CHAPTER THREE

The Scope for and Desirability of Land Expansion

For an accurate assessment of future trends in land use, it is important to look at supply as well as demand (Hertel 2010). By focusing only on demand, many analyses of large land acquisition to date are investor-centric rather than country-oriented. This risks creating the impression that large land acquisition is inevitable or an end in itself rather than exploring how investments can help countries achieve their development goals most effectively. A country-level assessment of rainfed land resources available, the effectiveness with which these are used, and ways to move closer to utilizing the productive potential of these resources, has three advantages:

- It highlights that large-scale land acquisition is only one of many options, the desirability of which has to be weighed against that of alternatives to increase output and improve smallholder welfare.
- It highlights that, even if unused land is available, investors are likely to make socially optimal land use decisions only if current uses are appropriately compensated and if external effects are considered.
- Having an independent assessment of land suitability to identify hotspots where investor interest may materialize in the future will allow countries to take measures in anticipation of such interest and can also provide a yardstick to assess whether investors do indeed focus on the most productive land.

Of course, even currently noncultivated land that is identified as "suitable" for rainfed cultivation by these criteria will normally be subject to existing claims that investors will have to recognize and compensate even if they are not formalized.

To identify the potential supply of land suitable for rainfed cultivation at the country level, we use agro-ecological modeling to simulate, for every pixel on the global map, the potential output from rainfed cultivation of five major crops. Linking this to current land use, population density, infrastructure access, and other variables allows us to determine the land that might be suitable for expansion of these crops using rainfed cultivation given the current climate.

At the country level, this approach allows us to quantify the scope for expansion of rainfed cultivated area and intensification on land already cultivated as the two main sources of higher output. The first is done by identifying currently noncultivated areas with different attributes that could be suitable for rainfed cultivation of main crops. The second is done by quantifying the gap between actual and potential yield for currently cultivated areas. This provides useful insights in several respects:

- The largest amount of land potentially suitable for rainfed agriculture is in Sub-Saharan Africa, followed by Latin America and the Caribbean. It is concentrated in a limited number of countries. In many of these countries, the ratio of land that is potentially suitable for rainfed agriculture to what is currently cultivated is large, highlighting the possibly far-reaching social impacts of outside investment. Where yield gaps are high, it will be important to explore options for increasing smallholder yields prior to or simultaneously with those for expanding the cultivated area and to ensure that investment addresses market, infrastructure, or technology constraints faced by existing producers.
- In the aggregate, there is no need to expand into forest to cope with projected increases in demand for agricultural commodities and land. However, we can identify countries where the presence of large tracts of forest that could be converted to agriculture together with little suitable nonforested land for potential area expansion is likely to generate pressure for conversion. Raising countries' and local populations' awareness of this is a precondition for putting in place more forceful efforts and innovative approaches for protecting such critical areas and monitoring their use more intensively to allow action before potentially irreversible changes have occurred.
- The magnitude and spatial concentration of land suitable for expansion of rainfed cultivation, and the fact that such land is often located far from infrastructure or in environments that lack technology, highlights that rainfed cultivated area expansion through large-scale investment faces numerous challenges. To overcome these challenges, a strategic approach and partnerships between private and public sectors in infrastructure investment and technology transfer will be needed. In many cases, such actions can also help smallholders increase their productivity and close the yield gap.
- A typology based on country yield gaps and the potential for expansion of rainfed cultivation allows comparison of the scope for area expansion with

that for intensification to identify ways in which investment at the country level can most effectively support broader development efforts. Using this information strategically can help countries set rules for the parameters of investments and engage more proactively with investors to ensure they contribute to development.

METHODOLOGY AND POTENTIAL AVAILABILITY OF LAND FOR RAINFED CROP PRODUCTION

To provide the basis for identifying yield gaps and thus the scope for raising productivity on existing farmland as well as aggregate area potentially suitable for rainfed cultivation, and to allow more specific identification of potential hotspots of investor interest, we assess the potential revenue from cultivation of five main crops (sugarcane, wheat, maize, oil palm, and soybean) under rainfed conditions and apply prices to determine the one with the highest value of output. Doing so allows us to identify three types of land:

- Land currently cultivated where comparing potential to actual yield provides a basis for estimating the "yield gap"—the amount by which output could be increased under best practice management and production technologies.[1]
- Land not cultivated, not forested, and not protected with low levels of population density that could potentially be suitable for rainfed agricultural production.
- Land currently forested in unprotected areas with low population density that are potentially suitable for rainfed crop production.

To be relevant for actual decisions, such an assessment will need to be complemented with data on other types of relevant land uses (for example, biodiversity), which, if at all, are available only at the country level. As long as their shortcomings are borne in mind, global data can, however, provide a first approximation. They point toward the availability of some 445 million hectares (ha) of currently uncultivated, nonforested land that would be ecologically suitable for rainfed cultivation in areas with less than 25 persons/square kilometer (km^2). This implies that projected future demands could in principle be satisfied without cutting down forests. Much of this land is concentrated in a limited number of countries, many in Africa, and some of it is far from infrastructure. Although transport cost will reduce economic land rents depending on the market for which output is produced, potential output values in many of these areas are likely to be far above what is obtained from the land under its current use. As it is imperative that any transfer of land to large-scale investors be voluntary, we can identify the areas where such voluntary land transfers would be an option in principle.

Methodology

The starting point for any assessment of the potential supply of land for rainfed cultivation is an assessment of potential yields that can be achieved on a given plot based on simulation of plant growth, which depends on agro-ecological factors, such as soil, temperature, precipitation, elevation, and other terrain factors.[2] We use the agro-ecological zoning (AEZ) methodology developed by the International Institute for Applied Systems Analysis (IIASA) for five main rainfed crops. It predicts potential yield for rainfed cultivation of five key crops based on a large array of environmental factors summarized in land use types globally at a very high resolution (Fischer and others 2002; Shah and others 2008). Together with assumptions on management and input intensity, this can be used to identify suitability and potential yields for different crops in each cell.[3] Applying a price vector then allows the determination of the crop that produces the highest revenue and the construction of a surface of output values. In other words, this information highlights the maximum potential value of output that can be produced from one of the five crops in our set at a given pixel based on current climate and prices. To illustrate the concept, the resulting output value surfaces (in 2000 U.S. dollars) for Europe, the Middle East and North Africa, Asia, Oceania, Latin America and the Caribbean, and Sub-Saharan Africa are shown in appendix 4.

To make these data useful for policy, we link agro-ecological potential for rainfed cultivation to information on current land use (for example, whether an area is protected or forested), population density, and infrastructure access. Overlays with protected areas currently under forest with high biodiversity value, for example, can identify areas where better enforcement of protection will be needed because the value of current and future social and environmental benefits from forest use exceeds that of potential cultivation for agriculture. For cultivated cells, the difference between potential and actual yield provides an estimate of the yield gap. For noncultivated cells, the map identifies the crop that would generate the highest monetary output under rainfed cultivation. All this information can then be used as an input into local land use planning. Such planning, especially if combined with identification and mapping of rights, can help identify both underused potential and subsequent measures to better use it, such as by attracting capable investors to directly farm, to contract local farmers, or to construct complementary infrastructure. Aggregation at the country level then provides information that can feed into policy formulation, classification of priority areas for identification and demarcation of land rights, and monitoring efforts.

Global Availability of Suitable Land

We use the AEZ methodology to identify regions and countries within regions where nonforested, unprotected, and currently noncultivated land suitable for rainfed cultivation of at least one of five key crops (wheat, sugarcane, oil palm, maize, and soybean) is available in areas with less than 5, 10, or 25 persons/km^2, implying availability of 100, 50, or 20 ha per household. Very little, if any, of this land will be free of existing claims that will have to be recognized by any potential investment, even if they are not formalized. But case studies suggest that, at such low levels of population density, voluntary land transfers that make everybody better off are possible. To highlight that in many cases effective use of such land may require addition of infrastructure, we classify land based on the travel time to the next city with a population of at least 50,000 inhabitants using the most common means of transport with a cutoff of six hours to market.

Results suggest that the nonforested noncultivated area suitable for rainfed cultivation of at least one of the crops considered here amounts to some 445 million ha, less than a third of the currently cultivated area of just over 1,500 million ha (table 3.1 and appendix 2, table A2.6). Depending on the cutoff in population density, the amount of nonforested and unprotected area suitable to cultivate the five crops considered here varies between 198 million ha and 446 million ha. As one moves toward successively lower levels of population density, the share of this area located within six hours of the next market is reduced from 59 percent to 51 percent and 44 percent, respectively, for the three levels considered here. In all cases, though, the largest total area available for rainfed cultivation is in Africa (202 million ha, 128 million ha, and 68 million ha corresponding to 45, 42, and 34 percent of the total, respectively), followed by Latin America. The concentration of currently uncultivated but potentially suitable land for rainfed cultivation illustrates that availability of such land in the rest of the world (namely, Eastern Europe, East and South Asia, Middle East and North Africa, and all other countries together) is less than what is available in Latin America and the Caribbean alone.

Even within regions, land not currently cultivated but potentially suitable for rainfed cultivation is concentrated in a few countries. Using the 25 persons/km^2 cutoff, the seven countries with the largest amount of land available (Sudan, Brazil, Australia, the Russian Federation, Argentina, Mozambique, and Democratic Republic of Congo, in that order) account for 224 million ha, or

Table 3.1 Potential Supply of Land for Rainfed Cultivation in Different Regions (thousand ha)

	Total area	Area < 6 hours	Area > 6 hours
Sub-Saharan Africa	201,540	94,919	106,621
Latin America and the Caribbean	123,342	93,957	29,385
Eastern Europe and Central Asia	52,387	43,734	8,653
East and South Asia	14,341	3,320	11,021
Middle East and North Africa	3,043	2,647	396
Rest of world	50,971	24,554	26,417
Total	**445,624**	**263,131**	**182,493**

Source: Fischer and Shah 2010.

more than half of global availability. The 32 countries with more than 3 million ha of land each account for more than 90 percent of available land. Of these, 16 are in Sub-Saharan Africa, 8 in Latin America and the Caribbean, 3 in Eastern Europe and Central Asia, and 5 in the rest of the world. Many of the countries with ample land available have only limited amounts of land under cultivation. Currently uncultivated land suitable for cultivation is more than double what is currently cultivated in 11 countries and more than triple the currently cultivated area in 6 countries.[4]

Using 2005 prices to determine output-maximizing crops and focusing on areas not currently cultivated, not forested, and within six hours to the next market, we find some interesting patterns (table 3.2 and appendix 2, table A2.7).[5] First, for the total area of 263 million ha, just under a third is suited for maize and soybean (some 83 million ha each), followed by about a fourth for wheat (71 million ha), a little less than a tenth for sugarcane (22 million ha), and less than a fiftieth for oil palm. Comparing the potential for area expansion with what is currently cultivated suggests that the potential area for expansion close to markets is significantly below what is currently cultivated for wheat, maize, and oil palm, and about equal to the area currently cropped for maize and sugarcane.

Table 3.2 Potential Area of Nonforested, Nonprotected Land Close to Market Most Suitable for Different Crops under Rainfed Cultivation, (thousand ha)

	5 crop total	Maize	Soybean	Wheat	Sugarcane	Oil palm
Sub-Saharan Africa	94,919	44,868	38,993	3,840	6,023	1,194
Latin America and the Caribbean	93,957	28,385	37,716	11,043	15,021	1,793
Europe and Central Asia	43,734	3,851	419	39,464	0	0
East and South Asia	3,320	465	443	1,045	500	867
Middle East and North Africa	2,647	0	10	2,637	0	0
Rest of World	24,554	5,741	5,289	12,747	722	55
Total < 6 hours to market	263,131	83,310	82,870	70,776	22,266	3,909
Total	445,624	156,828	137,711	88,149	41,176	21,760
Total cultivated 2008	520,411	161,017	96,870	223,564	24,375	14,585

Source: Fischer and Shah 2010.

Note: Assessments are based on fewer than 25 persons/km^2 and less than six hours to market. 2005 output prices are used to determine gross revenue.

The large amounts of nonforested areas with potential for rainfed production in areas with a low population density imply that there is no need, in principle, to draw on currently forested areas to satisfy demand for agricultural commodities in the future. As logging can generate large rents that could be further enhanced for land suitable for rainfed agricultural cultivation, it will be important to identify currently nonprotected forested areas suitable for agricultural cultivation to identify potential hotspots and help governments and other stakeholders take necessary precautions. Doing so reveals that most of these forests are in the Amazon, the Congo Basin, and the outer islands of Indonesia. Brazil has the largest area of unprotected forested land with high rainfed cultivation potential (some 131 million ha[6]), followed closely by Russia at 129 million ha. Other countries, including Colombia, the Democratic Republic of Congo, Gabon, Guyana, Peru, Suriname, and Zambia, have suitable nonprotected forested areas several times the size of their currently cultivated area. Cutting down such forests can result in the loss of a wide range of social and environmental benefits. Methods to value these benefits (box 3.1) will be important as a basis for decisions on how to compensate users for social benefits they provide, whether or not to protect these areas, and how to enforce such protection.

Comparing actual to potential physical yields for each cultivated pixel provides an estimate of the maximum potential output that can establish a benchmark for the scope of increasing output on currently cultivated areas. Aggregate results from doing so at the crop and regional level point to clear regional and cross-commodity differences (table 3.3). Oceania is close to realizing its full potential, followed by North America (0.89), Europe (0.81), and South America (0.65). By contrast, with only 20 percent of potential production realized, Sub-Saharan Africa offers large potential for increasing yields on currently cultivated areas.

To illustrate this concept, attaining 80 percent of potential yield—the level usually considered to be economical (Fischer and others 2009)—would quadruple maize output in Sub-Saharan Africa. This would be equivalent to a potential area expansion of 90 million ha—more than the total global area suitable for maize expansion within six hours of market. Such increases would provide significant benefits to local populations while involving lower risks—and often significantly lower cost—than area expansion. Countries with large areas of land potentially suitable for rainfed production and large yield gaps will thus need to strategically assess how to combine intensification with area expansion. They will also need to identify public and private investments and the incentives required to attract private investors accordingly.

While aggregate results from applying the AEZ methodology demonstrate the methodology's potential, its application at the country level can yield highly relevant policy insights. To do so, a first step is often to better organize existing information or to complement it with additional layers, such as data on land rights, to add value. Complementing global with country level analysis could, in particular, expand the analysis in three ways.

Box 3.1 Assessing and Valuing Indirect Impacts of Land Cover Change

Land characteristics (soils, slope) and vegetative cover (crops, pasture, forests, woodlands, grasslands) are linked to ecosystem services such as carbon sequestration, surface and groundwater flows, and biodiversity niches with implications far beyond an individual parcel. Converting land use from natural state to intensive use will have immediate and longer-term impacts on hydrology, carbon stocks, and biodiversity that often provide important livelihood support and safety nets for poor and landless people. Although these are at present mostly neglected, finding ways to quantify and value such impacts is an important challenge for research that has immediate policy implications.

To address this challenge, tools and decision support systems to provide stakeholders (local communities, local governments, and policy makers) with timely and spatially relevant information and projections of land and water use and interacting climate change are being developed in a number of contexts. One such model that many countries are currently using to assess impacts of infrastructure development, large-scale farming, and land cover changes, among others, is the Variable Infiltration Capacity (VIC) model (Richey and Fernandes 2007). The basic idea is to simulate the hydrometeorological cycle by building on layers of meteorological forcing (land surface climatology of daily precipitation, minimum and maximum temperature, and winds), vegetation attributes by vegetation class, a river network derived from a digital elevation model, and river discharge history at select stations. But these models can provide the basis for a wide range of applications, including prediction of the impact of climate change or deforestation. To apply them in practice, it will be important to bring these models to a sufficiently localized level where they can inform policy decisions and resource valuations.

Source: Richey and Fernandes 2007.

Table 3.3 Current Yield Relative to Estimated Potential Yield

Region	Maize	Oil palm	Soybean	Sugarcane
Asia (excluding West Asia)	0.62	0.74	0.47	0.68
Europe	0.81	n.a.	0.84	n.a.
North Africa and West Asia	0.62	n.a.	0.91	0.95
North America	0.89	n.a.	0.77	0.72
Oceania	1.02	0.6	1.05	0.91
South America	0.65	0.87	0.67	0.93
Sub-Saharan Africa	0.20	0.32	0.32	0.54

Source: Fischer and Shah 2010.
Note: n.a. = not applicable.

- First, it would allow adjusting for input costs to compute net profit rather than gross revenue. Computing net profit would allow us to impute the implicit market value or Ricardian rent for every grid cell on the surface. These implicit land values could be an important input into land valuation and land price negotiations.
- Second, apart from considering the time to market, use of the cost of transporting inputs and outputs on a cost per ton-km basis, for example, could help obtain more realistic estimates of profit and, more interestingly, simulate potential impacts of investment in transport infrastructure on land prices and potential local welfare.
- Third, the model is static and does not include investment costs, risk, or price changes due to shifts in global supply and demand. However, climate projections under different climate change scenarios can, for example, be used to simulate crop output in a way that incorporates long-run impacts of climate change on countries' potential.

ADOPTING A COMMODITY PERSPECTIVE

To explore the implications for policy, the potential for expanding currently cultivated area needs to be compared with that for increasing output and productivity on areas already cultivated. Making this comparison will identify how private investment in agriculture—badly needed in many circumstances—can improve smallholder productivity as the central pillar of a pro-poor development strategy.

Wheat

Food security concerns have led to a surge in investments for wheat, often originating in Middle Eastern countries. Compared with a total cultivated area of 223 million ha, our analysis points to availability of an additional 88, 56, or 38 million ha in areas with fewer than 25, 10, and 5 persons/km^2, respectively (appendix 2, table A2.8). The suitable uncultivated area is largest in Argentina (6 million ha compared with 4.2 million ha used) and Russia (36 million ha compared with 26 million ha). For many countries with expansion potential, and for some large producers, the scope for increasing yields is considerable. Kazakhstan cultivates 13 million ha of wheat, with an additional 2.8 million ha potentially available for expansion. Yields, however, are less than 1 t/ha. If productivity on currently cultivated land were to increase to the regional average, the associated increase in output would be more than 10 times the 2.8 million tons from bringing all of the suitable area under rainfed cultivation at current yields. Interestingly, with the exception of Ethiopia, none of the African countries that have recently been the targets of large-scale investment have much potential for wheat cultivation, suggesting that efforts to cultivate wheat in Africa on a large scale must overcome a number of agro-ecological challenges.

Maize

The total area for maize expansion is almost equal to the 161 million ha already under the crop. There is considerable potential for expansion in countries that have recently attracted investor interest. Well-established producers in Latin America and the Caribbean, mainly Argentina and Brazil, already achieve rather high yields (6.5 and 4.1 t/ha) and have the potential of adding some 20 million ha to the 3.5 and 14 million ha currently cultivated, respectively. Depending on land prices, they appear to provide the most immediate potential for area expansion.

A second group is made up of countries that cultivate more than 1 million ha of the crop (Angola, the Democratic Republic of Congo, Ethiopia, Kenya, Mozambique, and Tanzania) but with low yields. In this situation, any efforts at area expansion will need to be combined with efforts to improve output by existing smallholders. Mozambique could add 7.1 million ha of maize (3.1 million ha in areas close to markets) to the 1.4 million ha it already cultivates. With current yields of 0.92 t/ha (less than a tenth of potential yields), however, this land is far from reaching its productive potential. Infrastructure access is also a major issue, as only 4 million ha are within six hours from the next market. Infrastructure access differs markedly across countries: Zambia has some 13 million ha available for maize, more than 80 percent of which is located within six hours of a market town. In Ethiopia, on the other hand, virtually all of the 3.6 million ha suitable for rainfed maize production is located far from infrastructure.

A third group of countries has large potential for area expansion but currently has little area under production. This group includes Sudan (32 million ha), Chad (9), Madagascar (7), República Bolivariana de Venezuela (5), Angola (4), Bolivia (2.5), Mali (2.4), and Burkina Faso (2.3), among others. Madagascar's maize yields are slightly higher (1.5 t/ha) than Mozambique's, but very little maize (0.25 million ha) is grown. In this context, the requirements of establishing the infrastructure, for example technology, markets, processing, and regulatory infrastructure, are much higher. To realize them, significant investment is likely required. A fourth group is made up of countries that cultivate large areas of maize such as India, Malawi, Nigeria, and Zimbabwe. Even though the uncultivated area for expansion is limited, the potential for increasing yields is significant (appendix 2, table A2.9).

Soybean

While soybean is currently grown on some 97 million ha, AEZ calculations point toward an estimated 138 million ha of noncultivated nonprotected area with a population density of fewer than 25 persons/km^2 that have high suitability for rainfed cultivation of this crop. Countries with large amounts of suitable but currently uncultivated area fall in three groups:

- Current producers, many with high yields and a history of past area expansion
- Current producers with potential for yield increases as well as area expansion
- Countries with potential for expansion but no experience with the crop.

In the first group, Brazil is not only the largest producer with the highest yields but also has 22 million ha of uncultivated land available to double its cultivated area. Argentina's capacity to add to its 16 million ha under the crop is more limited, with some 10 million ha of additional suitable land. However, Uruguay, Paraguay, and Bolivia, all countries into which Brazilian and Argentine firms have already expanded heavily, have another 10 million ha of suitable area, thus accounting for almost a third of the area potentially available for expansion globally. This contrasts sharply with the third group made up of many African countries with considerable potential but little current cultivation. This includes Sudan (14 million ha), the Democratic Republic of Congo (9), Mozambique (7), Chad, Madagascar, Zambia (6), Angola (5), and Tanzania (4), as highlighted in appendix 2, table A2.10. Realizing this potential is challenging in terms of establishing an industry almost from scratch similar to that discussed for maize.

Sugarcane

Countries with more than 1 million ha of cultivated area account for some three-fourths of total area (19 of 24 million ha) and 83 percent of the expansion potential (34 of 41 million ha), as illustrated in appendix 2, table A2.11. More than two-thirds (70 percent) of the area with expansion potential is in South America, mainly Brazil (9 million ha) and Argentina (4), followed by Sub-Saharan Africa (24 percent), mainly the Democratic Republic of Congo (7 million ha) and Madagascar (2.1). Discrepancies in infrastructure access are pronounced. For example, Argentina and the Democratic Republic of Congo have almost an equivalent amount of suitable area available (some 6.5 million ha each), but most of this area is reasonably close to markets in Argentina and very far from them in the Democratic Republic of Congo. Yields in Argentina (84 t/ha) are more than twice those in the Democratic Republic of Congo (39 t/ha). Thus, the extent to which sugarcane for biofuels as recently established in many Sub-Saharan African countries will be globally competitive remains to be seen.

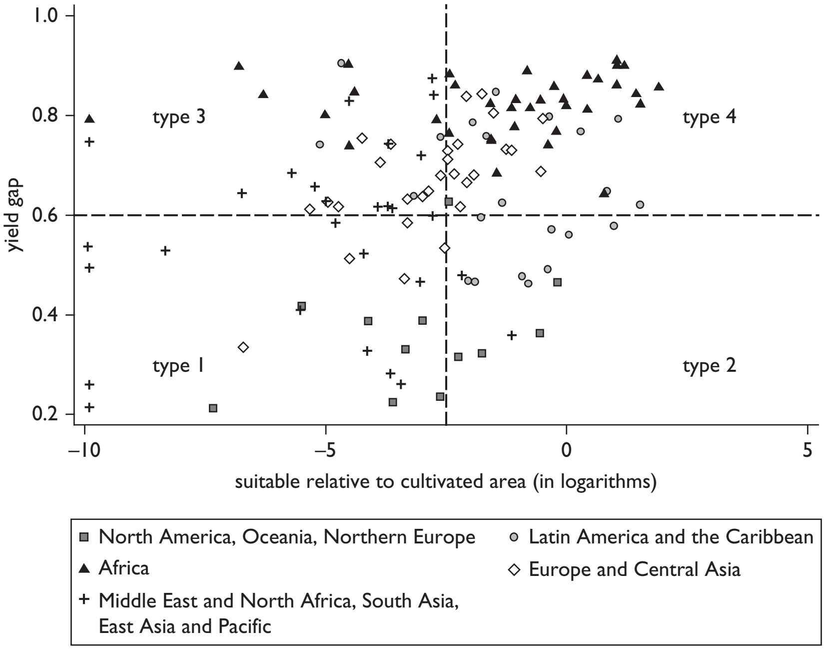
Oil Palm

Establishing oil palm on forested areas will be associated with greenhouse gas emissions and can lead to considerable loss of biodiversity. Appendix 2, table A2.12, points toward large productivity differences on already cultivated areas. Nigeria cultivated 3.2 million ha of oil palm in 2008, accounting for 20–25 percent of the global area under the crop. But it achieved yields of only 2.66 t/ha—less than half the yield in Ghana (6.33 t/ha) and just one-eighth that achieved in Malaysia (21.3 t/ha). In light of expected strong demand for palm oil, yield increases or expansion into degraded lands could relieve pressure on valuable intact forest lands elsewhere.

TOWARD A COUNTRY TYPOLOGY

To explore the potential tradeoff between intensification and expansion of the rainfed cultivated area at the country level, we plot, for each country, the yield gap (that is, the amount that actual yields, on either irrigated or rainfed areas, fall short of potential production) and the ratio of nonforested, noncultivated area suitable for rainfed production relative to what is actually cultivated (appendix 3, figures A3.1 through A3.5). This typology, which will be of interest from a country perspective, can be complemented by plotting absolute amounts of suitable noncultivated and nonprotected land in areas with low population density as in appendix 2, table A2.6. As figure 3.1 illustrates, classifying countries depending on whether they are above or below the mean yield gap (0.6) or relative land availability (a log value of –2), allows us to define a

Figure 3.1 Yield Gaps and Relative Land Availability for Different Countries



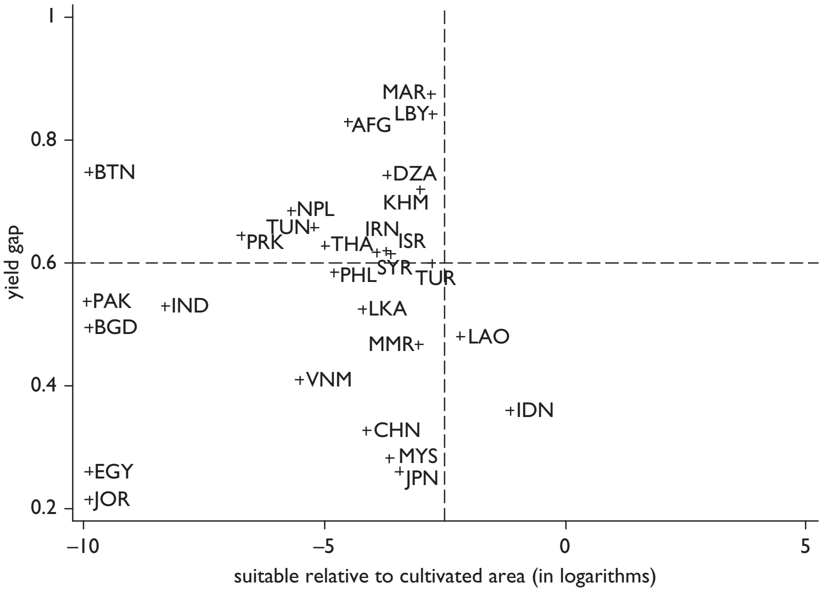
Source: Authors based on Fischer and Shah 2010.

typology that can provide insights as to the options open to different countries to use investor interest to promote their development agenda as well as the types of investors that may help them to do so most effectively. The global picture clearly points toward large differences across countries and regions in land availability and productivity levels.

Type 1: Little Land for Expansion, Low Yield Gap

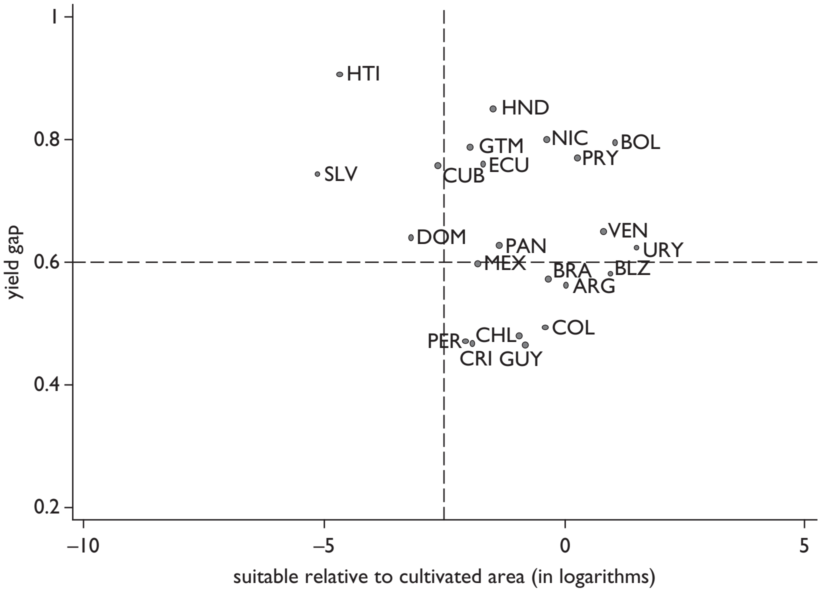
This group includes Asian countries with high population density, such as China, Vietnam, Malaysia, the Republic of Korea, and Japan, Western European countries, and some countries in the Middle East and North Africa with limited land suitable for rainfed production, such as the Arab Republic of Egypt and Jordan (figure 3.2). Agricultural growth has been, and will continue to be, led by highly productive smallholders. To meet expanding demand for horticultural and livestock products, private investors increasingly provide capital, technology, and access to markets through contract farming. As some of these countries reach declining agricultural population due to rural-urban migration, land consolidation—largely by entrepreneurial farmers leasing or buying plots from neighbors—will gradually increase farm sizes. Well-functioning land markets that allow such processes will thus be of

Figure 3.2 Yield Gaps and Relative Land Availability for South Asia, East Asia and Pacific, and the Middle East and North Africa



Source: Authors based on Fischer and Shah 2010.

Figure 3.3 Yield Gaps and Relative Land Availability for Latin America and the Caribbean



Source: Authors based on Fischer and Shah 2010.

increasing importance. The growing need for land for nonfarm industries, urban expansion, and infrastructure also implies a need for good governance of land and related natural resources in facilitating the transition.

Type 2: Suitable Land Available, Low Yield Gap

This group includes countries where land with reasonably well-defined property rights and where infrastructure access is fairly abundant and technology advanced, mainly in Latin America (Argentina, Uruguay, and central Brazil) and Eastern Europe (figure 3.3). It is here where savvy investors have exploited opportunities for cropland expansion. In many of these cases, past investment in technology, infrastructure, institutions, and human capital have helped increase productivity. If property rights are secure, markets function well, and areas with high social or environmental value are protected effectively (possibly using market mechanisms, such as payments for environmental services) the public sector's role is mainly regulatory. The public sector takes care of environmental externalities and allows markets, including those for land, to function smoothly and to encourage expansion into low grade pastures or degraded forest rather than into areas already occupied or with high biodiversity value. But if land rights are insecure or ill-defined, large-scale land acquisition may threaten forests or lead to conflict with existing land users. Good institutions and land governance will thus be critical to ensure that the technical potential is realized sustainably.

Type 3: Little Land Available, High Yield Gap

This group includes the majority of developing countries, including relatively densely populated areas in highland Ethiopia, Kenya, Malawi, the Philippines, Ukraine, Cambodia, and Central American countries (such as El Salvador) with limited land availability as well as Middle Eastern and North African countries where water availability constrains the expansion of agricultural production. Although there is little land available, large numbers of smallholders may be locked into poverty because the area cultivated remains far below the yield potential.

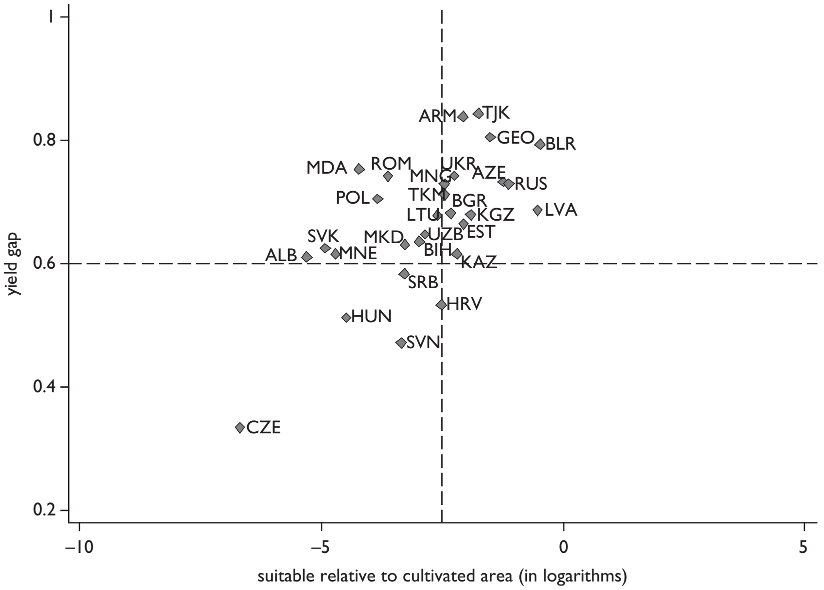
Strategic options depend on the size and evolution of the nonagricultural sector. If it is small, higher agricultural productivity will be the only viable mechanism for rapid poverty reduction. This will require public investment in technology, infrastructure, and market development to raise smallholder productivity, following the example of the green revolution in Asia. If the land sector is well-governed, private investment—largely through contract farming—can promote diversification into high value crops, especially for export markets. There is, however, a danger that insecure property rights will allow large-scale land acquisitions to push people off the land. With limited nonagricultural employment, grave equity effects could result in social tensions.

The situation is different if incomes and employment in the nonagricultural sector grow rapidly, land markets work reasonably well, and population growth is low, as in parts of Eastern Europe where there is scope for faster land consolidation and the associated move to larger operational units (figure 3.4). Parties will more likely enter into mutually advantageous contracts if the transaction costs of doing so, particularly those of enforcing agreements, are low. Commodity and market characteristics are also in play: contract farming, where investors provide capital and technology, is easier for crops where the need for processing limits side-selling and makes enforcement easier, such as oilseeds or sugarcane. If the investment needed is larger—for example, for horticulture, perennials, and oil palm, or in cases with high up-front investment in irrigation—ownership of land, or at least long-term contracts, is more likely to be chosen.

Type 4: Suitable Land Available, High Yield Gap

This group includes sparsely populated countries—such as the Democratic Republic of Congo, Mozambique, Sudan, Tanzania, and Zambia—with large tracts of land suitable for rainfed cultivation (in areas of sufficient precipitation) but also a large portion of smallholders who only achieve a fraction of

Figure 3.4 Yield Gaps and Relative Land Availability for Eastern Europe and Central Asia

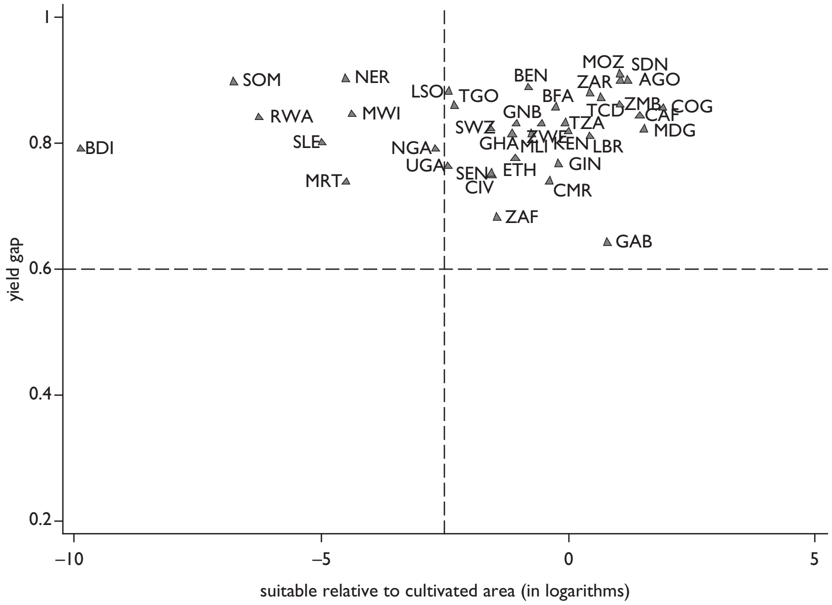


Source: Authors based on Fischer and Shah 2010.

potential productivity (figure 3.5). In some cases, such as Sudan, these areas are located in areas with political tensions and dispute. Labor supply often constrains expansion by smallholders, implying that not all potentially suitable land is used for crop production. The prospect of outside investment can help foster local development. If migration from other regions is inelastic in the medium term, as is often the case, intensification will require larger farm sizes, and labor-saving mechanization may be the most attractive short-term option. In some cases, the investment needed for this transition can be generated locally. However, if it requires the introduction of new crops and farming systems, large investments in processing, or links to export markets, the amounts of skill and capital available locally may not be sufficient, and outside investors can have a role. In these cases, bringing institutional arrangements, technology, and infrastructure together could thus provide a basis for mutually beneficial and agreed on land transfers.

It is this context that defines most of the recent upsurge in investor interest and where there is scope for the private sector to contribute technology, capital, and skills to increase productivity and output in the short to medium term. The most effective way of doing so will depend on local conditions.

Figure 3.5 Yield Gaps and Relative Land Availability for Sub-Saharan Africa



Source: Authors based on Fischer and Shah 2010.

Capital-intensive activities with low labor absorption, such as annual crops using fully mechanized production, will be appropriate only if population density is low, the likelihood of in-migration is limited, and a vibrant nonagricultural sector can absorb expected future growth of the labor force. Even then, expected changes in the long term, due for example to population growth or climate change, need to be considered as the transition from large-scale mechanized to smallholder farming has not been observed historically. Many countries in this group have weak institutional frameworks for land governance that can create challenges for reigning in opportunistic behavior by local or foreign elites, for example, by ensuring adequate consultation with local and indigenous populations.

To maximize benefits and ensure they are broadly shared, institutional arrangements must include recognition and respect for existing land rights. They must also identify the channels that will allow local people to benefit—employment generation, social benefits, access to markets and technology, or taxes—and technically and economically viable business models. Clear articulation of what is expected from investors, open processes, public disclosure of contractual arrangements, and the extent to which these arrangements are complied with over time will be critical to help realize the potential benefits inherent in such situations.

CONCLUSION

Complementing the focus on demand for land and associated natural resources that has long characterized the debate on this topic with an assessment of the potential supply of land suitable for rainfed production increases access to information for all involved. There is ample evidence to document that agro-ecological potential will be realized only in a supportive policy environment. However, assessing agro-ecological potential can help governments anticipate demand for agricultural land. It can also feed into development strategies and spatial planning to guide the provision of public goods (technology, infrastructure, property rights) to areas where they can complement and stimulate private investment to provide local benefits. Calculating agro-ecological potential can also help to assess the extent to which past land demand or actual transfers focused on areas with high potential. For communities, the ability to identify suitable land can help inform land use and local development planning, clarify visions of development, and take steps toward implementing them. And by determining the opportunity costs of a given piece of land, it can guide potential land price negotiations. For investors, reliable information about the potential supply of land can direct demand to areas that are economically viable and competitive and, especially if combined with information on rights, can reduce search costs.

Against this background, this chapter makes four substantive contributions. It highlights that, at the global level, there is enough nonforested, nonprotected land suitable for rainfed cultivation available to satisfy anticipated increases in demand for agricultural commodities for the foreseeable future. Africa has the most suitable land available, but access to infrastructure and technology are higher in Latin America and the Caribbean. Within countries, areas with the highest potential are clearly visible. In these areas, public investment to construct complementary infrastructure or educate local communities about their rights and take measures to document land rights on the ground may help increase the benefits of investment and reduce its risks. At the same time, in many of the countries with suitable land available, the potential for increasing output and welfare by narrowing high yield gaps on currently cultivated land rather than expanding cultivated area is very high. Tradeoffs and potential synergies between closing the yield gap and area expansion need to be carefully explored with a realistic assessment of the social, environmental, and financial costs of area expansion.

Aggregating data at the commodity level provides a global perspective. Doing so highlights that, with the exception of commodities more suited to temperate climates such as wheat, large amounts of land suitable for rainfed production are available in Sub-Saharan Africa. For each of these commodities, however, Latin America and the Caribbean also has suitable land that is in most cases closer to infrastructure than in Africa. The reason investor interest has recently shifted to Sub-Saharan Africa is because factors in

Latin America, such as infrastructure access and a large pool of readily available skilled manpower, have already been capitalized into land prices. In contrast, relatively cheap land in Sub-Saharan Africa appears to provide investors with potentially better deals. Still, any land transfers will need to be voluntary and negotiated to compensate current land users in a way that makes them better off than without the investment. It appears that opportunities exist at least in principle to use such investment to bring about increased productivity and equity by closing yield gaps on existing cultivated areas. We can compute the potential output increase from more fully using the available resource base.

Using the scope for area expansion with the magnitude of the yield gap to establish a typology of countries, the methodology highlights countries (and crops within countries) with small yield gaps where efforts to expand cultivated area can rely on available technology. In comparison, crops with large yield gaps will require up-front efforts to transfer and adapt technology. The latter is likely to require greater attention to the technical and managerial aspects of proposals and may disqualify passive investors. It does, however, provide considerable opportunities to pursue investment as a way to provide technology and market access to existing smallholder producers. The careful design and rigorous evaluation of business models to accomplish this outcome will thus be an important area for follow-up work.

NOTES

1. The *yield gap* is defined as the difference between attained and possible output on areas currently cultivated taking crop choice as given. Obviously, such a gap can come about for several reasons (distance to infrastructure, lack of access to markets and technology), a detailed analysis of which is beyond the scope of this study.
2. Cropped area yields are for 2008. Suitable area is not currently used for crop production, could attain at least 60 percent of the potential yield for this crop, is located in an area with population density less than 10 persons/km^2, and at 2005 prices will not yield higher gross revenues with any other of the five crops considered here (maize, soybean, sugarcane, oil palm, wheat). Close to infrastructure means a travel distance of less than six hours to the next market based on available transportation.
3. To keep things tractable, we use a 5' x 5' resolution that divides the world into 2.2 million grid cells but note that computation of output within each grid cell is based on far more disaggregated data.
4. Countries where the amount of suitable land is more than double what is currently cultivated include, in descending order, the Democratic Republic of Congo, Papua New Guinea, Madagascar, Uruguay, Central African Republic, Angola, Bolivia, Mozambique, Zambia, Sudan, and República Bolivariana de Venezuela).
5. To allow for the possibility that more than one crop is suitable for production on each grid cell, when aggregating at the country level we apply weights to each potential crop area based on the relative size to the available suitable area in that class for each country. This ensures that the sum of potential areas for all crops equals the total potential area.

6. This calculation does not account for two important factors that affect the total area of land potentially suitable for rainfed cultivation. Firstly, it does not consider Brazil's areas of permanent protection (APP) and legal reserve laws, which require that 20, 35 or 80 percent of an agricultural holding (depending on the biome) be set aside for conservation. The second factor that is not considered here is that areas with a declivity of more than 15 percent are not typically used for agricultural production for lack of ability to use mechanization.

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