: Within the extent of agriculture | Area within the extent of agriculture by favorability index: Irrigated areas | Area within the extent of agriculture by favorability index: Favored areas | Area within the extent of agriculture by favorability index: Less-favored areas | Area distribution within the extent of agriculture by favorability index: Irrigated areas | Area distribution within the extent of agriculture by favorability index: Favored areas | Area distribution within the extent of agriculture by favorability index: Less-favored areas | Area distribution within the extent of agriculture by favorability index: Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | area - 000 square kilometers | | | | | | share of agricultural land (percent) | | | |
| Kazakhstan | 2,644 | 120 | 2,523 | 57 | 3 | 2,464 | 2.3 | 0.1 | 97.6 | 100.0 |
| Lesotho | 31 | 0 | 31 | 0 | 2 | 29 | 0.0 | 7.9 | 92.1 | 100.0 |
| Macedonia | 25 | 1 | 25 | 4 | 13 | 7 | 14.9 | 54.8 | 30.3 | 100.0 |
| Moldova | 34 | 0 | 34 | 9 | 1 | 24 | 28.0 | 1.9 | 70.1 | 100.0 |
| Mongolia | 1,538 | 770 | 769 | 1 | 9 | 758 | 0.2 | 1.2 | 98.7 | 100.0 |
| Morocco | 404 | 147 | 258 | 32 | 32 | 193 | 12.5 | 12.6 | 74.9 | 100.0 |
| Namibia | 819 | 544 | 275 | 0 | 0 | 275 | 0.0 | 0.0 | 100.0 | 100.0 |
| Nicaragua | 118 | 16 | 102 | 1 | 47 | 54 | 1.0 | 45.8 | 53.2 | 100.0 |
| Paraguay | 400 | 53 | 346 | 1 | 166 | 179 | 0.3 | 48.0 | 51.7 | 100.0 |
| Peru | 1,293 | 952 | 341 | 43 | 20 | 278 | 12.6 | 5.9 | 81.5 | 100.0 |
| Philippines | 292 | 35 | 257 | 53 | 62 | 141 | 20.8 | 24.2 | 55.0 | 100.0 |
| Serbia | 84 | 3 | 80 | 2 | 50 | 28 | 3.0 | 61.9 | 35.1 | 100.0 |
| Sri Lanka | 66 | 10 | 55 | 20 | 12 | 23 | 35.6 | 22.1 | 42.3 | 100.0 |
| Sudan | 2,502 | 1,190 | 1,313 | 41 | 491 | 781 | 3.1 | 37.4 | 59.5 | 100.0 |
| Swaziland | 17 | 1 | 17 | 1 | 8 | 7 | 8.3 | 49.6 | 42.2 | 100.0 |
| Syria | 187 | 70 | 116 | 33 | 11 | 73 | 28.1 | 9.5 | 62.4 | 100.0 |
| Thailand | 517 | 110 | 407 | 117 | 154 | 136 | 28.8 | 37.9 | 33.4 | 100.0 |
| Trinidad and Tobago | 5 | 2 | 3 | 0 | 2 | 1 | 0.0 | 62.0 | 38.0 | 100.0 |
| Tunisia | 150 | 103 | 47 | 12 | 11 | 24 | 25.0 | 23.7 | 51.3 | 100.0 |
| Turkmenistan | 461 | 110 | 350 | 48 | 0 | 302 | 13.8 | 0.0 | 86.2 | 100.0 |
| Ukraine | 591 | 35 | 556 | 66 | 241 | 249 | 11.8 | 43.4 | 44.8 | 100.0 |
| Vanuatu | 7 | 7 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| West Bank | 6 | 2 | 4 | 1 | 1 | 3 | 13.6 | 20.5 | 65.9 | 100.0 |
| **Upper middle income** | **29,413** | **19,899** | **9,515** | **623** | **3,830** | **5,062** | **6.6** | **40.3** | **53.2** | **100.0** |
| Argentina | 2,734 | 1,350 | 1,385 | 44 | 700 | 640 | 3.2 | 50.6 | 46.2 | 100.0 |
| Belize | 21 | 19 | 3 | 0 | 2 | 0 | 0.0 | 84.9 | 15.1 | 100.0 |
| Botswana | 554 | 313 | 241 | 0 | 0 | 241 | 0.0 | 0.0 | 100.0 | 100.0 |
| Byelarus | 208 | 30 | 179 | 0 | 176 | 2 | 0.0 | 98.8 | 1.2 | 100.0 |
| Chile | 720 | 422 | 298 | 53 | 45 | 200 | 17.8 | 15.2 | 67.1 | 100.0 |

| Income group / country | Total land area: Grand total | Total land area: Outside the extent of agriculture | Total land area: Within the extent of agriculture | Area within the extent of agriculture by favorability index: Irrigated areas | Area within the extent of agriculture by favorability index: Favored areas | Area within the extent of agriculture by favorability index: Less-favored areas | Area distribution within the extent of agriculture by favorability index: Irrigated areas | Area distribution within the extent of agriculture by favorability index: Favored areas | Area distribution within the extent of agriculture by favorability index: Less-favored areas | Area distribution within the extent of agriculture by favorability index: Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | area - 000 square kilometers | | | | | | share of agricultural land (percent) | | | |
| Costa Rica | 50 | 7 | 43 | 2 | 21 | 20 | 5.5 | 48.4 | 46.1 | 100.0 |
| Croatia | 56 | 8 | 49 | 0 | 24 | 25 | 0.1 | 48.6 | 51.2 | 100.0 |
| Cuba | 110 | 10 | 100 | 29 | 42 | 29 | 28.8 | 42.5 | 28.7 | 100.0 |
| Czech Republic | 79 | 8 | 71 | 2 | 29 | 40 | 2.3 | 41.0 | 56.7 | 100.0 |
| Estonia | 43 | 17 | 26 | 0 | 25 | 0 | 0.0 | 98.9 | 1.1 | 100.0 |
| Fiji | 17 | 17 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Gabon | 265 | 245 | 19 | 0 | 16 | 3 | 0.9 | 81.6 | 17.5 | 100.0 |
| Grenada | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Jamaica | 11 | 1 | 10 | 1 | 2 | 7 | 7.7 | 23.6 | 68.6 | 100.0 |
| Latvia | 64 | 19 | 46 | 0 | 45 | 1 | 0.0 | 98.8 | 1.2 | 100.0 |
| Lebanon | 11 | 2 | 9 | 3 | 3 | 2 | 37.0 | 36.0 | 27.0 | 100.0 |
| Libya | 1,607 | 1,579 | 28 | 13 | 1 | 15 | 45.9 | 2.1 | 52.0 | 100.0 |
| Lithuania | 65 | 6 | 60 | 0 | 59 | 1 | 0.0 | 98.2 | 1.8 | 100.0 |
| Malaysia | 328 | 106 | 222 | 6 | 99 | 117 | 2.9 | 44.7 | 52.4 | 100.0 |
| Mauritius | 2 | 1 | 1 | 1 | 0 | 0 | 100.0 | 0.0 | 0.0 | 100.0 |
| Mexico | 1,939 | 691 | 1,248 | 170 | 362 | 716 | 13.7 | 29.0 | 57.4 | 100.0 |
| Montenegro | 14 | 1 | 13 | 0 | 12 | 1 | 1.0 | 90.9 | 8.2 | 100.0 |
| Panama | 75 | 21 | 53 | 0 | 16 | 37 | 0.2 | 29.9 | 69.9 | 100.0 |
| Poland | 310 | 26 | 283 | 2 | 254 | 28 | 0.7 | 89.5 | 9.8 | 100.0 |
| Romania | 235 | 27 | 208 | 45 | 74 | 89 | 21.4 | 35.8 | 42.8 | 100.0 |
| Russia | 16,676 | 13,781 | 2,895 | 70 | 1,069 | 1,755 | 2.4 | 36.9 | 60.6 | 100.0 |
| South Africa | 1,219 | 440 | 779 | 42 | 223 | 514 | 5.4 | 28.6 | 66.0 | 100.0 |
| Suriname | 143 | 141 | 1 | 1 | 0 | 0 | 69.7 | 30.3 | 0.0 | 100.0 |
| Turkey | 768 | 100 | 668 | 126 | 97 | 445 | 18.9 | 14.6 | 66.6 | 100.0 |
| Uruguay | 177 | 2 | 175 | 5 | 131 | 39 | 2.8 | 74.8 | 22.4 | 100.0 |
| Venezuela | 913 | 511 | 402 | 8 | 300 | 94 | 2.0 | 74.6 | 23.4 | 100.0 |
| Misc islands | 74 | 74 | 0 | 0 | 0 | 0 | 100.0 | 0.0 | 0.0 | 100.0 |
| **Grand total** | **130,512** | **72,010** | **58,502** | **6,987** | **20,377** | **31,138** | **11.9** | **34.8** | **53.2** | **100.0** |

Source: Country groupings per World Bank data (World Bank 2008); extent of agriculture and favorability index (Sebastian 2009); land area (CIESIN/IFPRI/CIAT 2008)

## Table 2. Total & rural population by favorability index & income groups

| | Total population | | | | | | Distribution of total population within agricultural lands | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *Within the extent of agriculture* | | | | | | | | |
| **Income group / country** | **Outside the extent of agriculture** | **Irrigated areas** | **Favored areas** | **Less-favored areas** | **Total** | **Grand total** | **Irrigated areas** | **Favored areas** | **Less-favored areas** | **Grand total** |
| | population (000 persons) | | | | | | share of total (percent) | | | |
| **High income** | **404,972** | **177,505** | **233,960** | **161,741** | **573,206** | **978,178** | **9.4** | **33.5** | **57.1** | **100.0** |
| High income - OECD | 366,971 | 159,209 | 227,468 | 155,051 | 541,728 | 908,699 | 9.7 | 33.7 | 56.6 | 100.0 |
| High income - Other | 38,000 | 18,297 | 6,492 | 6,690 | 31,479 | 69,479 | 6.2 | 29.2 | 64.5 | 100.0 |
| **Low to middle income** | **715,486** | **2,017,870** | **1,081,993** | **1,244,780** | **4,344,644** | **5,060,130** | **11.7** | **40.8** | **47.5** | **100.0** |
| Low income | 236,170 | 340,769 | 273,958 | 248,410 | 863,138 | 1,099,308 | 11.2 | 39.0 | 49.7 | 100.0 |
| Lower middle income | 340,535 | 1,599,143 | 618,001 | 823,684 | 3,040,827 | 3,381,362 | 11.4 | 42.0 | 46.7 | 100.0 |
| Upper middle income | 138,781 | 77,958 | 190,034 | 172,686 | 440,678 | 579,459 | 14.5 | 36.9 | 48.6 | 100.0 |
| **Misc island nations** | **342** | **155** | **0** | **0** | **155** | **497** | **0.0** | **0.0** | **0.0** | **0.0** |
| **Total** | **1,120,800** | **2,195,530** | **1,315,953** | **1,406,521** | **4,918,004** | **6,038,804** | **11.4** | **39.8** | **48.8** | **100.0** |
| Share of total | 18.6 | 36.4 | 21.8 | 23.3 | 81.4 | 100.0 | | | | |

| | Total rural population | | | | | | Distribution of rural populations within agricultural lands | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *Within the extent of agriculture* | | | | | | | | |
| **Income group / country** | **Outside the extent of agriculture** | **Irrigated areas** | **Favored areas** | **Less-favored areas** | **Total** | **Grand total** | **Irrigated areas** | **Favored areas** | **Less-favored areas** | **Grand total** |
| | **population (000 persons)** | | | | | | **share of rural population (percent)** | | | |
| **High income** | **57,227** | **27,391** | **62,120** | **46,126** | **135,636** | **192,864** | **12.3** | **36.2** | **51.5** | **100.0** |
| High income - OECD | 45,040 | 25,541 | 60,902 | 44,593 | 131,036 | 176,076 | 12.7 | 37.3 | 50.1 | 100.0 |
| High income - Other | 12,187 | 1,849 | 1,218 | 1,533 | 4,600 | 16,788 | 6.7 | 20.1 | 73.2 | 100.0 |
| **Low to middle income** | **358,237** | **1,177,968** | **692,413** | **832,484** | **2,702,866** | **3,061,103** | **12.6** | **41.0** | **46.4** | **100.0** |
| Low income | 171,775 | 236,338 | 204,324 | 197,236 | 637,897 | 809,673 | 12.0 | 38.8 | 49.2 | 100.0 |
| Lower middle income | 152,772 | 925,251 | 418,236 | 563,424 | 1,906,911 | 2,059,683 | 12.4 | 42.1 | 45.5 | 100.0 |
| Upper middle income | 33,690 | 16,380 | 69,854 | 71,824 | 158,058 | 191,748 | 17.0 | 37.5 | 45.5 | 100.0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Misc island nations** | **342** | **155** | **0** | **0** | **155** | **497** | | | | |
| **Total** | **415,806** | **1,205,514** | **754,533** | **878,610** | **2,838,657** | **3,254,463** | **12.6** | **40.7** | **46.7** | **100.0** |
| Share of total | 12.8 | 37.0 | 23.2 | 27.0 | 87.2 | 100.0 | | | | |

Source: Country groupings per World Bank data (World Bank 2008); extent of agriculture and favorability index (Sebastian 2009); population - GRUMP (CIESIN/IFPRI/CIAT 2008)

## Table 2a. Total population by favorability index & country/income groups

| | Total population | | | | | | Distribution of population within agricultural lands | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Income group / country | Outside the extent of agriculture | Within the extent of agriculture: Irrigated areas | Favored areas | Less-favored areas | Total | Grand total | Irrigated areas | Favored areas | Less-favored areas | Grand total |
| | *population (000 persons)* | | | | | | *share of urban population (percent)* | | | |
| High income - OECD | 366,971 | 159,209 | 227,468 | 155,051 | 541,728 | 908,699 | 29.4 | 42.0 | 28.6 | 100.0 |
| High income - Other | 38,000 | 18,297 | 6,492 | 6,690 | 31,479 | 69,479 | 58.1 | 20.6 | 21.3 | 100.0 |
| **Low income** | **236,170** | **340,769** | **273,958** | **248,410** | **863,138** | **1,099,308** | **39.5** | **31.7** | **28.8** | **100.0** |
| Afghanistan | 1,433 | 8,791 | 93 | 11,679 | 20,563 | 21,997 | 42.8 | 0.5 | 56.8 | 100.0 |
| Bangladesh | 2,983 | 113,822 | 18,314 | 1,739 | 133,874 | 136,856 | 85.0 | 13.7 | 1.3 | 100.0 |
| Benin | 2,573 | 21 | 3,409 | 430 | 3,861 | 6,434 | 0.6 | 88.3 | 11.1 | 100.0 |
| Bhutan | 1,649 | 87 | 253 | 511 | 851 | 2,500 | 10.2 | 29.7 | 60.1 | 100.0 |
| Burkina Faso | 896 | 26 | 2,760 | 7,751 | 10,537 | 11,433 | 0.3 | 26.2 | 73.6 | 100.0 |
| Burundi | 967 | 129 | 5,003 | 380 | 5,513 | 6,480 | 2.3 | 90.8 | 6.9 | 100.0 |
| Cambodia | 570 | 2,155 | 8,856 | 1,537 | 12,547 | 13,117 | 17.2 | 70.6 | 12.2 | 100.0 |
| Central African Republic | 3,018 | 0 | 609 | 66 | 676 | 3,694 | 0.0 | 90.2 | 9.8 | 100.0 |
| Chad | 525 | 10 | 3,230 | 4,000 | 7,240 | 7,765 | 0.1 | 44.6 | 55.3 | 100.0 |
| Congo | 1,197 | 0 | 970 | 641 | 1,611 | 2,808 | 0.0 | 60.2 | 39.8 | 100.0 |
| Eritrea | 600 | 4 | 0 | 3,049 | 3,053 | 3,653 | 0.1 | 0.0 | 99.9 | 100.0 |
| Ethiopia | 16,868 | 1,103 | 11,822 | 33,129 | 46,054 | 62,922 | 2.4 | 25.7 | 71.9 | 100.0 |
| Gambia, The | 394 | 0 | 191 | 677 | 868 | 1,262 | 0.0 | 22.0 | 78.0 | 100.0 |
| Ghana | 4,847 | 24 | 10,418 | 3,677 | 14,120 | 18,967 | 0.2 | 73.8 | 26.0 | 100.0 |
| Guinea | 3,783 | 527 | 2,721 | 1,147 | 4,395 | 8,178 | 12.0 | 61.9 | 26.1 | 100.0 |
| Guinea-Bissau | 227 | 13 | 962 | 13 | 987 | 1,215 | 1.3 | 97.4 | 1.3 | 100.0 |
| Haiti | 134 | 1,645 | 2,035 | 4,290 | 7,970 | 8,105 | 20.6 | 25.5 | 53.8 | 100.0 |
| Ivory Coast | 5,955 | 36 | 8,656 | 1,375 | 10,067 | 16,021 | 0.4 | 86.0 | 13.7 | 100.0 |
| Kenya | 10,412 | 1,723 | 9,211 | 9,105 | 20,039 | 30,451 | 8.6 | 46.0 | 45.4 | 100.0 |

| Income group / country | Total population: Outside the extent of agriculture | Within the extent of agriculture: Irrigated areas | Favored areas | Less-favored areas | Total | Grand total | Distribution of population within agricultural lands: Irrigated areas | Favored areas | Less-favored areas | Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | *population (000 persons)* | | | | | | *share of urban population (percent)* | | | |
| Kyrgyzstan | 14 | 2,304 | 0 | 2,983 | 5,287 | 5,301 | 43.6 | 0.0 | 56.4 | 100.0 |
| Laos | 3,259 | 598 | 871 | 645 | 2,114 | 5,372 | 28.3 | 41.2 | 30.5 | 100.0 |
| Liberia | 1,902 | 0 | 1,004 | 42 | 1,046 | 2,948 | 0.0 | 95.9 | 4.1 | 100.0 |
| Madagascar | 4,423 | 2,268 | 6,266 | 3,017 | 11,550 | 15,973 | 19.6 | 54.2 | 26.1 | 100.0 |
| Malawi | 4,114 | 336 | 6,133 | 721 | 7,189 | 11,303 | 4.7 | 85.3 | 10.0 | 100.0 |
| Mali | 1,263 | 498 | 1,906 | 7,631 | 10,035 | 11,298 | 5.0 | 19.0 | 76.0 | 100.0 |
| Mauritania | 468 | 31 | 0 | 627 | 658 | 1,127 | 4.7 | 0.0 | 95.3 | 100.0 |
| Mozambique | 3,235 | 296 | 10,695 | 4,111 | 15,101 | 18,337 | 2.0 | 70.8 | 27.2 | 100.0 |
| Myanmar (Burma) | 9,409 | 13,417 | 15,634 | 9,573 | 38,625 | 48,034 | 34.7 | 40.5 | 24.8 | 100.0 |
| Nepal | 3,026 | 11,842 | 7,400 | 2,456 | 21,698 | 24,724 | 54.6 | 34.1 | 11.3 | 100.0 |
| Niger | 431 | 236 | 0 | 10,054 | 10,290 | 10,721 | 2.3 | 0.0 | 97.7 | 100.0 |
| Nigeria | 11,211 | 688 | 56,807 | 45,324 | 102,819 | 114,030 | 0.7 | 55.2 | 44.1 | 100.0 |
| North Korea | 3,998 | 13,509 | 1,041 | 3,633 | 18,182 | 22,180 | 74.3 | 5.7 | 20.0 | 100.0 |
| Pakistan | 32,508 | 91,059 | 2,135 | 19,957 | 113,151 | 145,659 | 80.5 | 1.9 | 17.6 | 100.0 |
| Papua New Guinea | 4,524 | 0 | 95 | 23 | 118 | 4,642 | 0.0 | 80.2 | 19.8 | 100.0 |
| Rwanda | 1,226 | 38 | 5,360 | 1,144 | 6,541 | 7,767 | 0.6 | 81.9 | 17.5 | 100.0 |
| Senegal | 2,299 | 160 | 1,100 | 5,866 | 7,127 | 9,426 | 2.2 | 15.4 | 82.3 | 100.0 |
| Sierra Leone | 3,610 | 7 | 595 | 190 | 792 | 4,402 | 0.9 | 75.2 | 24.0 | 100.0 |
| Solomon Islands | 410 | 0 | 0 | 0 | 0 | 410 | 0.0 | 0.0 | 0.0 | 0.0 |
| Somalia | 3,126 | 464 | 0 | 5,214 | 5,677 | 8,803 | 8.2 | 0.0 | 91.8 | 100.0 |
| Tajikistan | 124 | 2,534 | 0 | 3,555 | 6,089 | 6,213 | 41.6 | 0.0 | 58.4 | 100.0 |
| Tanzania, United Republic | 7,210 | 814 | 19,371 | 7,911 | 28,096 | 35,306 | 2.9 | 68.9 | 28.2 | 100.0 |
| Togo | 716 | 3 | 2,994 | 823 | 3,821 | 4,537 | 0.1 | 78.4 | 21.5 | 100.0 |
| Uganda | 4,017 | 71 | 17,379 | 1,753 | 19,202 | 23,219 | 0.4 | 90.5 | 9.1 | 100.0 |
| Uzbekistan | 390 | 18,563 | 0 | 4,821 | 23,385 | 23,774 | 79.4 | 0.0 | 20.6 | 100.0 |
| Vietnam | 13,066 | 47,348 | 8,948 | 8,550 | 64,847 | 77,913 | 73.0 | 13.8 | 13.2 | 100.0 |
| Western Sahara | 186 | 0 | 0 | 0 | 0 | 186 | 0.0 | 0.0 | 0.0 | 0.0 |
| Yemen | 14,188 | 3,219 | 0 | 867 | 4,087 | 18,275 | 78.8 | 0.0 | 21.2 | 100.0 |
| Zaire | 35,995 | 40 | 11,381 | 2,984 | 14,404 | 50,400 | 0.3 | 79.0 | 20.7 | 100.0 |
| Zambia | 2,830 | 166 | 5,129 | 2,530 | 7,824 | 10,654 | 2.1 | 65.5 | 32.3 | 100.0 |
| Zimbabwe | 3,961 | 145 | 2,203 | 6,208 | 8,556 | 12,516 | 1.7 | 25.7 | 72.6 | 100.0 |

| Income group / country | Total population: Outside the extent of agriculture | Within the extent of agriculture: Irrigated areas | Favored areas | Less-favored areas | Total | Grand total | Distribution of population within agricultural lands: Irrigated areas | Favored areas | Less-favored areas | Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | *population (000 persons)* | | | | | | *share of urban population (percent)* | | | |
| **Lower middle income** | **340,535** | **1,599,143** | **618,001** | **823,684** | **3,040,827** | **3,381,362** | **52.6** | **20.3** | **27.1** | **100.0** |
| Albania | 238 | 1,582 | 892 | 385 | 2,859 | 3,098 | 55.3 | 31.2 | 13.5 | 100.0 |
| Algeria | 7,056 | 5,336 | 7,042 | 10,198 | 22,576 | 29,632 | 23.6 | 31.2 | 45.2 | 100.0 |
| Angola | 3,324 | 557 | 6,454 | 3,286 | 10,298 | 13,622 | 5.4 | 62.7 | 31.9 | 100.0 |
| Armenia | 80 | 2,523 | 0 | 1,162 | 3,685 | 3,765 | 68.5 | 0.0 | 31.5 | 100.0 |
| Azerbaijan | 847 | 3,505 | 161 | 3,524 | 7,190 | 8,037 | 48.7 | 2.2 | 49.0 | 100.0 |
| Bolivia | 1,838 | 162 | 2,079 | 4,242 | 6,483 | 8,320 | 2.5 | 32.1 | 65.4 | 100.0 |
| Bosnia and Herzegovina | 463 | 42 | 2,105 | 1,262 | 3,409 | 3,871 | 1.2 | 61.8 | 37.0 | 100.0 |
| Brazil | 66,109 | 3,432 | 71,375 | 29,282 | 104,089 | 170,198 | 3.3 | 68.6 | 28.1 | 100.0 |
| Bulgaria | 679 | 2,682 | 2,199 | 2,643 | 7,525 | 8,204 | 35.6 | 29.2 | 35.1 | 100.0 |
| Cameroon | 7,248 | 41 | 4,473 | 3,003 | 7,517 | 14,764 | 0.5 | 59.5 | 40.0 | 100.0 |
| China | 94,257 | 680,843 | 198,755 | 294,414 | 1,174,012 | 1,268,269 | 58.0 | 16.9 | 25.1 | 100.0 |
| Colombia | 2,144 | 4,698 | 16,838 | 18,245 | 39,782 | 41,926 | 11.8 | 42.3 | 45.9 | 100.0 |
| Djibouti | 627 | 0 | 0 | 0 | 0 | 627 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dominican Republic | 393 | 981 | 4,052 | 2,976 | 8,008 | 8,401 | 12.2 | 50.6 | 37.2 | 100.0 |
| Ecuador | 1,882 | 3,409 | 839 | 6,652 | 10,900 | 12,782 | 31.3 | 7.7 | 61.0 | 100.0 |
| Egypt | 10,765 | 57,062 | 0 | 12 | 57,074 | 67,838 | 100.0 | 0.0 | 0.0 | 100.0 |
| El Salvador | 34 | 435 | 3,976 | 1,858 | 6,270 | 6,304 | 6.9 | 63.4 | 29.6 | 100.0 |
| French Guiana | 165 | 0 | 0 | 0 | 0 | 165 | 0.0 | 0.0 | 0.0 | 0.0 |
| Gaza Strip | 90 | 1,060 | 0 | 0 | 1,060 | 1,150 | 100.0 | 0.0 | 0.0 | 100.0 |
| Georgia | 1,335 | 1,223 | 1,817 | 900 | 3,941 | 5,276 | 31.0 | 46.1 | 22.8 | 100.0 |
| Guatemala | 498 | 632 | 7,156 | 3,100 | 10,888 | 11,386 | 5.8 | 65.7 | 28.5 | 100.0 |
| Guyana | 204 | 387 | 144 | 1 | 532 | 736 | 72.7 | 27.1 | 0.2 | 100.0 |
| Honduras | 1,041 | 753 | 3,513 | 1,085 | 5,351 | 6,391 | 14.1 | 65.6 | 20.3 | 100.0 |
| India | 54,512 | 591,585 | 140,013 | 215,037 | 946,635 | 1,001,147 | 62.5 | 14.8 | 22.7 | 100.0 |
| Indonesia | 12,612 | 91,656 | 67,613 | 39,689 | 198,958 | 211,570 | 46.1 | 34.0 | 19.9 | 100.0 |
| Iran | 12,720 | 28,664 | 202 | 28,615 | 57,481 | 70,201 | 49.9 | 0.4 | 49.8 | 100.0 |
| Iraq | 5,068 | 14,214 | 1,543 | 2,122 | 17,879 | 22,947 | 79.5 | 8.6 | 11.9 | 100.0 |
| Jordan | 2,022 | 497 | 32 | 2,357 | 2,885 | 4,908 | 17.2 | 1.1 | 81.7 | 100.0 |
| Kazakhstan | 1,443 | 2,034 | 14 | 12,831 | 14,878 | 16,321 | 13.7 | 0.1 | 86.2 | 100.0 |
| Lesotho | 8 | 0 | 132 | 1,895 | 2,027 | 2,035 | 0.0 | 6.5 | 93.5 | 100.0 |

| Income group / country | Total population: Outside the extent of agriculture | Within the extent of agriculture: Irrigated areas | Within the extent of agriculture: Favored areas | Within the extent of agriculture: Less-favored areas | Within the extent of agriculture: Total | Grand total | Distribution of population within agricultural lands: Irrigated areas | Favored areas | Less-favored areas | Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | population (000 persons) | | | | | | share of urban population (percent) | | | |
| Macedonia | 15 | 638 | 686 | 729 | 2,054 | 2,069 | 31.1 | 33.4 | 35.5 | 100.0 |
| Moldova | 383 | 1,180 | 57 | 2,660 | 3,896 | 4,279 | 30.3 | 1.5 | 68.3 | 100.0 |
| Mongolia | 479 | 6 | 22 | 1,985 | 2,013 | 2,492 | 0.3 | 1.1 | 98.6 | 100.0 |
| Morocco | 3,989 | 6,902 | 3,102 | 15,798 | 25,802 | 29,791 | 26.8 | 12.0 | 61.2 | 100.0 |
| Namibia | 512 | 2 | 0 | 997 | 999 | 1,511 | 0.2 | 0.0 | 99.8 | 100.0 |
| Nicaragua | 186 | 108 | 1,796 | 2,947 | 4,850 | 5,037 | 2.2 | 37.0 | 60.8 | 100.0 |
| Paraguay | 33 | 103 | 2,734 | 2,621 | 5,458 | 5,491 | 1.9 | 50.1 | 48.0 | 100.0 |
| Peru | 13,709 | 5,077 | 541 | 6,160 | 11,777 | 25,486 | 43.1 | 4.6 | 52.3 | 100.0 |
| Philippines | 4,969 | 29,623 | 10,931 | 28,627 | 69,181 | 74,150 | 42.8 | 15.8 | 41.4 | 100.0 |
| Serbia | 336 | 783 | 4,846 | 3,622 | 9,250 | 9,586 | 8.5 | 52.4 | 39.2 | 100.0 |
| Sri Lanka | 1,016 | 3,975 | 5,504 | 8,360 | 17,839 | 18,854 | 22.3 | 30.9 | 46.9 | 100.0 |
| Sudan | 7,060 | 5,614 | 5,263 | 13,206 | 24,082 | 31,143 | 23.3 | 21.9 | 54.8 | 100.0 |
| Swaziland | 41 | 101 | 514 | 280 | 895 | 936 | 11.3 | 57.4 | 31.3 | 100.0 |
| Syria | 2,122 | 7,252 | 1,208 | 5,618 | 14,078 | 16,200 | 51.5 | 8.6 | 39.9 | 100.0 |
| Thailand | 3,923 | 27,732 | 19,585 | 11,353 | 58,670 | 62,594 | 47.3 | 33.4 | 19.4 | 100.0 |
| Trinidad and Tobago | 136 | 0 | 576 | 580 | 1,157 | 1,293 | 0.0 | 49.8 | 50.2 | 100.0 |
| Tunisia | 3,312 | 2,232 | 862 | 3,076 | 6,170 | 9,482 | 36.2 | 14.0 | 49.9 | 100.0 |
| Turkmenistan | 589 | 2,326 | 0 | 2,092 | 4,418 | 5,007 | 52.7 | 0.0 | 47.3 | 100.0 |
| Ukraine | 7,474 | 5,440 | 15,747 | 21,161 | 42,348 | 49,822 | 12.8 | 37.2 | 50.0 | 100.0 |
| Vanuatu | 68 | 0 | 0 | 0 | 0 | 68 | 0.0 | 0.0 | 0.0 | 0.0 |
| West Bank | 481 | 52 | 607 | 1,042 | 1,701 | 2,182 | 3.1 | 35.7 | 61.3 | 100.0 |
| **Upper middle income** | **138,781** | **77,958** | **190,034** | **172,686** | **440,524** | **579,459** | **17.7** | **43.1** | **39.2** | **100.0** |
| Argentina | 15,824 | 3,832 | 13,173 | 4,150 | 21,154 | 36,978 | 18.1 | 62.3 | 19.6 | 100.0 |
| Belize | 179 | 0 | 39 | 3 | 42 | 221 | 0.0 | 93.5 | 6.5 | 100.0 |
| Botswana | 446 | 0 | 0 | 1,126 | 1,126 | 1,573 | 0.0 | 0.0 | 100.0 | 100.0 |
| Byelarus | 1,760 | 0 | 8,370 | 112 | 8,482 | 10,242 | 0.0 | 98.7 | 1.3 | 100.0 |
| Chile | 2,346 | 7,557 | 2,565 | 2,651 | 12,772 | 15,118 | 59.2 | 20.1 | 20.8 | 100.0 |
| Costa Rica | 242 | 76 | 2,825 | 862 | 3,763 | 4,005 | 2.0 | 75.1 | 22.9 | 100.0 |
| Croatia | 326 | 4 | 1,379 | 2,321 | 3,704 | 4,030 | 0.1 | 37.2 | 62.7 | 100.0 |
| Cuba | 1,190 | 2,463 | 4,368 | 3,177 | 10,008 | 11,198 | 24.6 | 43.6 | 31.7 | 100.0 |
| Czech Republic | 810 | 283 | 3,917 | 5,311 | 9,511 | 10,321 | 3.0 | 41.2 | 55.8 | 100.0 |

| Income group / country | Total population: Outside the extent of agriculture | Within the extent of agriculture: Irrigated areas | Favored areas | Less-favored areas | Total | Grand total | Distribution of population within agricultural lands: Irrigated areas | Favored areas | Less-favored areas | Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | population (000 persons) | | | | | | share of urban population (percent) | | | |
| Estonia | 643 | 0 | 707 | 3 | 711 | 1,354 | 0.0 | 99.6 | 0.4 | 100.0 |
| Fiji | 787 | 0 | 0 | 0 | 0 | 787 | 0.0 | 0.0 | 0.0 | 0.0 |
| Gabon | 884 | 1 | 339 | 12 | 352 | 1,235 | 0.2 | 96.5 | 3.3 | 100.0 |
| Grenada | 92 | 0 | 0 | 0 | 0 | 92 | 0.0 | 0.0 | 0.0 | 0.0 |
| Jamaica | 163 | 253 | 546 | 1,615 | 2,414 | 2,577 | 10.5 | 22.6 | 66.9 | 100.0 |
| Latvia | 940 | 0 | 1,457 | 39 | 1,495 | 2,436 | 0.0 | 97.4 | 2.6 | 100.0 |
| Lebanon | 1,217 | 906 | 711 | 696 | 2,314 | 3,531 | 39.1 | 30.8 | 30.1 | 100.0 |
| Libya | 2,070 | 1,981 | 75 | 828 | 2,884 | 4,955 | 68.7 | 2.6 | 28.7 | 100.0 |
| Lithuania | 438 | 0 | 3,149 | 143 | 3,292 | 3,731 | 0.0 | 95.7 | 4.3 | 100.0 |
| Malaysia | 1,696 | 1,997 | 9,470 | 8,579 | 20,046 | 21,742 | 10.0 | 47.2 | 42.8 | 100.0 |
| Mauritius | 547 | 567 | 0 | 0 | 567 | 1,113 | 100.0 | 0.0 | 0.0 | 100.0 |
| Mexico | 20,819 | 24,176 | 21,926 | 31,372 | 77,473 | 98,292 | 31.2 | 28.3 | 40.5 | 100.0 |
| Montenegro | 35 | 4 | 533 | 126 | 663 | 699 | 0.7 | 80.4 | 19.0 | 100.0 |
| Panama | 575 | 4 | 650 | 1,629 | 2,283 | 2,859 | 0.2 | 28.5 | 71.3 | 100.0 |
| Poland | 6,120 | 125 | 27,656 | 4,484 | 32,265 | 38,385 | 0.4 | 85.7 | 13.9 | 100.0 |
| Romania | 2,147 | 3,511 | 6,932 | 9,341 | 19,784 | 21,931 | 17.7 | 35.0 | 47.2 | 100.0 |
| Russia | 50,496 | 3,504 | 45,667 | 42,204 | 91,376 | 141,872 | 3.8 | 50.0 | 46.2 | 100.0 |
| South Africa | 8,088 | 2,768 | 16,178 | 16,232 | 35,178 | 43,266 | 7.9 | 46.0 | 46.1 | 100.0 |
| Suriname | 285 | 6 | 120 | 0 | 125 | 411 | 4.5 | 95.5 | 0.0 | 100.0 |
| Turkey | 10,778 | 20,284 | 6,735 | 28,788 | 55,807 | 66,585 | 36.3 | 12.1 | 51.6 | 100.0 |
| Uruguay | 322 | 23 | 2,716 | 303 | 3,042 | 3,364 | 0.8 | 89.3 | 10.0 | 100.0 |
| Venezuela | 6,175 | 3,481 | 7,828 | 6,580 | 17,889 | 24,064 | 19.5 | 43.8 | 36.8 | 100.0 |
| misc islands | 342 | 155 | 0 | 0 | 155 | 497 | 100.0 | 0.0 | 0.0 | 100.0 |
| **Grand total** | **1,120,800** | **2,195,530** | **1,315,953** | **1,406,521** | **4,917,850** | **6,038,804** | **44.6** | **26.8** | **28.6** | **100.0** |

Source: Country groupings per World Bank data (World Bank 2008); extent of agriculture and favorability index (Sebastian 2009); population - GRUMP (CIESIN/IFPRI/CIAT 2008)

## Table 2b. Rural population by favorability index & country/income groups

| Income group / country | Total rural population: Outside the extent of agriculture | Within the extent of agriculture: Irrigated areas | Within the extent of agriculture: Favored areas | Within the extent of agriculture: Less-favored areas | Within the extent of agriculture: Total | Grand total | Distribution of rural populations within agricultural lands: Irrigated areas | Favored areas | Less-favored areas | Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | population (000 persons) | | | | | | share of rural population (percent) | | | |
| High income - OECD | 45,040 | 25,541 | 60,902 | 44,593 | 131,036 | 176,076 | 19.5 | 46.5 | 34.0 | 100.0 |
| High income - Other | 12,187 | 1,849 | 1,218 | 1,533 | 4,600 | 16,788 | 40.2 | 26.5 | 33.3 | 100.0 |
| **Low income** | **171,775** | **236,338** | **204,324** | **197,236** | **637,897** | **809,673** | **37.0** | **32.0** | **30.9** | **100.0** |
| Afghanistan | 1,392 | 5,430 | 93 | 10,619 | 16,143 | 17,535 | 33.6 | 0.6 | 65.8 | 100.0 |
| Bangladesh | 2,615 | 87,539 | 14,623 | 1,330 | 103,492 | 106,107 | 84.6 | 14.1 | 1.3 | 100.0 |
| Benin | 1,099 | 21 | 2,580 | 302 | 2,903 | 4,002 | 0.7 | 88.9 | 10.4 | 100.0 |
| Bhutan | 1,577 | 68 | 233 | 473 | 773 | 2,351 | 8.8 | 30.1 | 61.1 | 100.0 |
| Burkina Faso | 515 | 23 | 2,568 | 6,873 | 9,464 | 9,979 | 0.2 | 27.1 | 72.6 | 100.0 |
| Burundi | 961 | 120 | 4,464 | 370 | 4,955 | 5,916 | 2.4 | 90.1 | 7.5 | 100.0 |
| Cambodia | 569 | 2,041 | 7,225 | 1,430 | 10,697 | 11,266 | 19.1 | 67.5 | 13.4 | 100.0 |
| Central African Republic | 1,786 | 0 | 475 | 38 | 513 | 2,299 | 0.0 | 92.6 | 7.4 | 100.0 |
| Chad | 448 | 10 | 2,956 | 2,670 | 5,636 | 6,085 | 0.2 | 52.5 | 47.4 | 100.0 |
| Congo | 684 | 0 | 292 | 145 | 437 | 1,122 | 0.0 | 66.7 | 33.3 | 100.0 |
| Eritrea | 554 | 4 | 0 | 2,505 | 2,509 | 3,063 | 0.2 | 0.0 | 99.8 | 100.0 |
| Ethiopia | 15,874 | 916 | 11,070 | 27,611 | 39,598 | 55,471 | 2.3 | 28.0 | 69.7 | 100.0 |
| Gambia, The | 38 | 0 | 135 | 418 | 553 | 590 | 0.0 | 24.4 | 75.6 | 100.0 |
| Ghana | 2,565 | 24 | 6,803 | 2,858 | 9,685 | 12,250 | 0.3 | 70.2 | 29.5 | 100.0 |
| Guinea | 2,458 | 97 | 2,177 | 906 | 3,180 | 5,637 | 3.0 | 68.5 | 28.5 | 100.0 |
| Guinea-Bissau | 194 | 13 | 649 | 13 | 675 | 869 | 1.9 | 96.2 | 1.9 | 100.0 |
| Haiti | 65 | 654 | 1,650 | 2,956 | 5,260 | 5,325 | 12.4 | 31.4 | 56.2 | 100.0 |
| Ivory Coast | 2,839 | 36 | 5,637 | 901 | 6,573 | 9,412 | 0.5 | 85.8 | 13.7 | 100.0 |
| Kenya | 7,323 | 1,219 | 8,207 | 7,542 | 16,968 | 24,292 | 7.2 | 48.4 | 44.5 | 100.0 |
| Kyrgyzstan | 14 | 966 | 0 | 2,748 | 3,715 | 3,729 | 26.0 | 0.0 | 74.0 | 100.0 |
| Laos | 3,012 | 353 | 732 | 472 | 1,556 | 4,568 | 22.7 | 47.0 | 30.3 | 100.0 |
| Liberia | 1,549 | 0 | 318 | 9 | 327 | 1,876 | 0.0 | 97.4 | 2.6 | 100.0 |
| Madagascar | 3,937 | 845 | 5,364 | 2,750 | 8,960 | 12,897 | 9.4 | 59.9 | 30.7 | 100.0 |
| Malawi | 3,014 | 302 | 5,392 | 676 | 6,369 | 9,382 | 4.7 | 84.7 | 10.6 | 100.0 |
| Mali | 1,049 | 267 | 1,669 | 5,592 | 7,527 | 8,576 | 3.5 | 22.2 | 74.3 | 100.0 |

| Income group / country | Total rural population: Outside the extent of agriculture | Within the extent of agriculture: Irrigated areas | Within the extent of agriculture: Favored areas | Within the extent of agriculture: Less-favored areas | Within the extent of agriculture: Total | Grand total | Distribution of rural populations within agricultural lands: Irrigated areas | Favored areas | Less-favored areas | Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | population (000 persons) | | | | | | share of rural population (percent) | | | |
| Mauritania | 222 | 7 | 0 | 533 | 540 | 762 | 1.3 | 0.0 | 98.7 | 100.0 |
| Mozambique | 1,922 | 141 | 7,329 | 3,588 | 11,058 | 12,980 | 1.3 | 66.3 | 32.4 | 100.0 |
| Myanmar (Burma) | 8,762 | 8,935 | 9,832 | 8,036 | 26,803 | 35,564 | 33.3 | 36.7 | 30.0 | 100.0 |
| Nepal | 3,020 | 9,817 | 6,544 | 2,407 | 18,768 | 21,788 | 52.3 | 34.9 | 12.8 | 100.0 |
| Niger | 147 | 110 | 0 | 8,545 | 8,656 | 8,803 | 1.3 | 0.0 | 98.7 | 100.0 |
| Nigeria | 4,287 | 562 | 36,033 | 33,240 | 69,835 | 74,122 | 0.8 | 51.6 | 47.6 | 100.0 |
| North Korea | 3,974 | 8,670 | 833 | 2,986 | 12,490 | 16,464 | 69.4 | 6.7 | 23.9 | 100.0 |
| Pakistan | 20,147 | 59,421 | 1,997 | 15,941 | 77,359 | 97,506 | 76.8 | 2.6 | 20.6 | 100.0 |
| Papua New Guinea | 3,812 | 0 | 73 | 23 | 96 | 3,908 | 0.0 | 75.6 | 24.4 | 100.0 |
| Rwanda | 899 | 38 | 4,969 | 1,121 | 6,128 | 7,026 | 0.6 | 81.1 | 18.3 | 100.0 |
| Senegal | 346 | 69 | 880 | 3,769 | 4,719 | 5,064 | 1.5 | 18.7 | 79.9 | 100.0 |
| Sierra Leone | 2,271 | 7 | 552 | 159 | 718 | 2,989 | 0.9 | 77.0 | 22.1 | 100.0 |
| Solomon Islands | 335 | 0 | 0 | 0 | 0 | 335 | 0.0 | 0.0 | 0.0 | 0.0 |
| Somalia | 2,569 | 309 | 0 | 3,863 | 4,172 | 6,740 | 7.4 | 0.0 | 92.6 | 100.0 |
| Tajikistan | 123 | 1,308 | 0 | 2,911 | 4,219 | 4,342 | 31.0 | 0.0 | 69.0 | 100.0 |
| Tanzania, United Republic | 4,494 | 400 | 14,081 | 5,036 | 19,517 | 24,012 | 2.0 | 72.1 | 25.8 | 100.0 |
| Togo | 183 | 3 | 2,176 | 709 | 2,888 | 3,072 | 0.1 | 75.3 | 24.6 | 100.0 |
| Uganda | 3,450 | 71 | 15,361 | 1,430 | 16,862 | 20,311 | 0.4 | 91.1 | 8.5 | 100.0 |
| Uzbekistan | 390 | 9,670 | 0 | 4,434 | 14,103 | 14,493 | 68.6 | 0.0 | 31.4 | 100.0 |
| Vietnam | 11,609 | 34,443 | 6,535 | 7,933 | 48,911 | 60,519 | 70.4 | 13.4 | 16.2 | 100.0 |
| Western Sahara | 148 | 0 | 0 | 0 | 0 | 148 | 0.0 | 0.0 | 0.0 | 0.0 |
| Yemen | 11,891 | 1,208 | 0 | 733 | 1,941 | 13,832 | 62.3 | 0.0 | 37.7 | 100.0 |
| Zaire | 27,242 | 40 | 6,980 | 1,365 | 8,384 | 35,626 | 0.5 | 83.2 | 16.3 | 100.0 |
| Zambia | 1,607 | 37 | 3,334 | 1,828 | 5,199 | 6,806 | 0.7 | 64.1 | 35.2 | 100.0 |
| Zimbabwe | 1,795 | 124 | 1,502 | 4,439 | 6,066 | 7,861 | 2.0 | 24.8 | 73.2 | 100.0 |
| **Lower middle income** | **152,772** | **925,251** | **418,236** | **563,424** | **1,906,911** | **2,059,683** | **48.5** | **21.9** | **29.5** | **100.0** |
| Albania | 175 | 682 | 755 | 196 | 1,633 | 1,808 | 41.7 | 46.2 | 12.0 | 100.0 |
| Algeria | 4,273 | 669 | 3,268 | 4,518 | 8,455 | 12,728 | 7.9 | 38.7 | 53.4 | 100.0 |
| Angola | 1,894 | 18 | 6,373 | 931 | 7,322 | 9,216 | 0.2 | 87.0 | 12.7 | 100.0 |
| Armenia | 46 | 443 | 0 | 617 | 1,060 | 1,106 | 41.8 | 0.0 | 58.2 | 100.0 |

| Income group / country | Total rural population: Outside the extent of agriculture | Within the extent of agriculture: Irrigated areas | Within the extent of agriculture: Favored areas | Within the extent of agriculture: Less-favored areas | Within the extent of agriculture: Total | Grand total | Distribution of rural populations within agricultural lands: Irrigated areas | Favored areas | Less-favored areas | Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | population (000 persons) | | | | | | share of rural population (percent) | | | |
| Azerbaijan | 275 | 1,483 | 139 | 1,855 | 3,477 | 3,752 | 42.7 | 4.0 | 53.3 | 100.0 |
| Bolivia | 847 | 55 | 564 | 1,847 | 2,467 | 3,313 | 2.2 | 22.9 | 74.9 | 100.0 |
| Bosnia and Herzegovina | 350 | 1 | 1,254 | 655 | 1,910 | 2,260 | 0.1 | 65.7 | 34.3 | 100.0 |
| Brazil | 8,437 | 722 | 25,647 | 11,537 | 37,907 | 46,343 | 1.9 | 67.7 | 30.4 | 100.0 |
| Bulgaria | 298 | 932 | 982 | 1,589 | 3,503 | 3,802 | 26.6 | 28.0 | 45.4 | 100.0 |
| Cameroon | 3,063 | 38 | 2,974 | 2,387 | 5,399 | 8,462 | 0.7 | 55.1 | 44.2 | 100.0 |
| China | 67,668 | 403,461 | 155,415 | 212,116 | 770,992 | 838,660 | 52.3 | 20.2 | 27.5 | 100.0 |
| Colombia | 1,142 | 545 | 6,137 | 3,991 | 10,673 | 11,815 | 5.1 | 57.5 | 37.4 | 100.0 |
| Djibouti | 174 | 0 | 0 | 0 | 0 | 174 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dominican Republic | 157 | 442 | 1,064 | 1,353 | 2,859 | 3,016 | 15.4 | 37.2 | 47.3 | 100.0 |
| Ecuador | 638 | 961 | 669 | 2,848 | 4,478 | 5,116 | 21.5 | 14.9 | 63.6 | 100.0 |
| Egypt | 2,098 | 6,516 | 0 | 12 | 6,527 | 8,625 | 99.8 | 0.0 | 0.2 | 100.0 |
| El Salvador | 22 | 201 | 1,314 | 1,398 | 2,914 | 2,935 | 6.9 | 45.1 | 48.0 | 100.0 |
| French Guiana | 59 | 0 | 0 | 0 | 0 | 59 | 0.0 | 0.0 | 0.0 | 0.0 |
| Gaza Strip | 3 | 16 | 0 | 0 | 16 | 20 | 100.0 | 0.0 | 0.0 | 100.0 |
| Georgia | 487 | 342 | 837 | 557 | 1,736 | 2,223 | 19.7 | 48.2 | 32.1 | 100.0 |
| Guatemala | 402 | 407 | 3,884 | 2,352 | 6,643 | 7,044 | 6.1 | 58.5 | 35.4 | 100.0 |
| Guyana | 197 | 184 | 84 | 1 | 270 | 467 | 68.3 | 31.3 | 0.5 | 100.0 |
| Honduras | 562 | 81 | 2,185 | 779 | 3,045 | 3,607 | 2.6 | 71.8 | 25.6 | 100.0 |
| India | 18,629 | 409,757 | 105,238 | 166,690 | 681,686 | 700,315 | 60.1 | 15.4 | 24.5 | 100.0 |
| Indonesia | 5,455 | 46,057 | 47,991 | 30,687 | 124,735 | 130,190 | 36.9 | 38.5 | 24.6 | 100.0 |
| Iran | 5,787 | 6,262 | 202 | 18,060 | 24,524 | 30,312 | 25.5 | 0.8 | 73.6 | 100.0 |
| Iraq | 2,470 | 2,744 | 749 | 1,335 | 4,828 | 7,298 | 56.8 | 15.5 | 27.7 | 100.0 |
| Jordan | 472 | 219 | 6 | 445 | 669 | 1,141 | 32.7 | 0.8 | 66.5 | 100.0 |
| Kazakhstan | 234 | 541 | 6 | 6,746 | 7,293 | 7,527 | 7.4 | 0.1 | 92.5 | 100.0 |
| Lesotho | 8 | 0 | 109 | 1,359 | 1,469 | 1,477 | 0.0 | 7.4 | 92.6 | 100.0 |
| Macedonia | 14 | 116 | 462 | 251 | 828 | 842 | 14.0 | 55.7 | 30.3 | 100.0 |
| Moldova | 0 | 607 | 54 | 1,822 | 2,482 | 2,482 | 24.4 | 2.2 | 73.4 | 100.0 |
| Mongolia | 297 | 2 | 11 | 730 | 743 | 1,039 | 0.2 | 1.5 | 98.3 | 100.0 |
| Morocco | 1,764 | 1,795 | 1,885 | 7,752 | 11,432 | 13,196 | 15.7 | 16.5 | 67.8 | 100.0 |

| Income group / country | Total rural population: Outside the extent of agriculture | Within the extent of agriculture: Irrigated areas | Favored areas | Less-favored areas | Total | Grand total | Distribution of rural populations within agricultural lands: Irrigated areas | Favored areas | Less-favored areas | Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | population (000 persons) | | | | | | share of rural population (percent) | | | |
| Namibia | 432 | 2 | 0 | 614 | 616 | 1,048 | 0.3 | 0.0 | 99.7 | 100.0 |
| Nicaragua | 129 | 51 | 1,027 | 1,057 | 2,135 | 2,263 | 2.4 | 48.1 | 49.5 | 100.0 |
| Paraguay | 23 | 26 | 987 | 1,437 | 2,451 | 2,474 | 1.1 | 40.3 | 58.6 | 100.0 |
| Peru | 6,319 | 2,157 | 286 | 4,999 | 7,442 | 13,760 | 29.0 | 3.8 | 67.2 | 100.0 |
| Philippines | 3,747 | 13,571 | 8,577 | 23,418 | 45,566 | 49,313 | 29.8 | 18.8 | 51.4 | 100.0 |
| Serbia | 202 | 144 | 2,625 | 1,532 | 4,301 | 4,503 | 3.3 | 61.0 | 35.6 | 100.0 |
| Sri Lanka | 812 | 3,458 | 3,286 | 7,079 | 13,823 | 14,635 | 25.0 | 23.8 | 51.2 | 100.0 |
| Sudan | 4,499 | 1,990 | 4,116 | 10,373 | 16,479 | 20,978 | 12.1 | 25.0 | 62.9 | 100.0 |
| Swaziland | 24 | 31 | 392 | 276 | 699 | 723 | 4.4 | 56.1 | 39.5 | 100.0 |
| Syria | 1,396 | 2,272 | 809 | 3,408 | 6,489 | 7,885 | 35.0 | 12.5 | 52.5 | 100.0 |
| Thailand | 3,719 | 12,119 | 16,133 | 9,658 | 37,910 | 41,629 | 32.0 | 42.6 | 25.5 | 100.0 |
| Trinidad and Tobago | 60 | 0 | 49 | 76 | 124 | 185 | 0.0 | 39.0 | 61.0 | 100.0 |
| Tunisia | 912 | 589 | 477 | 1,541 | 2,608 | 3,520 | 22.6 | 18.3 | 59.1 | 100.0 |
| Turkmenistan | 517 | 583 | 0 | 1,895 | 2,478 | 2,995 | 23.5 | 0.0 | 76.5 | 100.0 |
| Ukraine | 1,399 | 1,921 | 9,155 | 8,388 | 19,464 | 20,863 | 9.9 | 47.0 | 43.1 | 100.0 |
| Vanuatu | 57 | 0 | 0 | 0 | 0 | 57 | 0.0 | 0.0 | 0.0 | 0.0 |
| West Bank | 130 | 38 | 57 | 258 | 352 | 482 | 10.8 | 16.1 | 73.2 | 100.0 |
| **Upper middle income** | **33,690** | **16,380** | **69,854** | **71,824** | **158,058** | **191,748** | **10.4** | **44.2** | **45.4** | **100.0** |
| Argentina | 2,270 | 240 | 2,571 | 1,278 | 4,088 | 6,359 | 5.9 | 62.9 | 31.3 | 100.0 |
| Belize | 111 | 0 | 12 | 2 | 15 | 126 | 0.0 | 85.3 | 14.7 | 100.0 |
| Botswana | 333 | 0 | 0 | 659 | 660 | 993 | 0.0 | 0.0 | 100.0 | 100.0 |
| Byelarus | 462 | 0 | 3,288 | 36 | 3,324 | 3,786 | 0.0 | 98.9 | 1.1 | 100.0 |
| Chile | 808 | 1,077 | 656 | 1,026 | 2,758 | 3,567 | 39.0 | 23.8 | 37.2 | 100.0 |
| Costa Rica | 228 | 66 | 721 | 644 | 1,431 | 1,658 | 4.6 | 50.4 | 45.0 | 100.0 |
| Croatia | 257 | 4 | 776 | 1,582 | 2,362 | 2,619 | 0.2 | 32.8 | 67.0 | 100.0 |
| Cuba | 181 | 709 | 1,094 | 946 | 2,748 | 2,929 | 25.8 | 39.8 | 34.4 | 100.0 |
| Czech Republic | 307 | 77 | 987 | 1,541 | 2,604 | 2,912 | 2.9 | 37.9 | 59.2 | 100.0 |
| Estonia | 164 | 0 | 248 | 3 | 250 | 414 | 0.0 | 98.9 | 1.1 | 100.0 |
| Fiji | 407 | 0 | 0 | 0 | 0 | 407 | 0.0 | 0.0 | 0.0 | 0.0 |
| Gabon | 315 | 1 | 37 | 5 | 43 | 358 | 1.4 | 86.3 | 12.3 | 100.0 |

| Income group / country | Total rural population: Outside the extent of agriculture | Within the extent of agriculture: Irrigated areas | Within the extent of agriculture: Favored areas | Within the extent of agriculture: Less-favored areas | Within the extent of agriculture: Total | Grand total | Distribution of rural populations within agricultural lands: Irrigated areas | Favored areas | Less-favored areas | Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | population (000 persons) | | | | | | share of rural population (percent) | | | |
| Grenada | 36 | 0 | 0 | 0 | 0 | 36 | 0.0 | 0.0 | 0.0 | 0.0 |
| Jamaica | 60 | 69 | 246 | 781 | 1,097 | 1,156 | 6.3 | 22.5 | 71.2 | 100.0 |
| Latvia | 259 | 0 | 587 | 6 | 593 | 852 | 0.0 | 98.9 | 1.1 | 100.0 |
| Lebanon | 69 | 179 | 174 | 134 | 487 | 556 | 36.8 | 35.6 | 27.6 | 100.0 |
| Libya | 377 | 30 | 1 | 43 | 73 | 451 | 40.8 | 1.1 | 58.1 | 100.0 |
| Lithuania | 95 | 0 | 1,157 | 24 | 1,181 | 1,275 | 0.0 | 98.0 | 2.0 | 100.0 |
| Malaysia | 1,005 | 663 | 3,493 | 2,901 | 7,057 | 8,062 | 9.4 | 49.5 | 41.1 | 100.0 |
| Mauritius | 138 | 57 | 0 | 0 | 57 | 194 | 100.0 | 0.0 | 0.0 | 100.0 |
| Mexico | 5,064 | 4,885 | 11,132 | 14,270 | 30,287 | 35,351 | 16.1 | 36.8 | 47.1 | 100.0 |
| Montenegro | 23 | 4 | 324 | 22 | 350 | 373 | 1.3 | 92.5 | 6.2 | 100.0 |
| Panama | 206 | 4 | 309 | 688 | 1,001 | 1,207 | 0.4 | 30.9 | 68.7 | 100.0 |
| Poland | 998 | 65 | 12,867 | 2,202 | 15,134 | 16,132 | 0.4 | 85.0 | 14.5 | 100.0 |
| Romania | 743 | 2,308 | 3,376 | 4,795 | 10,479 | 11,222 | 22.0 | 32.2 | 45.8 | 100.0 |
| Russia | 13,853 | 1,393 | 12,698 | 16,190 | 30,281 | 44,134 | 4.6 | 41.9 | 53.5 | 100.0 |
| South Africa | 870 | 793 | 7,807 | 8,178 | 16,777 | 17,647 | 4.7 | 46.5 | 48.7 | 100.0 |
| Suriname | 101 | 6 | 3 | 0 | 8 | 109 | 68.5 | 31.5 | 0.0 | 100.0 |
| Turkey | 3,295 | 3,701 | 3,476 | 12,648 | 19,826 | 23,120 | 18.7 | 17.5 | 63.8 | 100.0 |
| Uruguay | 11 | 11 | 428 | 102 | 541 | 552 | 2.0 | 79.1 | 18.9 | 100.0 |
| Venezuela | 644 | 39 | 1,387 | 1,118 | 2,544 | 3,188 | 1.5 | 54.5 | 43.9 | 100.0 |
| misc islands | 342 | 155 | 0 | 0 | 155 | 497 | 100.0 | 0.0 | 0.0 | 100.0 |
| **Grand Total** | **415,806** | **1,205,514** | **754,533** | **878,610** | **2,838,657** | **3,254,463** | **42.5** | **26.6** | **31.0** | **100.0** |

Source: Country groupings per World Bank data (World Bank 2008); extent of agriculture and favorability index (Sebastian 2009); population - GRUMP (CIESIN/IFPRI/CIAT 2008)

## Table 2c. Urban population by favorability index & country/income groups

| Income group / country | Total urban population: Outside the extent of agriculture | Within the extent of agriculture: Irrigated areas | Within the extent of agriculture: Favored areas | Within the extent of agriculture: Less-favored areas | Within the extent of agriculture: Total | Grand total | Distribution of urban populations within agricultural lands: Irrigated areas | Favored areas | Less-favored areas | Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | population (000 persons) | | | | | | share of urban population (percent) | | | |
| High income - OECD | 321,931 | 133,667 | 166,566 | 110,458 | 410,691 | 732,622 | 32.5 | 40.6 | 26.9 | 100.0 |
| High income - Other | 25,813 | 16,447 | 5,274 | 5,157 | 26,878 | 52,691 | 61.2 | 19.6 | 19.2 | 100.0 |
| **Low income** | **64,395** | **104,431** | **69,635** | **51,174** | **225,241** | **289,636** | **46.4** | **30.9** | **22.7** | **100.0** |
| Afghanistan | 41 | 3,361 | 0 | 1,059 | 4,421 | 4,462 | 76.0 | 0.0 | 24.0 | 100.0 |
| Bangladesh | 368 | 26,283 | 3,690 | 409 | 30,382 | 30,750 | 86.5 | 12.1 | 1.3 | 100.0 |
| Benin | 1,474 | 0 | 829 | 128 | 958 | 2,431 | 0.0 | 86.6 | 13.4 | 100.0 |
| Bhutan | 72 | 19 | 20 | 39 | 77 | 149 | 24.2 | 25.7 | 50.1 | 100.0 |
| Burkina Faso | 381 | 3 | 192 | 878 | 1,073 | 1,453 | 0.3 | 17.9 | 81.8 | 100.0 |
| Burundi | 6 | 9 | 539 | 10 | 558 | 564 | 1.7 | 96.5 | 1.8 | 100.0 |
| Cambodia | 1 | 113 | 1,630 | 106 | 1,850 | 1,851 | 6.1 | 88.1 | 5.7 | 100.0 |
| Central African Republic | 1,232 | 0 | 134 | 29 | 163 | 1,395 | 0.0 | 82.4 | 17.6 | 100.0 |
| Chad | 77 | 0 | 273 | 1,330 | 1,604 | 1,680 | 0.0 | 17.0 | 83.0 | 100.0 |
| Congo | 512 | 0 | 678 | 496 | 1,174 | 1,686 | 0.0 | 57.8 | 42.2 | 100.0 |
| Eritrea | 46 | 0 | 0 | 544 | 544 | 590 | 0.0 | 0.0 | 100.0 | 100.0 |
| Ethiopia | 994 | 187 | 752 | 5,518 | 6,457 | 7,451 | 2.9 | 11.6 | 85.5 | 100.0 |
| Gambia, The | 356 | 0 | 56 | 260 | 316 | 672 | 0.0 | 17.7 | 82.3 | 100.0 |
| Ghana | 2,282 | 0 | 3,615 | 820 | 4,435 | 6,716 | 0.0 | 81.5 | 18.5 | 100.0 |
| Guinea | 1,325 | 431 | 545 | 240 | 1,216 | 2,541 | 35.4 | 44.8 | 19.8 | 100.0 |
| Guinea-Bissau | 34 | 0 | 312 | 0 | 312 | 346 | 0.0 | 100.0 | 0.0 | 100.0 |
| Haiti | 69 | 991 | 385 | 1,334 | 2,710 | 2,780 | 36.6 | 14.2 | 49.2 | 100.0 |
| Ivory Coast | 3,116 | 0 | 3,019 | 474 | 3,493 | 6,609 | 0.0 | 86.4 | 13.6 | 100.0 |
| Kenya | 3,089 | 504 | 1,005 | 1,562 | 3,071 | 6,159 | 16.4 | 32.7 | 50.9 | 100.0 |
| Kyrgyzstan | 0 | 1,338 | 0 | 235 | 1,572 | 1,572 | 85.1 | 0.0 | 14.9 | 100.0 |
| Laos | 247 | 245 | 139 | 173 | 557 | 804 | 44.0 | 24.9 | 31.0 | 100.0 |
| Liberia | 353 | 0 | 686 | 34 | 719 | 1,072 | 0.0 | 95.3 | 4.7 | 100.0 |
| Madagascar | 486 | 1,423 | 901 | 266 | 2,591 | 3,076 | 54.9 | 34.8 | 10.3 | 100.0 |
| Malawi | 1,101 | 34 | 741 | 45 | 820 | 1,921 | 4.1 | 90.4 | 5.5 | 100.0 |

| Income group / country | Total urban population: Outside the extent of agriculture | Within the extent of agriculture: Irrigated areas | Within the extent of agriculture: Favored areas | Within the extent of agriculture: Less-favored areas | Within the extent of agriculture: Total | Grand total | Distribution of urban populations within agricultural lands: Irrigated areas | Favored areas | Less-favored areas | Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | population (000 persons) | | | | | | share of urban population (percent) | | | |
| Mali | 214 | 232 | 238 | 2,038 | 2,508 | 2,722 | 9.2 | 9.5 | 81.3 | 100.0 |
| Mauritania | 246 | 24 | 0 | 95 | 119 | 365 | 20.3 | 0.0 | 79.7 | 100.0 |
| Mozambique | 1,314 | 155 | 3,366 | 523 | 4,043 | 5,357 | 3.8 | 83.3 | 12.9 | 100.0 |
| Myanmar (Burma) | 648 | 4,482 | 5,802 | 1,537 | 11,822 | 12,470 | 37.9 | 49.1 | 13.0 | 100.0 |
| Nepal | 5 | 2,025 | 857 | 49 | 2,930 | 2,936 | 69.1 | 29.2 | 1.7 | 100.0 |
| Niger | 284 | 125 | 0 | 1,509 | 1,634 | 1,918 | 7.7 | 0.0 | 92.3 | 100.0 |
| Nigeria | 6,924 | 126 | 20,774 | 12,084 | 32,984 | 39,908 | 0.4 | 63.0 | 36.6 | 100.0 |
| North Korea | 24 | 4,838 | 207 | 647 | 5,692 | 5,716 | 85.0 | 3.6 | 11.4 | 100.0 |
| Pakistan | 12,360 | 31,639 | 138 | 4,017 | 35,793 | 48,153 | 88.4 | 0.4 | 11.2 | 100.0 |
| Papua New Guinea | 712 | 0 | 22 | 0 | 22 | 734 | 0.0 | 100.0 | 0.0 | 100.0 |
| Rwanda | 327 | 0 | 391 | 23 | 414 | 741 | 0.0 | 94.5 | 5.5 | 100.0 |
| Senegal | 1,954 | 91 | 220 | 2,097 | 2,408 | 4,361 | 3.8 | 9.1 | 87.1 | 100.0 |
| Sierra Leone | 1,339 | 0 | 43 | 31 | 74 | 1,414 | 0.0 | 57.9 | 42.1 | 100.0 |
| Solomon Islands | 75 | 0 | 0 | 0 | 0 | 75 | 0.0 | 0.0 | 0.0 | 0.0 |
| Somalia | 557 | 155 | 0 | 1,351 | 1,506 | 2,063 | 10.3 | 0.0 | 89.7 | 100.0 |
| Tajikistan | 2 | 1,225 | 0 | 644 | 1,870 | 1,871 | 65.5 | 0.0 | 34.5 | 100.0 |
| Tanzania, United Republic | 2,716 | 414 | 5,290 | 2,875 | 8,579 | 11,294 | 4.8 | 61.7 | 33.5 | 100.0 |
| Togo | 532 | 0 | 818 | 114 | 932 | 1,465 | 0.0 | 87.8 | 12.2 | 100.0 |
| Uganda | 567 | 0 | 2,018 | 323 | 2,341 | 2,908 | 0.0 | 86.2 | 13.8 | 100.0 |
| Uzbekistan | 0 | 8,894 | 0 | 388 | 9,281 | 9,281 | 95.8 | 0.0 | 4.2 | 100.0 |
| Vietnam | 1,457 | 12,906 | 2,414 | 617 | 15,936 | 17,393 | 81.0 | 15.1 | 3.9 | 100.0 |
| Western Sahara | 39 | 0 | 0 | 0 | 0 | 39 | 0.0 | 0.0 | 0.0 | 0.0 |
| Yemen | 2,298 | 2,011 | 0 | 135 | 2,146 | 4,443 | 93.7 | 0.0 | 6.3 | 100.0 |
| Zaire | 8,754 | 0 | 4,401 | 1,619 | 6,020 | 14,774 | 0.0 | 73.1 | 26.9 | 100.0 |
| Zambia | 1,222 | 129 | 1,795 | 702 | 2,625 | 3,848 | 4.9 | 68.4 | 26.7 | 100.0 |
| Zimbabwe | 2,165 | 20 | 700 | 1,769 | 2,490 | 4,655 | 0.8 | 28.1 | 71.1 | 100.0 |
| **Lower middle income** | **187,763** | **673,892** | **199,765** | **260,260** | **1,133,917** | **1,321,679** | **59.4** | **17.6** | **23.0** | **100.0** |
| Albania | 63 | 900 | 137 | 189 | 1,226 | 1,290 | 73.4 | 11.2 | 15.4 | 100.0 |
| Algeria | 2,783 | 4,666 | 3,774 | 5,680 | 14,121 | 16,904 | 33.0 | 26.7 | 40.2 | 100.0 |
| Angola | 1,430 | 539 | 81 | 2,355 | 2,976 | 4,406 | 18.1 | 2.7 | 79.1 | 100.0 |
| Armenia | 33 | 2,081 | 0 | 545 | 2,626 | 2,659 | 79.2 | 0.0 | 20.8 | 100.0 |

| Income group / country | Total urban population | | | | | | Distribution of urban populations within agricultural lands | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Outside the extent of agriculture | Within the extent of agriculture | | | | Grand total | Irrigated areas | Favored areas | Less-favored areas | Grand total |
| | | Irrigated areas | Favored areas | Less-favored areas | Total | | | | | |
| | population (000 persons) | | | | | | share of urban population (percent) | | | |
| Azerbaijan | 573 | 2,022 | 22 | 1,669 | 3,712 | 4,285 | 54.5 | 0.6 | 45.0 | 100.0 |
| Bolivia | 991 | 107 | 1,515 | 2,394 | 4,016 | 5,007 | 2.7 | 37.7 | 59.6 | 100.0 |
| Bosnia and Herzegovina | 113 | 41 | 851 | 607 | 1,498 | 1,611 | 2.7 | 56.8 | 40.5 | 100.0 |
| Brazil | 57,673 | 2,709 | 45,728 | 17,745 | 66,182 | 123,855 | 4.1 | 69.1 | 26.8 | 100.0 |
| Bulgaria | 381 | 1,750 | 1,218 | 1,054 | 4,021 | 4,402 | 43.5 | 30.3 | 26.2 | 100.0 |
| Cameroon | 4,185 | 2 | 1,499 | 617 | 2,117 | 6,303 | 0.1 | 70.8 | 29.1 | 100.0 |
| China | 26,590 | 277,382 | 43,340 | 82,298 | 403,020 | 429,610 | 68.8 | 10.8 | 20.4 | 100.0 |
| Colombia | 1,002 | 4,153 | 10,701 | 14,255 | 29,109 | 30,111 | 14.3 | 36.8 | 49.0 | 100.0 |
| Djibouti | 453 | 0 | 0 | 0 | 0 | 453 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dominican Republic | 235 | 539 | 2,988 | 1,623 | 5,149 | 5,385 | 10.5 | 58.0 | 31.5 | 100.0 |
| Ecuador | 1,244 | 2,448 | 170 | 3,804 | 6,422 | 7,666 | 38.1 | 2.6 | 59.2 | 100.0 |
| Egypt | 8,667 | 50,546 | 0 | 0 | 50,546 | 59,213 | 100.0 | 0.0 | 0.0 | 100.0 |
| El Salvador | 12 | 235 | 2,662 | 459 | 3,356 | 3,368 | 7.0 | 79.3 | 13.7 | 100.0 |
| French Guiana | 105 | 0 | 0 | 0 | 0 | 105 | 0.0 | 0.0 | 0.0 | 0.0 |
| Gaza Strip | 87 | 1,044 | 0 | 0 | 1,044 | 1,131 | 100.0 | 0.0 | 0.0 | 100.0 |
| Georgia | 848 | 882 | 981 | 343 | 2,205 | 3,053 | 40.0 | 44.5 | 15.6 | 100.0 |
| Guatemala | 96 | 225 | 3,272 | 748 | 4,245 | 4,341 | 5.3 | 77.1 | 17.6 | 100.0 |
| Guyana | 7 | 203 | 60 | 0 | 263 | 269 | 77.2 | 22.8 | 0.0 | 100.0 |
| Honduras | 479 | 673 | 1,327 | 306 | 2,306 | 2,785 | 29.2 | 57.6 | 13.3 | 100.0 |
| India | 35,882 | 181,828 | 34,775 | 48,346 | 264,949 | 300,832 | 68.6 | 13.1 | 18.2 | 100.0 |
| Indonesia | 7,157 | 45,599 | 19,622 | 9,002 | 74,223 | 81,380 | 61.4 | 26.4 | 12.1 | 100.0 |
| Iran | 6,933 | 22,402 | 0 | 10,555 | 32,957 | 39,889 | 68.0 | 0.0 | 32.0 | 100.0 |
| Iraq | 2,599 | 11,471 | 793 | 786 | 13,050 | 15,649 | 87.9 | 6.1 | 6.0 | 100.0 |
| Jordan | 1,550 | 278 | 26 | 1,912 | 2,217 | 3,767 | 12.6 | 1.2 | 86.3 | 100.0 |
| Kazakhstan | 1,209 | 1,493 | 7 | 6,085 | 7,585 | 8,794 | 19.7 | 0.1 | 80.2 | 100.0 |
| Lesotho | 0 | 0 | 23 | 536 | 558 | 558 | 0.0 | 4.1 | 95.9 | 100.0 |
| Macedonia | 1 | 522 | 225 | 478 | 1,225 | 1,227 | 42.6 | 18.3 | 39.0 | 100.0 |
| Moldova | 383 | 573 | 3 | 838 | 1,414 | 1,797 | 40.5 | 0.2 | 59.3 | 100.0 |
| Mongolia | 182 | 4 | 11 | 1,255 | 1,270 | 1,452 | 0.3 | 0.8 | 98.8 | 100.0 |
| Morocco | 2,224 | 5,107 | 1,217 | 8,046 | 14,371 | 16,595 | 35.5 | 8.5 | 56.0 | 100.0 |
| Namibia | 80 | 0 | 0 | 383 | 383 | 463 | 0.0 | 0.0 | 100.0 | 100.0 |

| Income group / country | Total urban population: Outside the extent of agriculture | Within the extent of agriculture: Irrigated areas | Within the extent of agriculture: Favored areas | Within the extent of agriculture: Less-favored areas | Within the extent of agriculture: Total | Grand total | Distribution of urban populations within agricultural lands: Irrigated areas | Favored areas | Less-favored areas | Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | population (000 persons) | | | | | | share of urban population (percent) | | | |
| Nicaragua | 58 | 56 | 769 | 1,890 | 2,716 | 2,773 | 2.1 | 28.3 | 69.6 | 100.0 |
| Paraguay | 9 | 77 | 1,747 | 1,183 | 3,007 | 3,016 | 2.6 | 58.1 | 39.4 | 100.0 |
| Peru | 7,390 | 2,920 | 255 | 1,161 | 4,335 | 11,726 | 67.3 | 5.9 | 26.8 | 100.0 |
| Philippines | 1,222 | 16,052 | 2,355 | 5,209 | 23,615 | 24,838 | 68.0 | 10.0 | 22.1 | 100.0 |
| Serbia | 133 | 639 | 2,220 | 2,090 | 4,949 | 5,082 | 12.9 | 44.9 | 42.2 | 100.0 |
| Sri Lanka | 204 | 517 | 2,218 | 1,281 | 4,015 | 4,219 | 12.9 | 55.2 | 31.9 | 100.0 |
| Sudan | 2,562 | 3,624 | 1,146 | 2,833 | 7,604 | 10,165 | 47.7 | 15.1 | 37.3 | 100.0 |
| Swaziland | 17 | 70 | 122 | 4 | 196 | 213 | 35.9 | 62.1 | 2.0 | 100.0 |
| Syria | 726 | 4,980 | 399 | 2,210 | 7,588 | 8,315 | 65.6 | 5.3 | 29.1 | 100.0 |
| Thailand | 204 | 15,613 | 3,452 | 1,695 | 20,760 | 20,965 | 75.2 | 16.6 | 8.2 | 100.0 |
| Trinidad and Tobago | 76 | 0 | 528 | 504 | 1,032 | 1,109 | 0.0 | 51.1 | 48.9 | 100.0 |
| Tunisia | 2,400 | 1,642 | 385 | 1,535 | 3,562 | 5,962 | 46.1 | 10.8 | 43.1 | 100.0 |
| Turkmenistan | 72 | 1,743 | 0 | 197 | 1,940 | 2,012 | 89.9 | 0.0 | 10.1 | 100.0 |
| Ukraine | 6,075 | 3,519 | 6,592 | 12,773 | 22,884 | 28,959 | 15.4 | 28.8 | 55.8 | 100.0 |
| Vanuatu | 10 | 0 | 0 | 0 | 0 | 10 | 0.0 | 0.0 | 0.0 | 0.0 |
| West Bank | 351 | 14 | 550 | 784 | 1,349 | 1,699 | 1.0 | 40.8 | 58.1 | 100.0 |
| **Upper middle income** | **105,091** | **61,579** | **120,180** | **100,862** | **282,466** | **387,712** | **21.8** | **42.5** | **35.7** | **100.0** |
| Argentina | 13,554 | 3,592 | 10,603 | 2,871 | 17,066 | 30,620 | 21.0 | 62.1 | 16.8 | 100.0 |
| Belize | 67 | 0 | 27 | 1 | 28 | 95 | 0.0 | 97.9 | 2.1 | 100.0 |
| Botswana | 113 | 0 | 0 | 467 | 467 | 580 | 0.0 | 0.0 | 100.0 | 100.0 |
| Byelarus | 1,297 | 0 | 5,082 | 76 | 5,158 | 6,455 | 0.0 | 98.5 | 1.5 | 100.0 |
| Chile | 1,538 | 6,480 | 1,908 | 1,625 | 10,014 | 11,552 | 64.7 | 19.1 | 16.2 | 100.0 |
| Costa Rica | 15 | 10 | 2,104 | 218 | 2,332 | 2,347 | 0.4 | 90.2 | 9.3 | 100.0 |
| Croatia | 69 | 0 | 603 | 739 | 1,343 | 1,411 | 0.0 | 44.9 | 55.1 | 100.0 |
| Cuba | 1,009 | 1,754 | 3,274 | 2,231 | 7,260 | 8,269 | 24.2 | 45.1 | 30.7 | 100.0 |
| Czech Republic | 502 | 207 | 2,930 | 3,770 | 6,907 | 7,409 | 3.0 | 42.4 | 54.6 | 100.0 |
| Estonia | 479 | 0 | 460 | 0 | 460 | 939 | 0.0 | 99.9 | 0.1 | 100.0 |
| Fiji | 380 | 0 | 0 | 0 | 0 | 380 | 0.0 | 0.0 | 0.0 | 0.0 |
| Gabon | 569 | 0 | 302 | 6 | 309 | 877 | 0.0 | 97.9 | 2.1 | 100.0 |
| Grenada | 56 | 0 | 0 | 0 | 0 | 56 | 0.0 | 0.0 | 0.0 | 0.0 |
| Jamaica | 103 | 184 | 300 | 834 | 1,317 | 1,420 | 13.9 | 22.8 | 63.3 | 100.0 |

| Income group / country | Total urban population | | | | | | Distribution of urban populations within agricultural lands | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Outside the extent of agriculture | Within the extent of agriculture | | | | Grand total | Irrigated areas | Favored areas | Less-favored areas | Grand total |
| | | Irrigated areas | Favored areas | Less-favored areas | Total | | | | | |
| | population (000 persons) | | | | | | share of urban population (percent) | | | |
| Latvia | 682 | 0 | 870 | 32 | 902 | 1,584 | 0.0 | 96.4 | 3.6 | 100.0 |
| Lebanon | 1,148 | 726 | 538 | 562 | 1,826 | 2,974 | 39.8 | 29.5 | 30.8 | 100.0 |
| Libya | 1,693 | 1,951 | 74 | 786 | 2,811 | 4,504 | 69.4 | 2.6 | 28.0 | 100.0 |
| Lithuania | 344 | 0 | 1,992 | 119 | 2,111 | 2,455 | 0.0 | 94.4 | 5.6 | 100.0 |
| Malaysia | 691 | 1,334 | 5,977 | 5,678 | 12,989 | 13,680 | 10.3 | 46.0 | 43.7 | 100.0 |
| Mauritius | 409 | 510 | 0 | 0 | 510 | 919 | 100.0 | 0.0 | 0.0 | 100.0 |
| Mexico | 15,755 | 19,291 | 10,793 | 17,101 | 47,186 | 62,941 | 40.9 | 22.9 | 36.2 | 100.0 |
| Montenegro | 12 | 0 | 209 | 104 | 313 | 326 | 0.0 | 66.8 | 33.2 | 100.0 |
| Panama | 370 | 0 | 341 | 941 | 1,283 | 1,652 | 0.0 | 26.6 | 73.4 | 100.0 |
| Poland | 5,122 | 60 | 14,789 | 2,282 | 17,131 | 22,253 | 0.3 | 86.3 | 13.3 | 100.0 |
| Romania | 1,403 | 1,203 | 3,556 | 4,546 | 9,305 | 10,708 | 12.9 | 38.2 | 48.9 | 100.0 |
| Russia | 36,643 | 2,111 | 32,970 | 26,014 | 61,095 | 97,738 | 3.5 | 54.0 | 42.6 | 100.0 |
| South Africa | 7,218 | 1,976 | 8,371 | 8,054 | 18,401 | 25,619 | 10.7 | 45.5 | 43.8 | 100.0 |
| Suriname | 184 | 0 | 117 | 0 | 117 | 301 | 0.0 | 100.0 | 0.0 | 100.0 |
| Turkey | 7,483 | 16,582 | 3,259 | 16,140 | 35,981 | 43,464 | 46.1 | 9.1 | 44.9 | 100.0 |
| Uruguay | 310 | 12 | 2,288 | 201 | 2,501 | 2,812 | 0.5 | 91.5 | 8.0 | 100.0 |
| Venezuela | 5,531 | 3,442 | 6,441 | 5,462 | 15,345 | 20,876 | 22.4 | 42.0 | 35.6 | 100.0 |
| misc islands | 342 | 155 | 0 | 0 | 155 | 497 | 100.0 | 0.0 | 0.0 | 100.0 |
| **Grand Total** | **705,335** | **990,171** | **561,420** | **527,911** | **2,079,347** | **2,784,837** | **47.6** | **27.0** | **25.4** | **100.0** |

Source: Country groupings per World Bank data (World Bank 2008); extent of agriculture and favorability index (Sebastian 2009); population - GRUMP (CIESIN/IFPRI/CIAT 2008)

## Table 3. Agricultural area by income group, favorability index and market accessibility

| Income Group by Favorability Class | Market Accessibility: High 0–2 hours | Medium 2–4 hours | Low 4–8 hours | Remote > 8 hours | Grand total | Distribution by Market Accessibility Class: High 0–2 hours | Medium 2–4 hours | Low 4–8 hours | Remote > 8 hours | Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | area - 000 square kilometers | | | | | share by market accessibility (percent) | | | | |
| **Low income** | **1,818** | **2,690** | **3,706** | **2,883** | **11,096** | **16.4** | **24.2** | **33.4** | **26.0** | **100.0** |
| Irrigated areas | 442 | 250 | 148 | 26 | 865 | 51.1 | 28.9 | 17.1 | 3.0 | 100.0 |
| Favored rainfed areas | 706 | 1,155 | 1,414 | 1,036 | 4,310 | 16.4 | 26.8 | 32.8 | 24.0 | 100.0 |
| Less-favored rainfed areas | 670 | 1,285 | 2,144 | 1,821 | 5,921 | 11.3 | 21.7 | 36.2 | 30.8 | 100.0 |
| **Lower-middle income** | **6,840** | **6,025** | **6,504** | **7,450** | **26,819** | **25.5** | **22.5** | **24.3** | **27.8** | **100.0** |
| Irrigated areas | 2,258 | 1,137 | 569 | 121 | 4,085 | 55.3 | 27.8 | 13.9 | 3.0 | 100.0 |
| Favored rainfed areas | 2,038 | 1,974 | 2,048 | 2,541 | 8,601 | 23.7 | 23.0 | 23.8 | 29.5 | 100.0 |
| Less-favored rainfed areas | 2,545 | 2,914 | 3,887 | 4,788 | 14,133 | 18.0 | 20.6 | 27.5 | 33.9 | 100.0 |
| **Upper-middle income** | **3,450** | **2,970** | **2,141** | **955** | **9,516** | **36.3** | **31.2** | **22.5** | **10.0** | **100.0** |
| Irrigated areas | 393 | 163 | 63 | 9 | 627 | 62.6 | 26.0 | 10.0 | 1.4 | 100.0 |
| Favored rainfed areas | 1,611 | 1,184 | 739 | 293 | 3,827 | 42.1 | 30.9 | 19.3 | 7.7 | 100.0 |
| Less-favored rainfed areas | 1,446 | 1,623 | 1,339 | 653 | 5,062 | 28.6 | 32.1 | 26.5 | 12.9 | 100.0 |
| **Total Low to Upper middle income** | **12,108** | **11,685** | **12,351** | **11,288** | **47,432** | **25.5** | **24.6** | **26.0** | **23.8** | **100.0** |
| Irrigated areas | 3,093 | 1,550 | 779 | 156 | 5,578 | 55.5 | 27.8 | 14.0 | 2.8 | 100.0 |
| Favored rainfed areas | 4,354 | 4,313 | 4,202 | 3,869 | 16,738 | 26.0 | 25.8 | 25.1 | 23.1 | 100.0 |
| Less-favored rainfed areas | 4,661 | 5,822 | 7,371 | 7,263 | 25,116 | 18.6 | 23.2 | 29.3 | 28.9 | 100.0 |
| High income - OECD | 4,228 | 3,000 | 2,399 | 1,236 | 10,863 | 38.9 | 27.6 | 22.1 | 11.4 | 100.0 |
| High income - Other | 64 | 24 | 26 | 13 | 127 | 50.1 | 18.6 | 20.8 | 10.5 | 100.0 |
| **Grand total area within the extent of agriculture** | **16,400** | **14,708** | **14,776** | **12,537** | **58,421** | **28.1** | **25.2** | **25.3** | **21.5** | **100.0** |

Source: Country groupings per World Bank data (World Bank 2008); extent of agriculture and favorability index (Sebastian 2009); Market access (Nelson 2008); land area (CIESIN/IFPRI/CIAT 2008)

Note: The totals here may differ slightly from the totals in Table 2b due to varying resolutions of the overlay datasets. The differences are negligible and do not change the overall distribution.

## Table 4. Rural population (within the extent of agriculture) by income group, favorability index and market accessibility

| Income Group by Favorability Index | Market Accessibility: High 0–2 hours | Medium 2–4 hours | Low 4–8 hours | Remote > 8 hours | Grand total | Distribution of Rural Population by Market Accessibility Class: High 0–2 hours | Medium 2–4 hours | Low 4–8 hours | Remote > 8 hours | Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | rural population - millions persons | | | | | share by market accessibility (percent) | | | | |
| **Low income** | **264** | **185** | **133** | **55** | **637** | **41.4** | **29.1** | **20.9** | **8.7** | **100.0** |
| Irrigated areas | 149 | 61 | 23 | 3 | 235 | 63.2 | 25.9 | 9.8 | 1.1 | 100.0 |
| Favored rainfed areas | 67 | 65 | 52 | 20 | 204 | 32.9 | 31.7 | 25.6 | 9.8 | 100.0 |
| Less-favored rainfed areas | 48 | 60 | 58 | 33 | 198 | 24.2 | 30.2 | 29.1 | 16.5 | 100.0 |
| **Lower-middle income** | **907** | **550** | **325** | **121** | **1,904** | **47.7** | **28.9** | **17.1** | **6.4** | **100.0** |
| Irrigated areas | 539 | 265 | 110 | 14 | 927 | 58.1 | 28.5 | 11.8 | 1.5 | 100.0 |
| Favored rainfed areas | 159 | 116 | 88 | 53 | 415 | 38.2 | 27.8 | 21.3 | 12.7 | 100.0 |
| Less-favored rainfed areas | 210 | 170 | 127 | 55 | 562 | 37.4 | 30.2 | 22.6 | 9.8 | 100.0 |
| **Upper-middle income** | **80** | **46** | **25** | **7** | **158** | **50.8** | **28.9** | **15.9** | **4.4** | **100.0** |
| Irrigated areas | 11 | 4 | 1 | 0 | 17 | 67.2 | 24.2 | 7.7 | 1.0 | 100.0 |
| Favored rainfed areas | 37 | 19 | 10 | 3 | 70 | 53.8 | 27.3 | 14.5 | 4.5 | 100.0 |
| Less-favored rainfed areas | 32 | 23 | 14 | 4 | 72 | 44.2 | 31.6 | 19.1 | 5.1 | 100.0 |
| **Total Low to Upper middle income** | **1,251** | **781** | **483** | **183** | **2,699** | **46.4** | **28.9** | **17.9** | **6.8** | **100.0** |
| Irrigated areas | 698 | 329 | 134 | 17 | 1,178 | 59.3 | 28.0 | 11.4 | 1.4 | 100.0 |
| Favored rainfed areas | 264 | 199 | 151 | 76 | 689 | 38.2 | 28.9 | 21.8 | 11.0 | 100.0 |
| Less-favored rainfed areas | 290 | 252 | 198 | 91 | 831 | 34.8 | 30.3 | 23.9 | 10.9 | 100.0 |
| High income - OECD | 92 | 29 | 9 | 1 | 131 | 70.5 | 21.8 | 7.0 | 0.7 | 100.0 |
| High income - Other | 3 | 1 | 1 | 0 | 5 | 65.5 | 19.4 | 12.0 | 3.1 | 100.0 |
| **Grand total rural population within the extent of agriculture** | **1,347** | **810** | **493** | **184** | **2,834** | **47.5** | **28.6** | **17.4** | **6.5** | **100.0** |

Source: Country groupings per World Bank data (World Bank 2008); extent of agriculture and favorability index (Sebastian 2009); Market access (Nelson 2008); population - GRUMP (CIESIN/IFPRI/CIAT 2008)

Note: The totals here may differ slightly from the totals in Table 2b due to varying resolutions of the overlay datasets. The differences are negligible and do not change the overall distribution.

## Table 5. Total land area by income groups and land cover class*

| Land cover class | Grand total | High income subtotal | | Low / middle income subtotal | | Low income | | Lower middle income | | Upper middle income | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | area - 000 sqkm | area - 000 sqkm | percent of area by income group | area - 000 sqkm | percent of area by income group | area - 000 sqkm | percent of area by income group | area - 000 sqkm | percent of area by income group | area - 000 sqkm | percent of area by income group |
| Post-flooding or irrigated croplands | 2,165 | 18 | 0.1 | 2,147 | 2.2 | 501 | 2.3 | 1,642 | 3.6 | 3 | 0.0 |
| Rainfed croplands | 7,764 | 1,638 | 4.9 | 6,125 | 6.3 | 810 | 3.7 | 4,135 | 9.1 | 1,181 | 4.0 |
| Mosaic cropland/vegetation (grassland/shrubland/forest) | 6,921 | 762 | 2.3 | 6,158 | 6.4 | 1,083 | 4.9 | 3,523 | 7.7 | 1,552 | 5.3 |
| Mosaic vegetation (grassland/shrubland/forest)/cropland | 9,537 | 1,072 | 3.2 | 8,462 | 8.7 | 2,566 | 11.7 | 4,125 | 9.1 | 1,772 | 6.0 |
| **Total cropland area (per GlobCover)** | **26,386** | **3,489** | **10.4** | **22,893** | **23.6** | **4,960** | **22.5** | **13,424** | **29.5** | **4,508** | **15.3** |
| *percent of total cropland area* | *100* | *13* | | *87* | | *19* | | *51* | | *17* | |
| Closed to open forest | 15,020 | 1,842 | 5.5 | 13,178 | 13.6 | 2,323 | 10.6 | 8,270 | 18.2 | 2,585 | 8.8 |
| Closed forest | 8,944 | 3,805 | 11.4 | 5,139 | 5.3 | 1,049 | 4.8 | 1,878 | 4.1 | 2,211 | 7.5 |
| Open forest | 12,760 | 3,328 | 9.9 | 9,426 | 9.7 | 1,851 | 8.4 | 978 | 2.2 | 6,597 | 22.4 |
| Mosaic forest, grassland & shrubland | 9,770 | 4,156 | 12.4 | 5,556 | 5.7 | 1,310 | 6.0 | 1,275 | 2.8 | 2,972 | 10.1 |
| Shrubland & grassland | 18,505 | 5,524 | 16.5 | 12,980 | 13.4 | 4,269 | 19.4 | 5,425 | 11.9 | 3,287 | 11.2 |
| **Total natural vegetation** | **65,000** | **18,655** | **55.7** | **46,280** | **47.8** | **10,802** | **49.1** | **17,826** | **39.2** | **17,652** | **60.0** |
| *percent of total natural vegetation* | *100* | *29* | | *71* | | *17* | | *27* | | *27* | |
| Sparse vegetation, bare areas &/or permanent snow and ice | 35,385 | 10,282 | 30.7 | 25,028 | 25.8 | 5,668 | 25.8 | 13,087 | 28.8 | 6,273 | 21.3 |
| Flooded areas | 1,759 | 154 | 0.5 | 1,605 | 1.7 | 431 | 2.0 | 622 | 1.4 | 552 | 1.9 |
| Urban &/or artificial surfaces | 330 | 148 | 0.4 | 182 | 0.2 | 14 | 0.1 | 123 | 0.3 | 44 | 0.2 |
| Water bodies | 1,653 | 761 | 2.3 | 893 | 0.9 | 121 | 0.6 | 387 | 0.9 | 384 | 1.3 |
| **Total area** | **130,513** | **33,490** | **100.0** | **96,880** | **100.0** | **21,997** | **100.0** | **45,470** | **100.0** | **29,413** | **100.0** |
| *percent of total area* | *100.0* | *25.7* | | *74.3* | | *16.9* | | *34.9* | | *22.6* | |

*Land cover classes were aggregated from the GlobCover land cover dataset (GlobCover 2008).

Source: Country groupings per World Bank data (World Bank 2008); land cover (GlobCover 2008); land area (CIESIN/IFPRI/CIAT 2008)

## Table 6. Distribution of agricultural areas by favorability and land cover class for low to middle income populations

| | Low income | | | | | Lower middle income | | | | | Upper middle income | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Land cover class** | **Irrigated lands** | **Favored lands** | **Less-favored lands** | **Total** | | **Irrigated lands** | **Favored lands** | **Less-favored lands** | **Total** | | **Irrigated lands** | **Favored lands** | **Less-favored lands** | **Total** | |
| | **area share by income group - percent** | | | | **area - 000 sqkm** | **area share by income group - percent** | | | | **area - 000 sqkm** | **area share by income group - percent** | | | | **area - 000 sqkm** |
| Post-flooding or irrigated croplands | 79.3 | 9.8 | 10.9 | 100.0 | 487 | 67.1 | 11.4 | 21.5 | 100.0 | 1,603 | 67.6 | 13.3 | 19.1 | 100.0 | 3 |
| Rainfed croplands | 10.7 | 26.8 | 62.4 | 100.0 | 657 | 25.6 | 31.0 | 43.4 | 100.0 | 3,928 | 7.9 | 47.9 | 44.3 | 100.0 | 1,113 |
| Mosaic cropland/vegetation | 6.6 | 42.2 | 51.1 | 100.0 | 815 | 15.3 | 37.4 | 47.3 | 100.0 | 3,156 | 6.3 | 42.1 | 51.7 | 100.0 | 1,446 |
| Mosaic vegetation/cropland | 4.9 | 35.5 | 59.6 | 100.0 | 1,646 | 11.9 | 31.2 | 56.9 | 100.0 | 3,651 | 7.0 | 38.2 | 54.8 | 100.0 | 1,573 |
| **Total cropland area (per GlobCover)** | **16.4** | **32.0** | **51.6** | **100.0** | **3,605** | **24.3** | **30.2** | **45.5** | **100.0** | **12,338** | **7.0** | **42.1** | **50.9** | **100.0** | **4,134** |
| *percent of total cropland area* | | | | | | | | | | | | | | | |
| Closed to open forest | 2.0 | 63.6 | 34.4 | 100.0 | 370 | 5.1 | 61.7 | 33.3 | 100.0 | 2,690 | 3.5 | 57.3 | 39.2 | 100.0 | 664 |
| Closed forest | 2.5 | 71.9 | 25.6 | 100.0 | 647 | 11.1 | 48.2 | 40.7 | 100.0 | 1,364 | 3.4 | 55.5 | 41.1 | 100.0 | 977 |
| Open forest | 1.4 | 74.4 | 24.3 | 100.0 | 1,285 | 3.3 | 71.7 | 25.0 | 100.0 | 624 | 4.0 | 45.0 | 51.0 | 100.0 | 239 |
| Mosaic forest, grassland & shrubland | 3.1 | 30.6 | 66.3 | 100.0 | 917 | 6.9 | 35.7 | 57.4 | 100.0 | 975 | 8.0 | 29.3 | 62.6 | 100.0 | 801 |
| Shrubland & grassland | 2.5 | 38.2 | 59.3 | 100.0 | 2,967 | 5.5 | 38.6 | 55.8 | 100.0 | 3,796 | 8.6 | 27.9 | 63.5 | 100.0 | 1,726 |
| **Total natural vegetation** | **2.3** | **49.6** | **48.0** | **100.0** | **6,186** | **6.2** | **48.5** | **45.4** | **100.0** | **9,449** | **6.3** | **39.6** | **54.0** | **100.0** | **4,406** |
| *percent of total natural vegetation* | | | | | | | | | | | | | | | |
| Sparse vegetation, bare areas &/or ice | 9.7 | 1.1 | 89.3 | 100.0 | 1,153 | 8.5 | 1.3 | 90.2 | 100.0 | 4,554 | 5.9 | 27.3 | 66.8 | 100.0 | 726 |
| Flooded areas | 5.5 | 56.3 | 38.1 | 100.0 | 81 | 2.5 | 86.2 | 11.4 | 100.0 | 237 | 2.4 | 74.1 | 23.5 | 100.0 | 114 |

| Land cover class | Low income | | | | | Lower middle income | | | | | Upper middle income | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Irrigated lands | Favored lands | Less-favored lands | Total | | Irrigated lands | Favored lands | Less-favored lands | Total | | Irrigated lands | Favored lands | Less-favored lands | Total | |
| | area share by income group - percent | | | | area - 000 sqkm | area share by income group - percent | | | | area - 000 sqkm | area share by income group - percent | | | | area - 000 sqkm |
| Urban &/or artificial surfaces | 38.9 | 33.7 | 27.4 | 100.0 | 10 | 59.6 | 13.2 | 27.3 | 100.0 | 105 | 12.9 | 49.1 | 38.0 | 100.0 | 28 |
| Water bodies | 21.3 | 41.5 | 37.3 | 100.0 | 62 | 22.1 | 34.3 | 43.5 | 100.0 | 216 | 5.1 | 41.7 | 53.1 | 100.0 | 106 |
| **Total area** | **7.8** | **38.8** | **53.3** | **100.0** | **11,096** | **15.2** | **32.2** | **52.6** | **100.0** | **26,898** | **6.6** | **40.2** | **53.2** | **100.0** | **9,514** |
| *percent of total area* | | | | | | | | | | | | | | | |

| | Total low to middle income | | | | |
|---|---|---|---|---|---|
| **Land cover class** | **Irrigated lands** | **Favored lands** | **Less-favored lands** | **Total** | |
| | | **area share by income group - percent** | | | **area - 000 sqkm** |
| Post-flooding or irrigated croplands | 69.9 | 11.0 | 19.0 | 100.0 | 2,092 |
| Rainfed croplands | 20.5 | 33.8 | 45.7 | 100.0 | 5,698 |
| Mosaic cropland/vegetation | 11.6 | 39.4 | 49.0 | 100.0 | 5,417 |
| Mosaic vegetation/cropland | 9.1 | 33.8 | 57.1 | 100.0 | 6,869 |
| **Total cropland area (per GlobCover)** | **19.3** | **32.9** | **47.7** | **100.0** | **20,077** |
| *percent of total cropland area* | | | | | |
| Closed to open forest | 4.5 | 61.1 | 34.4 | 100.0 | 3,724 |
| Closed forest | 6.7 | 55.7 | 37.5 | 100.0 | 2,987 |
| Open forest | 2.2 | 70.3 | 27.5 | 100.0 | 2,148 |
| Mosaic forest, grassland & shrubland | 5.9 | 32.1 | 62.0 | 100.0 | 2,693 |
| Shrubland & grassland | 5.1 | 36.3 | 58.6 | 100.0 | 8,489 |
| **Total natural vegetation** | **5.0** | **46.9** | **48.1** | **100.0** | **20,041** |
| *percent of total natural vegetation* | | | | | |
| Sparse vegetation, bare areas &/or ice | 8.4 | 4.2 | 87.4 | 100.0 | 6,433 |
| Flooded areas | 3.0 | 77.4 | 19.6 | 100.0 | 432 |
| Urban &/or artificial surfaces | 49.1 | 21.5 | 29.4 | 100.0 | 143 |
| Water bodies | 17.3 | 37.5 | 45.2 | 100.0 | 383 |
| **Total area** | **11.7** | **35.3** | **52.9** | **100.0** | **47,508** |
| *percent of total area* | | | | | |

Source: Country groupings per World Bank data (World Bank 2008); extent of agriculture and favorability index (Sebastian 2009); land cover (GlobCover 2008); land area (CIESIN/IFPRI/CIAT 2008)

* Land cover classes were aggregated from the GlobCover land cover dataset (GlobCover 2000).

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