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Transforming Rural Economies

CHAPTER 2

AGRICULTURAL PRODUCTIVITY: DEVELOPMENTS, DETERMINANTS AND IMPACTS

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CHAPTER 2

Agricultural Productivity: Developments, Determinants and Impacts

A. Introduction

The level and growth of agricultural productivity are critical both to the well-being of the population of the least developed countries (LDCs) and to the structural transformation of their economies.[1] They are major determinants of poverty and of the income gap that separates them from other developing countries (ODCs) and developed countries, and play an essential role in the processes of rural structural transformation and development and in strengthening the rural non-farm economy (RNFE).

The level and growth of agricultural productivity are critical to the well-being of the population of the LDCs.

This chapter analyses the dynamics of agricultural productivity in LDCs and its determinants. It is organized as follows: Section B explains the multiple channels through which agricultural productivity affects well-being, poverty, structural transformation, and economic and social development; Section C presents recent trends in the level and growth of different aspects of agricultural productivity in LDCs; Section D examines the key determinants of these levels and trends; and Section E summarizes the chapter.

B. The crucial importance of agricultural productivity

Agricultural productivity is the major determinant of the income gap that separates LDCs from other developing countries and developed countries.

The level and dynamics of agricultural productivity affect well-being, structural transformation and development in LDCs (Gollin, 2010; Johnston and Mellor, 1961).

Poverty and well-being. Since agriculture is the dominant (and in some countries increasingly dominant) source of employment in LDCs (Chapter 1 of this Report), agricultural productivity is in most cases the main determinant of the incomes of the majority of the workforce. Low productivity in agriculture is thus a major reason for the prevalence and persistence of poverty in most LDCs, keeping much of the rural population trapped in a vicious circle of poverty, in which poverty results in undernutrition, poor health, poor cognitive development and limited adoption of new technologies, which in turn lead to low productivity and low earnings (chart 2.1). Agricultural productivity growth is therefore an essential precondition for poverty reduction in the short and medium term, contributing through several channels (box 2.1).

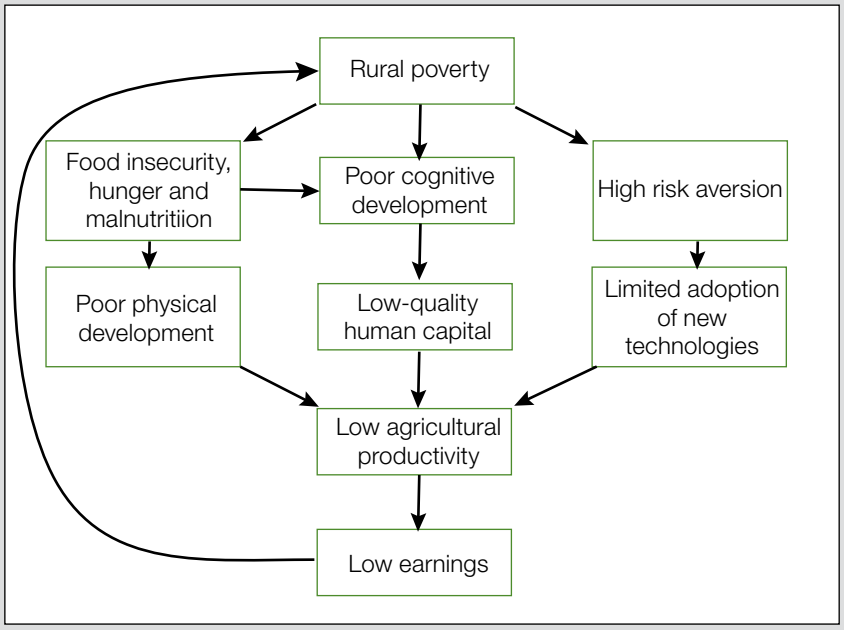
Low productivity in agriculture is a major reason for the prevalence and persistence of poverty in most LDCs.

Food prices. Rising agricultural productivity helps to lower food prices, effectively raising real rural and urban wages, since food is a major component of wage goods, and benefiting landless and other rural food-deficit households (Block, 2010; Sahn, Dorosh and Younger, 1999). By limiting increases in agricultural prices, this also prevents rural-urban terms of trade from turning against urban activities, which might otherwise stall the process of structural transformation (Lewis, 1954).

Rising agricultural productivity helps to raise real rural and urban wages.

Food security and hunger. "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (World Food Summit, 1996). According to the Food and Agriculture Organization of the United Nations (FAO), this definition covers four dimensions of food security: physical availability of food, economic and physical access to food, meeting nutritional requirements, and stability of these three aspects over time (Stamoulis and Zezza, 2003). These four dimensions are directly or indirectly influenced by the level of agricultural productivity. As well as reducing poverty and food prices, rising agricultural productivity helps to increase and stabilize

Chart 2.1. The vicious circle of low productivity and rural poverty



Source: UNCTAD secretariat elaboration.

Box 2.1. The effects of agricultural technological innovation on poverty

As discussed later in this chapter, one of the key drivers of productivity growth in agriculture is the adoption of innovation and new technologies. These can potentially reduce poverty through several channels (Hazell and Haddad, 2001):

- Technological advances can benefit poor farmers directly through an increase of own-farm production, allowing greater production both of food for home consumption and of marketed products, increasing farm income.
- They can benefit small farmers and landless labourers through greater agricultural employment opportunities and higher wages.
- They can benefit poor rural and urban households by developing higher value added non-farm activities, which generate more and better-paying jobs.
- They can reduce food prices for urban consumers and rural food-deficit households.
- They can increase the availability and reduce the cost of foods that are high in nutrients, which are crucial to the well-being of the poor, particularly pregnant and lactating women.
- They can empower the poor by increasing their access to decision-making processes, strengthening their capacity for collective action and reducing their vulnerability to shocks through asset accumulation.

While these benefits may be affected by such factors as population growth, and types of technology and technological innovation, initial income distribution, the extent and distribution of adoption, availability of infrastructure and social services, and employment impacts (Kerr and Kolavalli, 1999; Ravallion and Datt, 1999; Fan, Hazell and Thorat, 1999), most studies indicate a generally positive effect.

food supplies (Block, 1995). By improving food security, it provides a crucial contribution to the goal of ending hunger (Sustainable Development Goal (SDG) 2).

Increasing agricultural productivity releases labour for employment in more productive sectors.

Structural transformation. Increasing agricultural productivity plays several roles in the archetypal process of structural transformation. By reducing the labour required in agriculture, it releases labour for employment in other (in principle more productive) sectors. Rising agricultural surpluses increase domestic demand for industrial and service products, spurring supply growth in these sectors, as well as providing a source of capital for private and public investment in diversification of production. Productivity and output growth

in agriculture thus increase productivity in other sectors and in the overall growth rate, accelerating the development process. These linkages underlie the traditional view of increasing agricultural productivity as a precondition for industrialization (Boserup, 1981; Rostow, 1960; Timmer, 1988; Kuznets, 1966; Baumol, 1967; Murphy, Shleifer and Vishny, 1989).

Increasing agricultural productivity is a precondition for industrialization.

International trade. Increasing agricultural productivity can foster exports through two main mechanisms. First, it can attenuate the potential conflict of land use between cash and food crops, thereby generating larger exportable surpluses.[2] These, in turn, can be a source of capital accumulation to finance investment in new sectors and activities. Second, through their impact on real wages, lower food prices can increase the export competitiveness of the tradables sector. This was a major ingredient in the export-led development success stories of the twentieth century, especially in East and South-East Asia. Through its effects on both exports and imports (by reducing food import needs), higher agricultural productivity can attenuate the balance-of-payments constraint that stymies development in most LDCs.

Lower food prices can increase the export competitiveness of the tradables sector.

These processes and mechanisms highlight the essential role of increasing agricultural productivity in structural transformation and economic and social development. This has been important, not only to the historical processes of now-developed countries, but also in successful developing countries (e.g. Chile, China, Mauritius and Viet Nam, analysed in UNCTAD (2014: 89–114)). A strong increase in agricultural productivity is likewise a sine qua non for poverty eradication and structural transformation in LDCs, and for enabling these countries to achieve a higher level of development.

C. Trends in LDC agricultural productivity

1. Measuring agricultural productivity

The broadest productivity metric combines value added as a measure of output with an indicator of labour input.

In general terms, "productivity is a ratio of some measure of output to some index of input use" (Griliches, 1987). This section presents and analyses estimates of different concepts of agricultural productivity in LDCs in order to demonstrate its level and growth dynamics over the long term and to enable better understanding of its contribution to (or constraint on) rural and overall development.

The general definition of productivity presented here encompasses multiple possible combinations of measures of output and especially inputs. The broadest productivity metric, applied to all sectors of economic activity, combines value added as a measure of output with an indicator of labour input. While the resulting measure of value added per worker is a partial productivity ratio (in that it uses only one type of input, i.e. labour), it allows for ready comparison across sectors and countries.

Agricultural labour productivity can be broken down into land productivity and the land/labour ratio.

In the case of agriculture, however, the most widely used productivity measures are based on indicators of output volume rather than value added. This measure of labour productivity (output per worker) is often used to assess the evolution of productivity over time and to make cross-country comparisons. It is also a gauge of rural welfare or living standards, as it reflects the ability to acquire income through the sale of agricultural goods or produce (Block, 1995). Labour productivity can then be broken down into land productivity (output per hectare or yield) and the land/labour ratio. Yield is commonly used to assess the success of new production technology or practices. In combination, labour and land productivity ratios also indicate whether technological change in agriculture is predominantly labour-saving or land-saving.

The productivity estimate using the broadest aggregate of inputs is total factor productivity (TFP), which gauges the productivity of all productive inputs when used jointly. In the case of agriculture, this typically takes account of land, labour, physical capital and material inputs (especially fertilizers) employed in farm production, and compares them with the total quantity of agricultural output.

The productivity estimate using the broadest aggregate of inputs is total factor productivity.

The precision of any productivity estimate inevitably depends on the quality of the statistics on which computations are based, which is a major source of concern, particularly in LDCs and in cross-country comparisons (box 2.2).

2. Partial productivity measures

The Least Developed Countries Report 2014 provided an extensive analysis of developments in productivity in the three main sectors of economic activity (agriculture, industry and services) in LDCs, LDC subgroups and ODCs, based on value added per worker (UNCTAD, 2014: 59–88). The following analysis builds on this by updating and expanded the main findings on agricultural productivity.

In 2011–2013, LDC agricultural labour productivity was 18.7 per cent of that of ODCs and just 1.8 per cent that of developed countries.

- Agricultural labour productivity in LDCs is much lower than in ODCs and developed countries. While productivity in LDCs has grown by 2.2 per cent annually since 1991, this is substantially slower than in ODCs (4.2 per cent annually) and developed countries (3.9 per cent annually), so that the productivity gap has been widening over the long term. In 2011–2013, average LDC agricultural labour productivity was 18.7 per cent of that of ODCs and just 1.8 per cent that of developed countries (chart 2.2).
- The labour productivity gap between LDCs and ODCs or developed countries in agriculture is wider than that in industry and services (chart

Box 2.2. Caveats to the use of data on LDC agricultural inputs and outputs

The empirical measurement of agricultural production and agricultural input use, and hence the calculation of the sector's productivity in LDCs, is beset by a series of difficulties, starting with the compilation of quantitative data. First, agricultural output encompasses production of multiple crops and of livestock, which are commonly measured by weight or volume. This raises the key question of how best to aggregate different agricultural products. While aggregation is sometimes based on a common unit, such as wheat equivalent (Hayami and Ruttan, 1985; Block, 1995), it more commonly uses monetary units for determining the total value of crop and livestock production at relative prices in a given base period. (Here, the Report follows FAO in using 2004–2006 as the base period.) This is referred to as "final output", and represents the amount of agricultural output available to the rest of the economy.*

A second complication is that some part of agricultural produce is generally consumed by farming households themselves (or bartered for other products), and therefore does not enter money-based markets and is not included in market-based statistics. Third, while labour input should ideally be measured by person-hours worked, data based on measures of this nature are not generally available for LDCs, except for occasional household or agricultural surveys. Labour input is therefore measured by data on total employment in agriculture, generally based on primary occupations. Where individuals or households diversify their incomes by engaging in non-farm activities (Chapter 3 of this Report), the time they devote to agriculture is reduced; but all their working time is effectively included as agricultural employment if this remains their main occupation. Since most available statistics do not reflect time allocation, calculations based on them are likely to underestimate labour productivity.

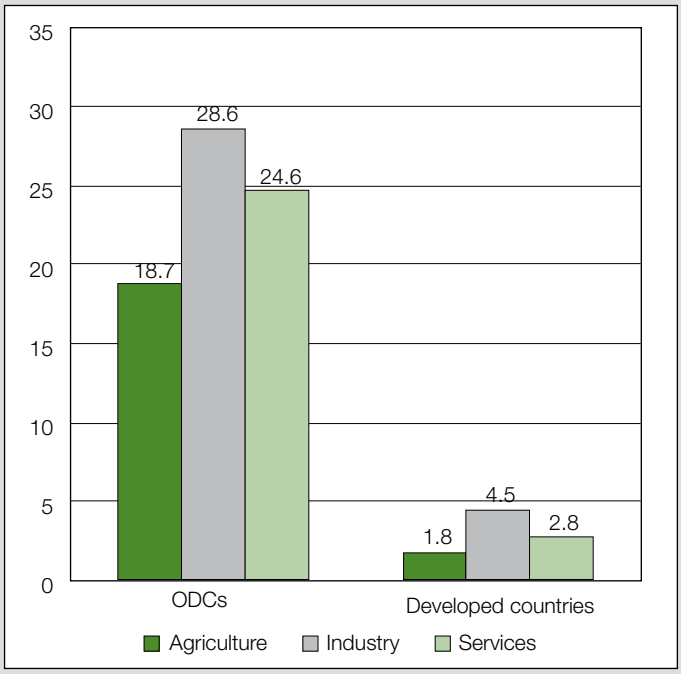
Fourth, output and input measures draw on different databases with different geographical and time coverage, each constructed according to its own methodology, raising potential problems of consistency. Fifth, like other economic statistics from LDCs, the reliability of data on agricultural input and output data may be adversely affected by the limited capacity and resources available to the statistical institutes, ministries and departments responsible for their compilation.

Finally, statistics on both inputs and output are simple quantitative indicators, and generally do not reflect qualitative differences – for example in education or health in the case of labour input data, land fertility and soil enrichment or degradation in the case of land data, and types of machinery in measures of physical capital inputs. Failure to account for land quality, for example, may lead researchers to misattribute the associated differences in production to differences in the use of other inputs (Fulginiti and Perrin, 1997).

These limitations need to be borne in mind when analysing trends and interpreting analyses of agricultural productivity, especially in LDCs.

* In the case of LDCs and their subgroups, this measure is highly correlated with the physical production of different crops, measured in tons and simply aggregated.

Chart 2.2. Sectoral labour productivity levels: LDCs as a share of other country groups, 2011–2013
(Per cent)



Sources: UNCTAD secretariat calculations, based on data from UNCTAD, UNCTADstat database (http://unctadstat.unctad.org/EN/), and ILO, WESO 2015 database (http://www.ilo.org/global/research/global-reports/weso/2015/lang--en/index.htm) (both accessed August 2015).
Note: Sectoral production measured by value added.

The labour productivity gap between LDCs and ODCs or developed countries in agriculture is wider than that in industry and services.

2.2). Given the strong concentration of the LDC labour force in agriculture, this wider productivity gap is the major cause of income divergence between LDCs and these other country groups.

- Among LDC subgroups, agricultural labour productivity has historically been lower in Asian LDCs than in African LDCs and Haiti,[3] but has grown faster (by 3.6 per cent annually), resulting in an 88-per-cent increase between 1991–1993 and 2011–2013 in Asian LDCs, compared with a 32-per-cent increase in African LDCs and Haiti. Consequently, agricultural productivity in Asian LDCs has surpassed that of African LDCs and Haiti since 2006.[4]

Agricultural productivity in Asian LDCs has surpassed that of African LDCs and Haiti since 2006.

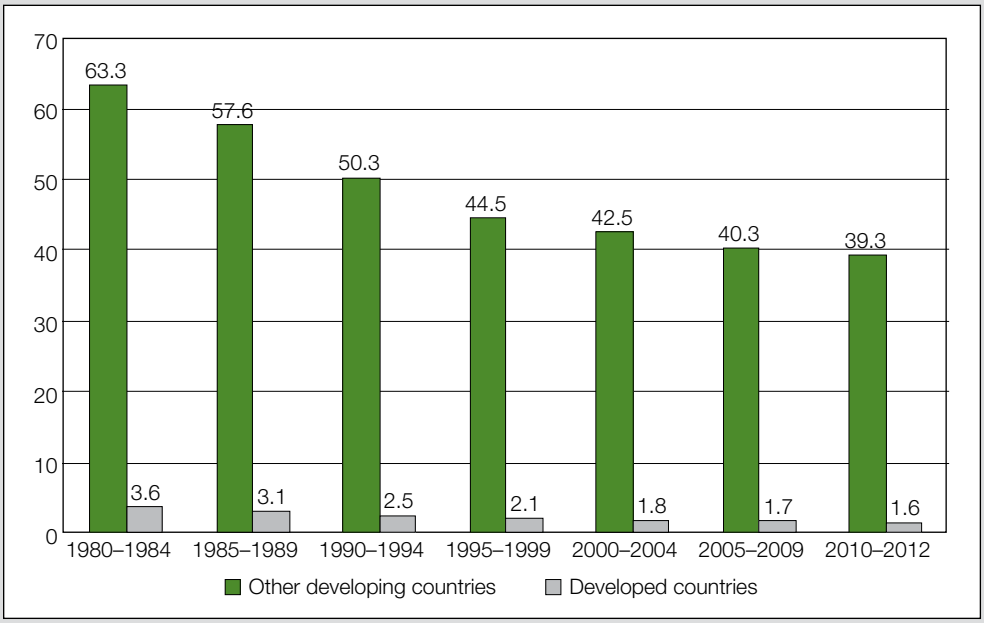
- While agricultural labour productivity in island LDCs has historically been higher than in the other two LDC subgroups, it has been declining slowly, falling by 5 per cent between 1991–1993 and 2011–2013.

Trends in agricultural labour productivity based on output measures (rather than value added) are similar: substantially lower historically in LDCs than in ODCs, and a fraction of that in developed countries, both gaps widening continuously over the past 35 years. Labour productivity growth in ODCs has doubled to more than 3 per cent annually since the 1990s. Developed countries have experienced a similar or higher rate of growth since the 1980s. In the LDCs as a group, however, it declined during the 1980s and grew only marginally in the 1990s, so that it was only by the turn of the century that it had recovered to the level of the early 1980s. It did not start to rise more robustly (at or above 2 per cent per annum) until after 2000. LDCs' agricultural productivity has thus diverged from that of the other two country groups since the early 1980s. In 2010–2012 it was 39.3 per cent that of ODCs and just 1.6 per cent that of developed countries (chart 2.3).

LDC agricultural productivity did not start to rise more robustly until after 2000.

LDC aggregate figures mask sharp contrasts among the main subgroups. In African LDCs and Haiti, labour productivity shrank in the last two decades of

Chart 2.3. Agricultural labour productivity level: LDCs as a share of other country groups, 1980–2012
(Per cent)



Sources: UNCTAD secretariat calculations, based on data from FAO, FAOSTAT database (http://faostat.fao.org/) (accessed August 2015).
Note: Production measured by final output value.

the last century and has grown since 2000, but slowly (just above 1 per cent annually). Considering the period since the early 1990s, only three countries in the group (Benin, Central African Republic and Mali) have managed to double labour productivity. At the same time, in 11 other countries in the group (Angola, Burkina Faso, Democratic Republic of the Congo, Djibouti, Eritrea, Ethiopia, Malawi, Mozambique, Sudan, Togo and United Republic of Tanzania), productivity actually declined over the same period. Major factors impeding significant improvements in agricultural labour productivity have been the low level of rural human capital, the slow accumulation thereof in many of these countries and the low level of conventional inputs (apart from land and labour) to agricultural production. Low levels of education and literacy, and poor health, also limit technical efficiency. Island LDCs have traditionally had a higher level of labour productivity (largely explained by their small population size), but the level has declined gradually over the past 35 years (chart 2.4A).

Major factors impeding significant improvements in agricultural labour productivity have been the low level of rural human capital and the low level of conventional inputs to agricultural production.

The opposite development has taken place in Asian LDCs. After stagnating in the 1980s, agricultural labour productivity growth picked up as early as the following decade. Since 2000 it has risen at a strong pace (3.5 per cent annually), which is higher than in all ODCs and Asian ODCs (in both country groups it has grown at approximately 3 per cent per year since 2000). Asian LDCs overtook the productivity level first of the African and then of the island LDCs (Chart 2.4A). Among Asian LDCs, productivity growth since the early 1990s has been strongest in Bangladesh, Lao People's Democratic Republic, Myanmar and Nepal, all of which succeeded in doubling (or almost doubling) labour productivity over the past quarter-century.

The strongest gains in productivity over the past 35 years have been recorded by manufactures exporters and mixed exporters.

According to export specialization, the LDC subgroup with the highest agricultural labour productivity levels has traditionally been the fuel exporters, especially Angola, Sudan and Yemen.[5] However, the strongest gains over the past 35 years have been recorded by manufactures exporters (most of which are in Asia) and mixed exporters (especially Benin, Kiribati, Lao People's Democratic Republic, Myanmar and Sierra Leone). By contrast, the exporter groups where

agricultural productivity is lower and has been rising at the most sluggish pace have been services and minerals exporters (chart 2.4B).

The welfare of agricultural workers ultimately depends on increasing output per worker, which relies on land productivity and the land/labour ratio.

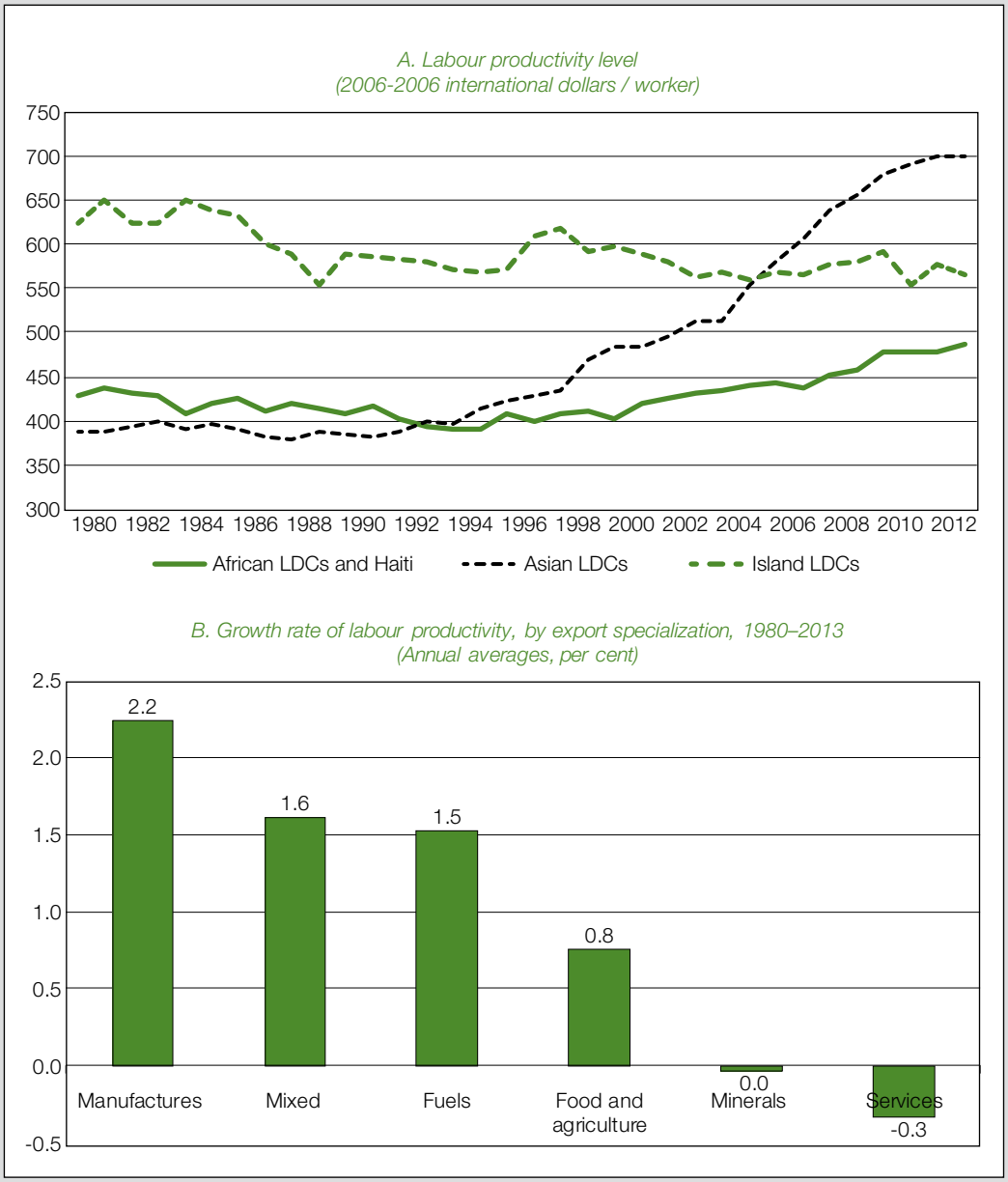
The analysis of agricultural labour productivity can be deepened by introducing the variable of cultivated area. Output per worker can be broken down in the following way, as proposed by Hayami and Ruttan (1985):

$$\frac{Y}{L} = \frac{Y}{A} \times \frac{A}{L} \quad (1)$$

where Y is output, A is area and L is labour.

The welfare of agricultural workers ultimately depends on increasing output per worker (Y/L), which relies on land productivity (or yield: Y/A) and the land/labour ratio (A/L). The equation above illustrates the challenge to that process in an environment characterized by rapid population growth and where the

Chart 2.4. Labour productivity in LDC agriculture, by country groups, 1980–2013



Source: UNCTAD secretariat calculations, based on data from FAO, FAOSTAT database (http://faostat.fao.org/) (accessed August 2015).
Note: Production measured by final output value.

expansion of cultivated area will eventually hit its limits or where, in a few cases, this has already been the case. To the extent that rural population growth outpaces the rate of expansion of the agricultural area, area per worker (A/L) declines, adding to the challenge of raising average labour productivity (Y/L) by means of increasing average yield (Y/A) in order to reduce poverty and improve the well-being of the rural population.

The gap between LDCs and other country groups in land productivity has traditionally been wide, though not as much as in the case of labour productivity.

The gap between LDCs and other country groups in land productivity (yield) has traditionally been wide, though not as much as in the case of labour productivity examined above. Still, since the 1980s, agricultural yields in LDCs have lagged behind the strong growth in ODCs, but they have gained some ground with respect to developed countries, especially since 2000. The LDC/ODC agricultural yield ratio fell from 36 per cent in 1980–1984 to 33 per cent in 2010–2012. With respect to developed countries, by contrast, the ratio rose from 20 per cent to 33 per cent. Nevertheless, this still leaves ample scope for catch-up by LDC agriculture.

Among LDCs the strongest growth in land productivity took place in Asia, where it has more than doubled since 1980.

Among LDCs the strongest growth in land productivity took place in Asia, where it has more than doubled since 1980. Vigorous expansion took place in all countries in this subgroup. At present, Asian LDC agricultural yields have reached a level similar to that of ODCs excluding China and India. In African LDCs and Haiti, by contrast, agricultural land productivity has traditionally been significantly lower than in the other LDC subgroups (chart 2.5A) and the performance was weaker and more varied across countries. There, land productivity growth was especially sluggish during the 1980s, but has accelerated somewhat since the following decade. The strongest gains in yield since the early 1980s have taken place in Angola, Burkina Faso, Ethiopia and Zambia, where it has more than tripled over the past 35 years. At the same time, in island LDCs, yields have grown at a slow pace since the early 1980s (chart 2.5A).

In African LDCs and Haiti, agricultural land productivity has traditionally been significantly lower than in the other LDC subgroups.

Examining developments in land productivity according to export specialization shows that manufactures-exporting LDCs have the highest level of yields, and have achieved some of the highest growth rates over the past 35 years. Land productivity picked up in the 1990s and has accelerated since 2000, so that at present the yield level is double that of the early 1990s. This mirrors positive performance of LDCs in Asia, since most of the LDC manufactures exporters are in that region. Fuel and mixed exporters have achieved a pace of yield gains slightly higher than manufactures exporters. (chart 2.5B).

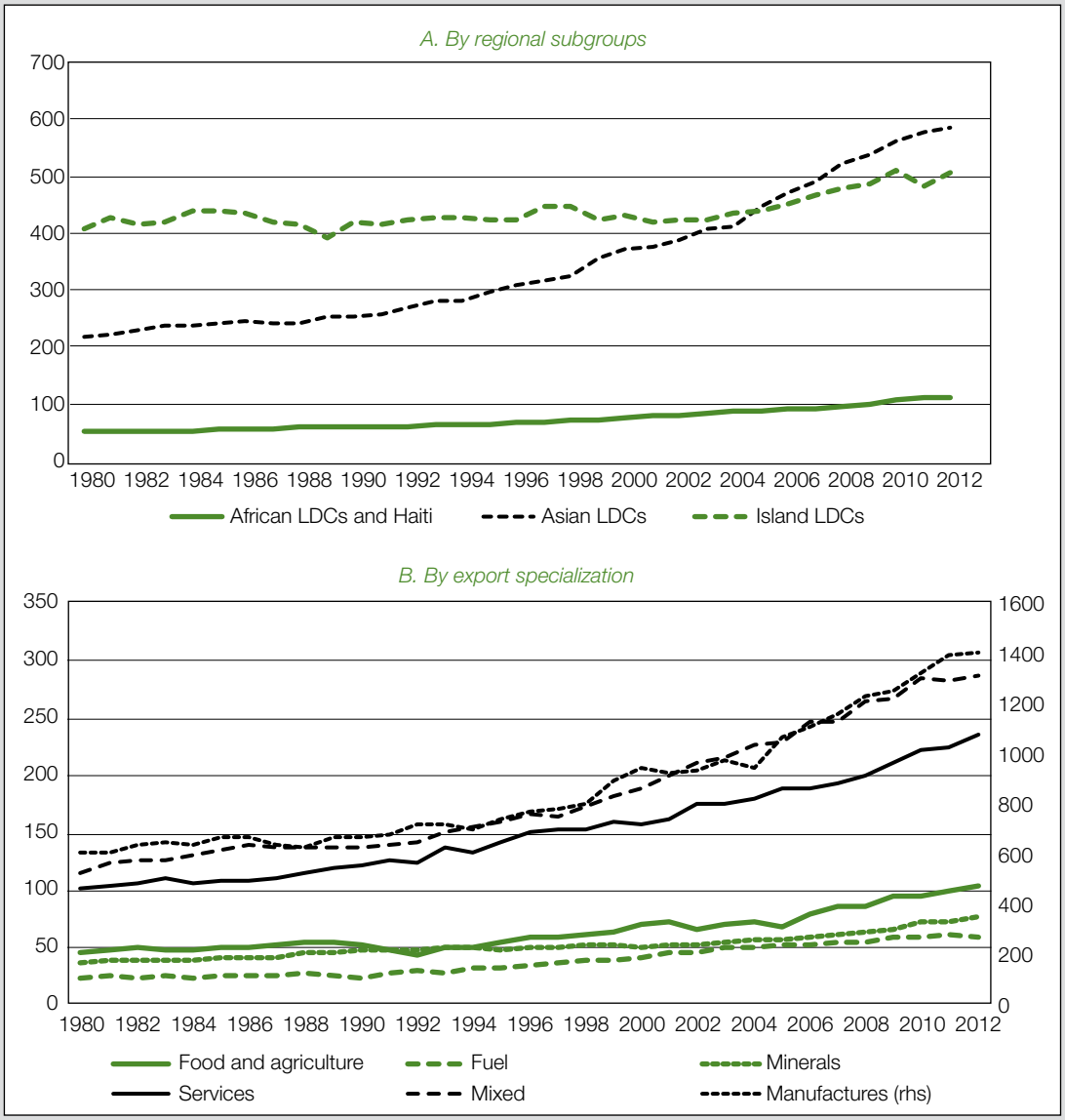
Of all the elements in equation (1) above, the one for which the level and developments in LDCs contrast most with all other groups of countries is the land/labour ratio (A/L). Divergent dynamics stem mainly from developments in population dynamics. Agricultural production expansion in LDCs since the early 1980s has occurred partly as a result of extensive growth, i.e. the expansion of the area used for agricultural production. In LDCs as a group it has grown by 10 per cent, slower than in ODCs, while in developed countries it actually contracted by 11 per cent. The extension of agricultural land use has been strongest in African LDCs and Haiti and in island LDCs.

The extension of agricultural land use has been strongest in African LDCs and Haiti and in island LDCs.

The outlook for continued expansion of agricultural production in LDCs through extensive expansion varies sharply among the countries in the group. Some LDCs are land-constrained, due to the lack of suitable land and to environmental priorities. This is particularly the case in those countries where the land/labour ratio is lowest, as seen below. This highlights the importance of achieving higher productivity in view of continuing demographic growth and the rise in food demand that accompanies it.

Other LDCs still have ample margin for increasing their cultivated area, given the presence of as yet uncultivated arable land. In some cases, however, bringing

Chart 2.5. Agricultural land productivity in LDCs, 1980–2012
(2006-2006 international dollars/hectare)



Source: UNCTAD secretariat calculations, based on data from FAO, FAOSTAT database (http://faostat.fao.org/) (accessed August 2015).
Note: rhs: Right-hand scale.

Many LDCs still have ample margin for increasing their cultivated area, but it may entail economic costs and/or environmental costs.

such land under production may entail economic costs (e.g. investment cost of infrastructure and the costs of human and animal disease control necessary to open these areas to farming) and/or environmental costs (e.g. deforestation and loss of critical wildlife habitats) (Staatz, 2011). In these circumstances, the critical question is the relative cost of area expansion vs. intensifying production on existing land.

Demographic trends in LDCs contrast sharply with those in other country groups. LDCs have the world's most rapid demographic growth (UNCTAD, 2013: 23–44), a trend that is bound to continue in the foreseeable future.[6] They also have the world's highest concentration of population in rural areas (Chapter 1 of this Report). These trends have resulted in increasing demographic pressure on land in several LDCs, although there is great diversity among these countries. The level of the land/labour ratio in African LDCs and Haiti is significantly lower than in African ODCs. Still, demographic pressure on land is greatest in Asia, where LDCs and ODCs have similar levels of the land/labour ratio, and those levels are the lowest among major country groups (chart 2.6A). The following

LDCs have a land/labour ratio lower than Asian ODCs and therefore face the greatest demographic pressure on land: Burundi, Djibouti, Eritrea, Ethiopia, Rwanda and Somalia in Africa, and Bangladesh, Bhutan and Nepal in Asia.

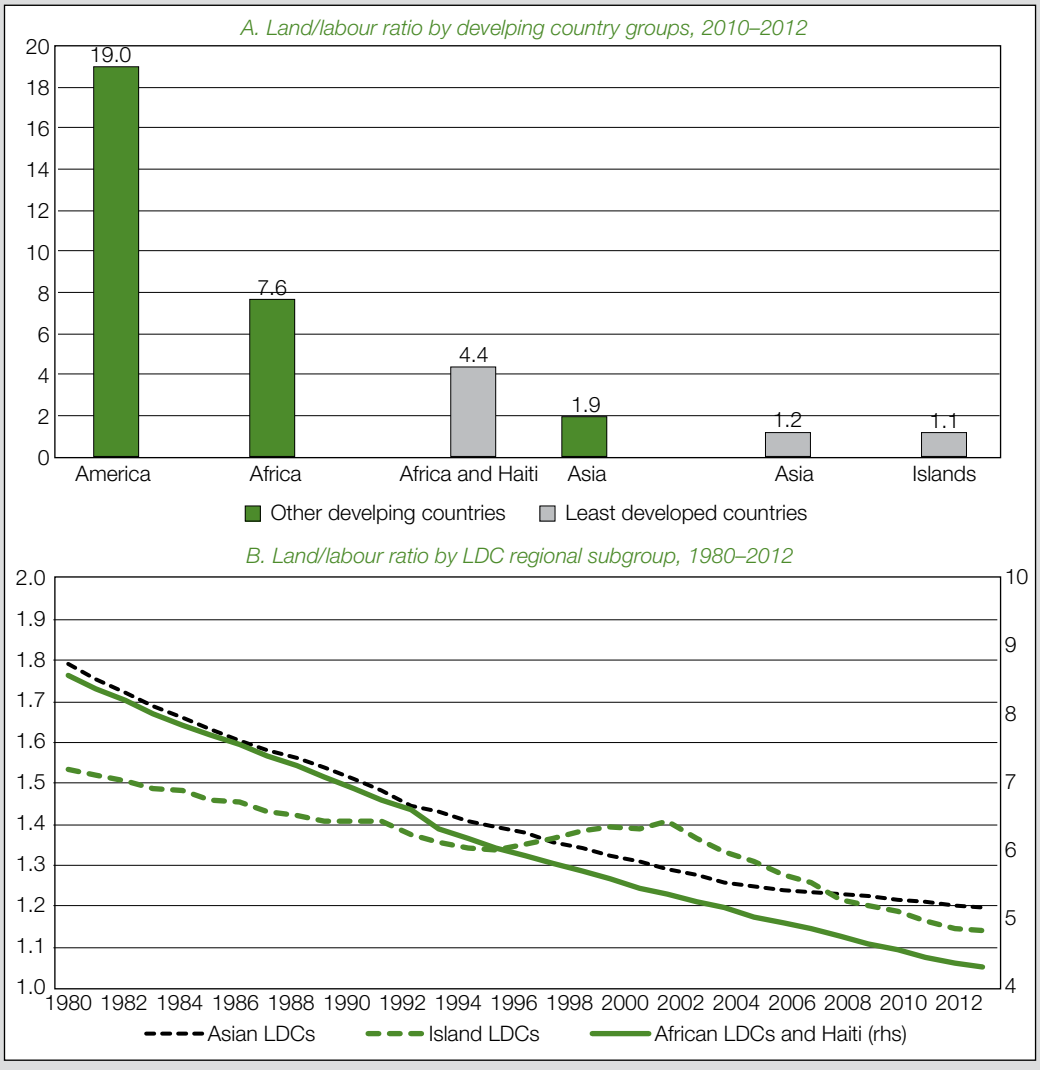
In both African LDCs and Haiti, and Asian LDCs, the expansion of the total agricultural area was more than compensated by the strong growth of the agricultural labour force, resulting in a one-third decline in the land/labour ratio since the early 1980s. (chart 2.6B).

In both African LDCs and Haiti, and Asian LDCs, the expansion of the total agricultural area was more than compensated by the strong growth of the agricultural labour force.

Following Hayami and Ruttan (1985) and Block (1995), the dynamics of partial productivity ratios in a chart can be represented by plotting changes over time in average labour productivity along the horizontal axis and changes in average land productivity along the vertical axis. A movement towards North in this chart (indicating growth in yield with no growth in average output per worker), for instance, may indicate population growth matched by increased yields through higher labour inputs or technological change, but no improvement in rural living standards.

Chart 2.7A implements this framework, comparing the performance of LDC agriculture with that of ODCs and developed countries. It shows that, in common with ODCs, LDC progress has been stronger in terms of land productivity than

Chart 2.6. Land/labour ratio, by country groups, 1980–2012
(Hectares/worker)



Source: UNCTAD secretariat calculations, based on data from FAO, FAOSTAT database (http://faostat.fao.org/) (accessed August 2015).
Note: rhs: Right-hand scale.

In common with ODCs, LDC progress has been stronger in terms of land productivity than of labour productivity.

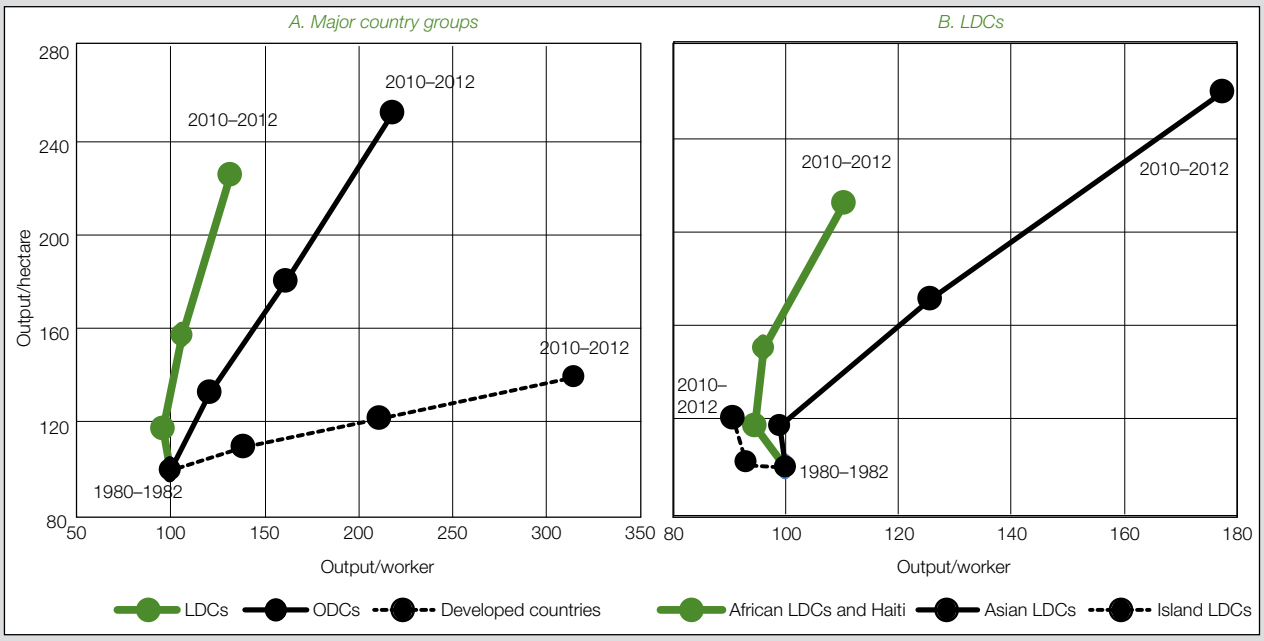
of labour productivity. Both groups of countries have succeeded in more than doubling land productivity, with somewhat stronger gains in ODCs. In the case of labour productivity, however, the performance gap is much wider. Since the early 1980s labour productivity in the LDCs has risen by only 31 per cent, while in ODCs it has more than doubled (chart 2.7A). This has been a major factor in preventing a faster reduction of poverty in LDCs (Chapter 1). Moreover, the performance of labour productivity in LDCs stands in sharp contrast to that of developed countries, where it has tripled over the same period. This is reflected in the divergence of agricultural labour productivity between the two groups of countries, shown in Chart 2.3.

While the 1980s were a decade of regress for the three LDC subgroups, productivity in Asian LDCs started growing as early as the 1990s, and has accelerated since the turn of the century.

Chart 2.7B repeats the same exercise for LDC subgroups and shows the striking contrasts between them. The sluggish performance of the LDC aggregate is heavily influenced by developments in African LDCs and Haiti and, to a lesser extent, island LDCs. While the 1980s were a decade of regress for the three subgroups, productivity in Asian LDCs started growing as early as the 1990s, and has accelerated since the turn of the century. Yields have risen by 159 per cent and labour productivity has risen by 77 per cent over the past 35 years. In African LDCs and Haiti, the recovery in productivity came later and was much slower. While these countries have successfully doubled their yields since the early 1980s, their labour productivity growth has been only 10 per cent over the entire period. Again, this largely explains the level and persistency of extreme poverty in this group of countries.[7] At the same time, productivity in island LDCs has remained broadly stagnant throughout the period. Although they have achieved some marginal improvement in land productivity, labour productivity has not yet recovered to the level of the early 1980s. Invariably, growth in terms of yields has been faster than the rise of labour productivity for all LDC subgroups, which means that improvements in the well-being of large parts of their population have also been slower.

Several essential features of the process of agricultural productivity growth in LDCs can be summarized based on the preceding analysis. First, growth in land productivity (yields) has been much stronger than in labour productivity, a

Chart 2.7. Partial productivity ratios for LDCs and other country groups, 1980-2012, selected periods
(Indices, 1980–1982 = 100)



Source: UNCTAD secretariat calculations, based on data from FAO, FAOSTAT database (http://faostat.fao.org/) (accessed August 2015).
Note: Each successive data point represents 10 years since the preceding point.

pattern that repeats itself for most individual countries. Twenty-six LDCs have achieved a doubling or more of their land productivity during the past 35 years, while only four have obtained similar results for labour productivity. Conversely, cases of long-term decline in agricultural productivity have been more prevalent in labour productivity (21 LDCs, or 45 per cent of the LDCs for which data are available) than in land productivity (just two cases). These developments have obviously had an adverse impact on the well-being of the population and have prevented a more rapid pace of poverty reduction. Still, there is a positive correlation between yield growth and labour productivity in LDCs (0.56), which is stronger than in ODCs (0.32).

Cases of long-term decline in agricultural productivity have been more prevalent in labour productivity than in land productivity.

Second, the groups that have generally been most successful along both dimensions of productivity since the early 1980s have been manufactures exporters and mixed exporters. Bangladesh and Nepal stand out among the former because they have doubled productivity of both land and labour. In the case of mixed exporters, Benin has achieved a similar outcome. These developments show that generally speaking, the countries that have advanced the most in terms of the structural transformation and diversification of their economy have been those which succeeded in raising their agricultural productivity. These developments confirm the link between agricultural progress and overall economic development, in which progress in agriculture and other productive sectors is mutually reinforcing. Agricultural productivity growth supports the process of structural transformation and productive diversification, as has long been highlighted in the economic development literature. Countries that have most successfully engaged in structural transformation and diversification are by the same token those which achieve greater advances in improving the well-being of their population and reducing poverty.

The countries that have advanced the most in terms of the structural transformation and diversification of their economy have been those which succeeded in raising their agricultural productivity.

Third, the other LDC subgroup that has achieved somewhat stronger growth in agricultural productivity is the fuel exporters, although here the fastest progress has been concentrated in the first decade of this century, which coincided with a long period of high oil prices. The best performers have been Angola and Yemen. Productivity gains in Angola, similarly to Mozambique and Sierra Leone, are related to post-conflict reconstruction. Under these circumstances agricultural production is carried out under better security and institutional conditions, access to input and output markets becomes easier, and in some cases governments adopt measures and programmes that support the sector (e.g. increased budget allocations).

Fourth, mineral and food and agricultural exporters experienced a much more moderate progression in both dimensions of productivity, and only since the turn of the century. At the same time, services exporters achieved a doubling of yields, coupled however with long-term decline in labour productivity.

Productivity gains in several LDCs are related to post-conflict reconstruction.

3. Total factor productivity

Available estimates of total factor productivity (TFP) enable the analysis of dynamics and trends of agricultural productivity over time, as well as their comparison across countries, but provide no indication of the (relative) level of productivity. In principle they provide a measure of the changes in production that are not accounted for in the variation in so-called conventional inputs (land, labour, material inputs, physical capital), which can thus be attributed to technology or other general factors (policies, etc.). There are some caveats to the computation and interpretation of TFP (box 2.3), but nevertheless it provides good indications of agricultural productivity trends.

The rhythm of growth of TFP in LDCs as a group has traditionally lagged considerably behind the performance of other country groups. More specifically,

Box 2.3. Total factor productivity, embodiment and the measurement of technological progress in agriculture

Gauging and quantifying technology and its impacts is a challenge in the case of agriculture, similar to what happens in other sectors of economic activity. A conventional measure of the impact of technology is total factor productivity (TFP). Most cross-country estimates of agricultural TFP are based on quantitative variations of inputs, but do not (adequately) take into account qualitative differences among them. TFP estimates rely on some assumptions, including that technology is disembodied and therefore its effects are captured by the magnitude of TFP growth (Block, 1995). While the assumption of disembodiment may hold for cultivation and water management techniques as well as other agricultural practices, a significant part of the results of agriculture-related research and development (R&D) is embodied in better-performing inputs, especially higher-yield varieties, better-quality fertilizers or superior agricultural machinery. Still, the effects of superior inputs will be reflected in TFP growth. Although fertilizers and machinery – and especially the latter – are still relatively less important for LDCs (due to the low input-intensity and capital-intensity of their agriculture), the use of higher-yield varieties or superior species of cattle has been a major source of productivity growth in their agriculture.

Concerning human capital input to agricultural production, all TFP estimates are based on some gauge of quantitative variations in labour input (subject to the caveats mentioned in Box 2.2). They do not, however, take account of qualitative differences in human capital, except for when some allowance is made for years of schooling. However, this is often not the case, due to the paucity of data specific to rural areas.

Agricultural TFP was largely stagnant in LDCs from the 1960s to the 1980s.

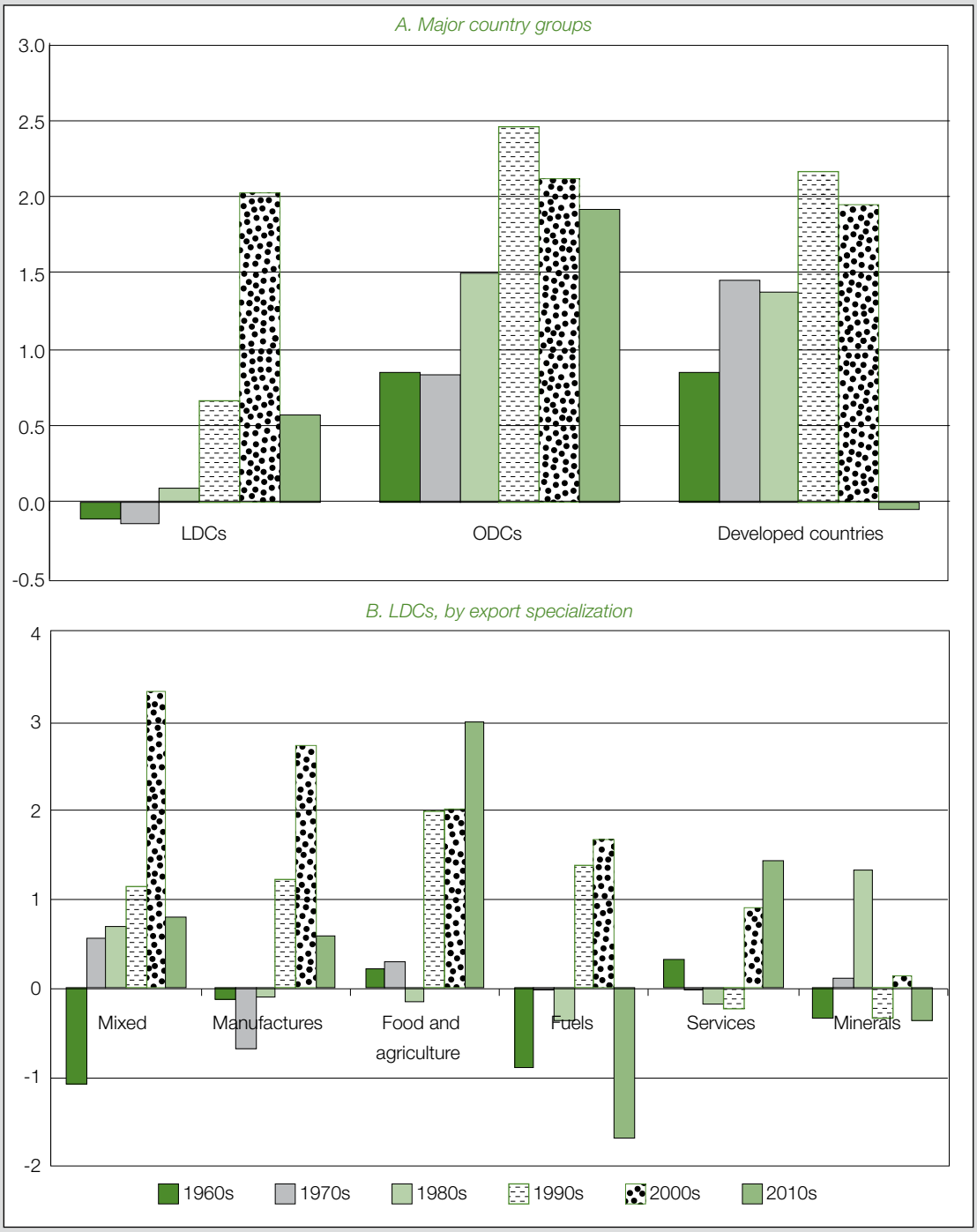
it was largely stagnant in LDCs from the 1960s to the 1980s. Growth turned positive in the 1990s and has accelerated significantly since the turn of the century (chart 2.8A). There is a marked contrast in the performance of LDC subgroups, similar to what has taken place with the partial productivity measures examined above. TFP growth turned positive in Asian LDCs in the 1990s and has accelerated since the turn of the century; since then it has outperformed all other major country groups (including ODCs and developed countries). In African LDCs and Haiti, by contrast, agricultural TFP was largely stagnant in the last four decades of the twentieth century, turning from near-stagnation in the 1960s to sluggish growth until the end of the century. Since then, however, TFP growth has turned positive, although it has been slower than in other country groups. In the island LDC subgroup, TFP has grown very slowly since the 1960s. It has alternated between periods of positive and negative growth, with a performance similar to that of partial productivity measures examined above.

LDC TFP growth turned positive in the 1990s and has accelerated significantly since the turn of the century.

The examination of TFP growth in LDCs according to export specialization yields some findings that confirm those resulting from partial productivity analysis, but also different ones. The former include the relatively positive agricultural productivity performance of mixed exporters and manufactures exporters, as well as fuel exporters (chart 2.8B). The manufactures exporters were led by Cambodia and Bangladesh, with average annual TFP rises of 3.3 per cent and 2.3 per cent, respectively, between 1990 and 2011. Among mixed exporters the strongest gains in productivity took place in Myanmar (with a 4.4-per-cent average annual growth rate), and Benin, Lao People's Democratic Republic and Sierra Leone, where TFP growth was approximately 2.5 per cent per annum. In the case of fuel exporters, TFP growth has been led by the performance of the agriculture of Angola and Yemen, where it rose on average by 4.5 per cent and 3 per cent annually, respectively, during the same period. The major new finding yielded by TFP analysis is the positive outcome of TFP growth in the exporters of food and agricultural products since the 1990s. Given that this is a very small group, the aggregate is driven by Malawi's TFP growth, which increased by 3 per cent annually during the same period.

Having examined the level and dynamics of agricultural productivity in LDCs according to different partial and total metrics, the question arises as to the drivers of these developments. They are analysed in the following section.

Chart 2.8. Growth of agricultural total factor productivity in LDCs and other country groups,1960–2011
(Annual averages, per cent)



Source: Fuglie and Rada, International Agricultural Productivity database (http://www.ers.usda.gov/data-products/international-agricultural-productivity.aspx) (accessed August 2015).

D. Determinants of agricultural productivity level and growth

The key drivers of partial and/or total productivity in agriculture are: quantity of conventional inputs; technology, input quality and human capital; ...

The following main factors have been identified in the literature as the key drivers of partial and/or total productivity in agriculture (Fuglie and Rada, 2013; Dias Avila and Evenson, 2010; Zepeda, 2001):

- Quantity of conventional inputs;
- Technology, input quality and human capital;
- Public investment and policies;
- Agroecological conditions and climate change;
- Rural diversification.

... as well as public investment and policies; agroecological conditions and climate change; and rural diversification.

Moreover, there are important interactions between these factors in determining productivity. The possibility of fertilizer use, for instance, depends on physical access to supply markets and hence on the availability of transport infrastructure and services (among other factors), while its efficiency is partly determined by the quality of the fertilizers themselves, the availability of water and the labour skills with which they are used. In another example of interaction, the contribution of transport access to agricultural productivity is enhanced in the presence of higher levels of farmer education.

An understanding of the determinants of agricultural productivity and hence of potential sources of productivity growth is important for formulating appropriate policies to raise productivity in LDCs, so as to accelerate their economies' structural transformation and boost their standard of living.

1. Quantity of conventional inputs

LDC agriculture employs labour very intensively; relies on the extensive use of land; and makes little use of other conventional inputs.

The quantity of agricultural output is most directly determined by the quantity of conventional inputs (land, labour, material inputs and physical capital inputs), especially in countries whose agriculture is at the lower stages of development. Therefore, partial productivity measures are also strongly influenced by the quantities of conventional inputs.

The trends in their use in LDCs are analysed below. The picture that emerges is that of an agriculture which: (1) employs labour very intensively; (2) relies on the extensive use of land; and (3) makes little use of other conventional inputs. The first two features have already been analysed in the preceding sections of this chapter. The third feature — the intensity of use of conventional inputs other than labour and land — is examined below.

Fertilizer use in many LDCs is constrained by poverty and low income, the lack of adequate water supply and foreign exchange shortage.

The intensity of manufactured input use varies widely across LDCs as a function of population density, inherent soil fertility and incidence of large-scale farming. Nonetheless, on average the use of fertilizers, plant health protection products and insecticides in LDC agriculture is extremely low. LDC consumption of synthetic fertilizers per area is just 10 per cent of the level in ODCs and 15 per cent that of developed countries. There are, however, significant differences among LDC groups. The use of fertilizers is lowest in island LDCs and African LDCs and Haiti. By contrast, Asian LDC farmers use fertilizers much more intensively than those of other LDCs (chart 2.9A). Their intensity corresponds to approximately half of the level of fertilizer use in developed countries.

Fertilizer use in many LDCs is constrained by poverty and low income (which render fertilizers unaffordable to many farmers), the lack of adequate water supply (which is required if fertilizers are to work efficiently) and foreign exchange shortage (which restricts the possibilities of importing fertilizers). Over the long term, however, increasing the use of inputs like fertilizer will be critical to increasing farm-level productivity, incomes and competitiveness. For this reason, many African LDCs have resorted to fertilizer subsidies, aiming to boost fertilizer use by farmers (Druilhe and Barreiro-Hurlé, 2012).

In African LDCs and Haiti, and in island LDCs, the low level of irrigation results in not only lower, but also more unstable, yield levels.

The degree to which water is used as an input for agricultural production in LDCs varies greatly from one region to another. It is low in African LDCs and Haiti, where just 3.4 per cent of arable land is equipped for irrigation and where access to water remains a major concern for agricultural development.[8] In island LDCs, the corresponding share (6.5 per cent) is somewhere between the level of African LDCs and Haiti and that of ODCs. This low level of irrigation results in not only lower, but also more unstable, yield levels.

In Asian LDCs, by contrast, the practice of irrigation is much more widespread, and has historically been so. The share of agricultural land that is irrigated (34.6 per cent) is more than double the proportion in ODCs and developed countries (chart 2.9B). It is, however, more in line with the regional average. The proportion of agricultural land that is equipped for irrigation in the non-LDC developing countries of Asia is 40.3 per cent, which is also the highest rate among the regional subgroups of ODCs.

The agriculture practised in LDCs is extremely labour-intensive and employs little physical capital.

Both farming and agro-industries are typically heavy users of water. The availability, quality and cost of water will be a progressively more important factor in the location and profitability of agribusiness activities. Climate change, increasing population pressures, and rising energy costs are all making water increasingly expensive; changes in the cost of water across different regions will affect the choice of where large international agribusinesses source their products, giving water-abundant areas in LDCs a potential advantage (Roepstoff et al., 2011).

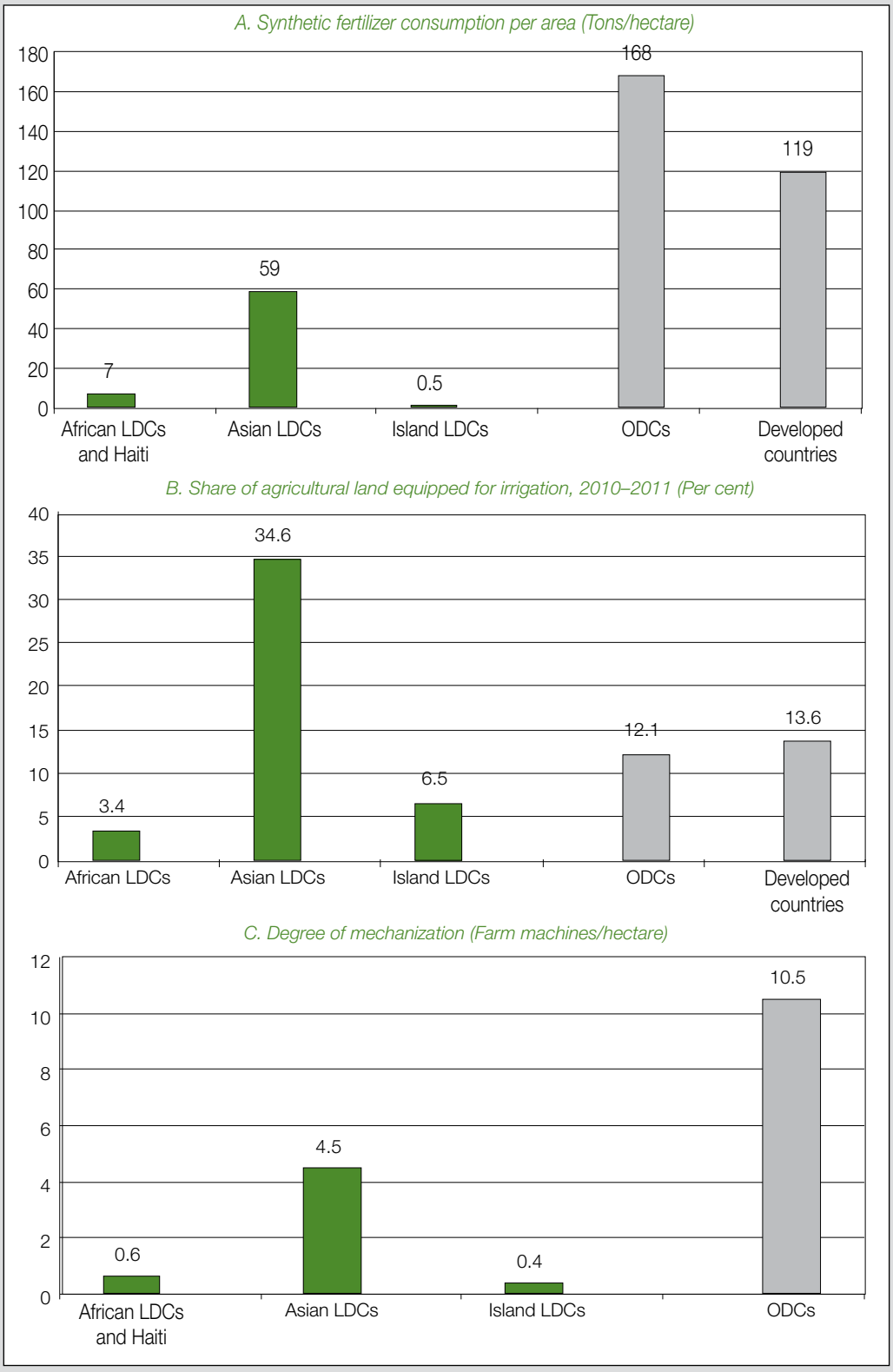
The agriculture practised in LDCs is extremely labour-intensive and employs little physical capital. It therefore has a very low degree of mechanization. Still, the contrast between Asian and other LDCs again arises with respect to this type of input. The intensity of use of agricultural machinery is very low in island LDCs and in African LDCs and Haiti, where less than one machine is used per hectare on average. In Asian LDCs, the degree of mechanization is much higher. On average, 4.5 machines are used per hectare in these countries, an intensity that is about half of the level of ODCs (chart 2.9C).[9]

LDC agriculture is not intensive in conventional inputs other than land and labour — especially fertilizers, machinery and water — but Asian LDCs use these inputs much more intensively than other LDCs.

In some cases a wide range of technological options may exist, e.g. in land preparation, where animal-traction equipment, hand tractors and large-scale tractors are all options. The choice depends on such factors as the heaviness of the soil to be ploughed, the rapidity with which the operation needs to take place (for example, in order to accommodate multiple cropping within a single year), the availability of maintenance services and spare parts, and the relative prices of labour and capital. For both agricultural machinery and agroprocessing equipment, a range of simpler, more labour-intensive but more economically efficient technologies is often available. The widespread importation into sub-Saharan Africa of simple grain mills, pumps and other agricultural technologies from India shows that African farmers and processors often opt for such “appropriate” technologies (Staatz, 2011).

While in general terms LDC agriculture is not intensive in conventional inputs other than land and labour — especially fertilizers, machinery and water — Asian

Chart 2.9. Indicators of input intensity in agriculture in LDCs and other country groups, 2010–2011



Source: Fuglie and Rada, International Agricultural Productivity database (http://www.ers.usda.gov/data-products/international-agricultural-productivity.aspx) (accessed August 2015) and FAO, FAOSTAT database (http://faostat.fao.org/) (accessed August 2015).

LDCs use these inputs much more intensively than other LDCs, and more in line with the practices of Asian ODCs. This explains to some extent why the partial indicators of productivity are much higher in Asian LDCs than in other LDCs.

At the same time, it points to an area for policy action to help reverse the low productivity in African LDCs. A survey was conducted with more than 100 agriculture experts working in Africa, asking them to identify the most important factors in advancing agriculture on the continent. Some 21 per cent of respondents identified such activities as enhancement of soil fertility, improved water management techniques and policy reform as the primary drivers of African agriculture, which were especially successful in southern Africa (Gabre-Madin and Haggblade, 2004).

The fact that the bulk of productivity enhancements achieved in LDCs have come from increased yields points to the importance of technology embodied in higher-yielding varieties or in superior species of cattle.

2. Technology, input quality and human capital

Technology plays a crucial role in determining agricultural productivity, as evidenced for instance by its effects on crop variety yields. The fact that the bulk of productivity enhancements achieved in LDCs have come from increased yields (rather than from labour productivity) points to the importance of technology embodied in higher-yielding varieties or in superior species of cattle, which can improve the well-being of farmers. Technology directly influences not only variety yields, but also the adaptation of plant and animal varieties to local agroecological conditions, the quality of inputs (seeds, fertilizers, machinery), the choice of cultivation and rearing techniques, etc. Producers' capacity to learn and adapt to new technologies and circumstances is partly determined by the quality of their human capital.

Successes tied to specific commodities (especially maize and cassava breeding) were key factors in advancing agriculture in Africa.

a. Technology and input quality

Agricultural innovations derive largely from agricultural research and development (R&D), which expands the set of technologies available to farmers. The importance of agricultural R&D is highlighted by the fact that the modest recovery in productivity gains in sub-Saharan Africa in the 1990s has been attributed to increased spending on agricultural R&D and extension services, as well as improved price incentives (Fuglie and Rada, 2013; Block, 1995). Successes tied to specific commodities (especially maize and cassava breeding) were cited as the key factors in advancing agriculture in Africa by the majority (62 per cent) of agriculture experts in the above-mentioned survey (Gabre-Madin and Haggblade, 2004). The case of maize deserves particular attention. As a staple food crop, it has received special policy attention in several countries. Between 1966 and 1990, more than 300 improved varieties and hybrids were released by national maize research programmes. This was especially successful in southern and eastern Africa (Byerlee and Jewell, 1997). The survey also pointed to the particular success of maize breeding programmes in eastern and southern Africa, where by the turn of the century 58 per cent of maize area was planted with improved hybrids, producing yields gains of about 40 per cent more than local varieties. In western and central Africa, by contrast, only some 20 per cent of total maize area was planted with improved varieties. Those regions were more dominated by improved open-pollinating varieties, with output gains of 15–45 per cent more than local varieties. Other major sources of success cited in the survey include the results of R&D activity, such as breeding to combat mosaic virus in cassava, and improved breeding of bananas in central Africa (Gabre-Madin and Haggblade, 2004).

There is strong complementarity between international and domestic research institutions.

There are high rates of return to public investment in developing and extending agricultural technologies.

Agricultural R&D is undertaken both by international and national institutions and by research centres. The former can be either global — such as the Consultative Group on International Agricultural Research (CGIAR) — or regional. There is strong complementarity between international and domestic research institutions.

Recent research documents the existence of high rates of return to public investment in developing and extending agricultural technologies. In a survey of studies on Asia, the rates of return to national research investment were estimated to range from 19 to 218 per cent, while those to national extension investment varied from 15 to 215 per cent. Returns to international research investment ranged from 68 to 108 per cent (Evenson and McKinsey Jr., 1991).[10] While the returns to R&D are high, several factors prevent them from having the kind of impact on LDC agricultural productivity that would bring them even remotely close to their potential.

The agricultural R&D intensity for low-income countries has declined marginally over the past 35 years.

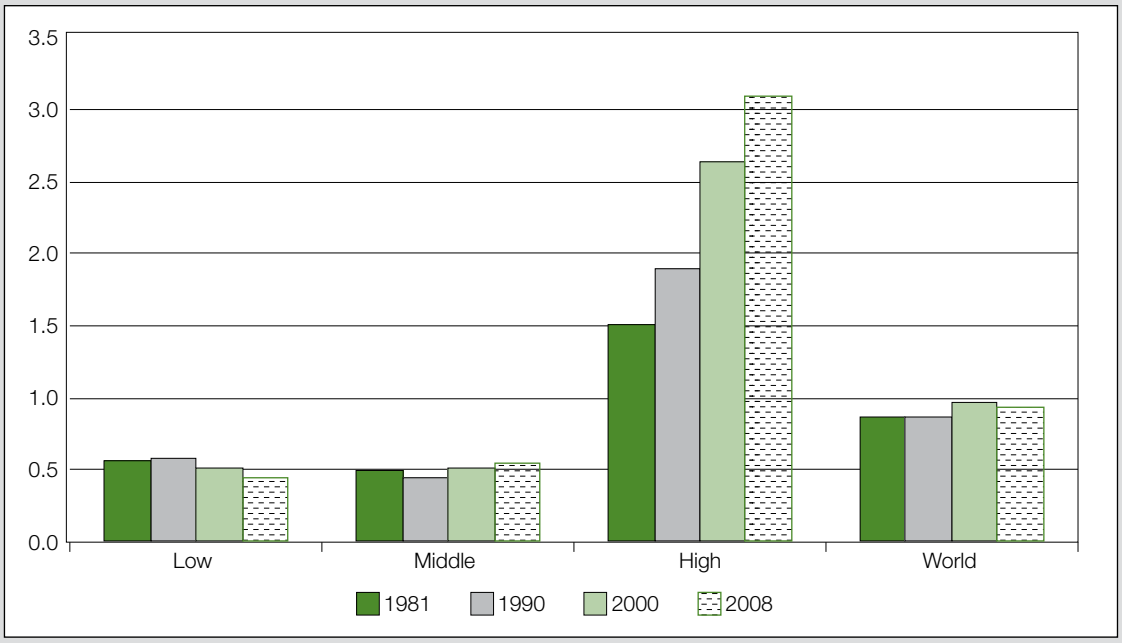
First, the level of agricultural R&D commitment in low-income countries is relatively low. The Agricultural Science and Technology Indicators compiled by the International Food Policy Research Institute (IFPRI) show that the sector's agricultural research spending relative to its gross domestic product (GDP) — the research intensity ratio — is substantially lower than in advanced economies. In 2008, low-income countries spent only $0.44 (at 2005 purchasing-power parity (PPP)) on public agricultural R&D for every $100 of agricultural GDP. The corresponding figure for high-income countries was more than $3 (chart 2.10). The average intensity ratio for low-income countries has declined marginally over the past 35 years, meaning that growth in R&D spending has lagged behind the expansion of agricultural GDP. In high-income countries, by contrast, public agricultural R&D spending for every $100 of agricultural GDP (2005 PPP) has risen steadily since the early 1980s, reaching $2.63 in 2000 and $3.07 in 2008.

In much of sub-Saharan Africa, public support for agricultural research and training of scientific personnel to undertake it stagnated or withered from the 1980s to 2005.

In much of sub-Saharan Africa, public support for agricultural research and training of scientific personnel to undertake it stagnated or withered from the 1980s to 2005, so that over half of the continent's national agricultural research systems had fewer than 100 scientists in 2000 (Beintema and Stads, 2006). Private research focused on a few profitable export crops, but there were few private-public partnerships like those which have characterized dynamic agricultural research systems, such as that of Brazil (Pardey et al., 2006).

Second, the high volatility of R&D in low-income economies presents an additional challenge. The inherent lag between the inception of a research

Chart 2.10. Public agricultural R&D expenditure by country income level, 1981–2008, selected years
(Per cent of agricultural GDP)



Source: Beintema et al. (2012).

project and the adoption of a new technology or crop variety demands that financial disbursements are sustained and stable, but this is often not the case. Annual agricultural R&D spending levels in low-income countries were twice as volatile as those of high-income countries, and considerably more volatile than those of middle-income countries during the period 2000–2008. Moreover, average volatility in sub-Saharan Africa proved to be much higher than in other developing regions. African LDCs such as Burkina Faso, Mauritania and United Republic of Tanzania recorded volatility coefficients as high as 0.40, compared with a modest 0.11 in the economies of the Organisation for Economic Co-operation and Development (OECD) (Beintema et al., 2012).

Annual agricultural R&D spending levels in low-income countries were twice as volatile as those of high-income countries during the period 2000–2008.

Third, in the case of African LDCs the challenge of undertaking locally appropriate R&D is much greater than in Asian LDCs. Several of the latter have to some extent benefited from the Asian green revolution, which relied heavily on productivity improvements in the cultivation of a few staples: rice, wheat and maize. Sub-Saharan Africa, by contrast, has very diversified farming systems, of which FAO has identified 14 major varieties, ranging from near-desert to forest-based systems, with significant diversity within each major category (AfDB et al., 2007). In contrast to the Asian countries that were at the heart of the green revolution, few African countries are heavily reliant on rice and wheat, while maize is dominant only in southern Africa. Sub-Saharan Africa's diverse agroecologies result in a wide range of farming systems and reliance on a large number of staples, such as cassava in central Africa and millet and sorghum in the Sahel, along with significant reliance on livestock in most farming systems. Accordingly, more varied processing and input technologies for staple crops are required than those which existed in Asia at a comparable stage of agricultural development. This implies a much greater need for investment in R&D that is appropriate to the specific agroecological conditions of the African LDCs.

Sub-Saharan Africa has very diversified farming systems and therefore quite varied processing and input technologies for staple crops are required.

In addition to generating new technologies with R&D, the innovation process needs to be complemented by (and interact with) the diffusion of these innovations. There is no exact correspondence between expenditures (an input indicator) and technology (an output). Even when technology is actually developed, it does not always result automatically in its adoption (Zepeda, 2001). The diffusion process involves the learning and mastery of new techniques by agricultural producers and their adoption of new varieties, animal species and other types of inputs (such as fertilizers and machinery). It may often take several years for innovation to be adopted by farmers. Typically, some farmers adopt it quickly, while others wait for extension or the results of their neighbours to convince them to do so.

Agricultural extension services are crucial to facilitating the dissemination of new technologies and their learning and adoption by farmers.

The fact that innovation diffusion is neither automatic nor rapid indicates the importance of agricultural extension services. They are crucial to facilitating the dissemination of new technologies and their learning and adoption by farmers. They provide a link between the generation of innovations by national and international research institutions and their mastery and adoption by producers at the farm level.

There is much potential for increasing agricultural productivity using existing technology.

The challenges of bringing about the diffusion even of existing technology are highlighted by the spread of high-yield varieties (HYV) of wheat and rice. They have been introduced on less than one third of the area planted with cereal grains in the developing world (Zepeda, 2001). Specifically, in Asia and the Middle East, 36 per cent of the grain area was HYV; in Latin America, 22 per cent; and in Africa, only 1 per cent (Wolf, 1987). This suggests there is much potential for increasing agricultural productivity using existing technology. The use of HYV requires increased use of fertilizer, however, but the inadequate water supply in many LDCs has made fertilizer use and hence HYV unprofitable. Moreover, low levels of adoption of HYV in African LDCs are also the result of a lack of appropriate technology development and of the few extension services

that target women (Jahnke, Kirschke and Lagemann, 1987). Furthermore, non-traditional crops have rarely been the focus of improved varieties or technology, and the potential exists to develop them in order to increase agricultural production.

Poorer farmers tend to be very risk-averse, which can negatively affect their adoption of new technologies.

Beyond the quality and availability of agricultural extension services, another oft-encountered obstacle to the adoption of new agricultural technologies — especially in LDCs — is poverty. Poorer farmers tend to be very risk-averse. They accept lower returns in exchange for lower risk in order to smooth their consumption. Wealthier farmers, particularly those with larger farms and diversified incomes, have higher rates of farm investment on a per hectare basis (Zepeda, 2001). This can negatively affect their adoption of new technologies, given the higher risks they often entail. This, in turn, reinforces their poverty and keeps them trapped in the vicious circle of poverty and low productivity (chart 2.1).

Interaction and feedback between users and generators of agricultural technological innovation are essential to spurring technological upgrading and productivity increase.

The difficulties of technological upgrading in LDC agriculture are illustrated by the relative weakness of the agro-industry sectors and agribusiness firms in the United Republic of Tanzania in promoting internal technological learning and acquiring technological capability through investments in new equipment. This weakness is due to inadequate public R&D, low private R&D spending, and weak training, extension, business and technical support systems. All types of (public and private) extension services for firms, in the form of support institutions that can be easily accessed to give advice on new technologies and on new equipment, are weak. Evidence from across the country suggests that management capacity, R&D spending, and extension services and training are crucial to business success and to steady productivity improvements in these sectors (Goedhuys, Janz and Mohnen, 2013). Also important is the intensified dialogue of public research, training and extension institutions with the private sector (and its associations) on reforming and adapting the research agenda, the delivery of extension services and the content of training programmes. Interaction and feedback between users and generators of technological innovation are essential to spurring technological upgrading and productivity increase, in an illustration of the circular model of innovation (Rosenberg, 1982).

Improvements in human capital influence the acquisition and assimilation of information, and the learning, mastery and implementation of technology.

b. Human capital

Human capital plays a key role in determining whether and how technology will be adopted in agricultural production, since it affects the use and combination of inputs by farmers. Improvements in human capital influence the acquisition and assimilation of information, and the learning, mastery and implementation of technology. Human capital also has an impact on farmers' ability to adapt technology to a particular situation and to changing needs (Schultz, 1972; Zepeda, 2001). Even in the absence of innovation, farm productivity may be enhanced by investments in education. There may be an efficiency advantage for farmers who are better prepared to anticipate and cope with instability. Farmers must adapt frequently in order to survive in an LDC environment characterized by high input and output price volatility (Asfaw and Admassie, 1996), unpredictable weather (which is increasingly common due to climate change), pests and crop disease. Therefore, the impact of agricultural extension services is enhanced by the quality of human capital, as research has shown (Dercon et al., 2008).

The quality of human capital derives from such factors as the level of education of the labour force, its health situation and its gender composition.

The quality of human capital, in turn, derives from such factors as the level of education of the labour force, its health situation and its gender composition. The first condition for a (reasonably) productive agricultural labour force is good health, especially in a situation of very low mechanization of agriculture, as is the case of LDCs. Health, in turn, depends on the nutritional situation of agricultural workers and, hence, on the absence of hunger. The latter has a negative impact

on agricultural labour productivity (and on wages), as evidenced by a number of empirical studies (Stamoulis and Zezza, 2003). Farmers who suffer from hunger are typically trapped in the vicious circle of poverty, hunger and low productivity, as shown in chart 2.1 (von Braun, Teklu and Webb, 1998).

Four years of primary schooling are needed if education is to have a significant effect on farm productivity.

Empirical evidence suggests that at least four years of primary schooling are needed if education is to have a significant effect on farm productivity (Weir, 1999). Eighteen studies representing 37 data sets (primarily in Asia) indicate a 9.5-per-cent increase in productivity associated with four years of schooling for modernizing farmers, but only 1.3 per cent for traditional farmers (Lockheed, Jamison and Lau, 1980). These general trends are confirmed by 12 other studies, which point to an average increase in output attributable to four additional years of schooling of 11.4 per cent for modernizing farmers, as compared with just 7.6 per cent for traditional farmers (Phillips, 1994). A more recent study of rural northern Nigeria finds productivity-enhancing effects of education (schooling and extension contact) only under improved technology. Factors that promote technology adoption will thus indirectly raise the marginal contributions of farmer education; these include schooling, participatory technology evaluation, improved seed supply, and market access (Alene and Manyong, 2007). The results demonstrate that schooling not only enhances agricultural productivity following technology adoption but also promotes the adoption itself.

Schooling not only enhances agricultural productivity following technology adoption but also promotes the adoption itself.

Beyond the impact of education on the human capital quality of the agricultural labour force, land productivity is also influenced by whether a household is male- or female-headed (Chapter 4 of this Report).

3. Public investment and policies

Public spending has a significant influence on agricultural productivity not only through outlays on knowledge-building, but also through its investment in physical infrastructure.

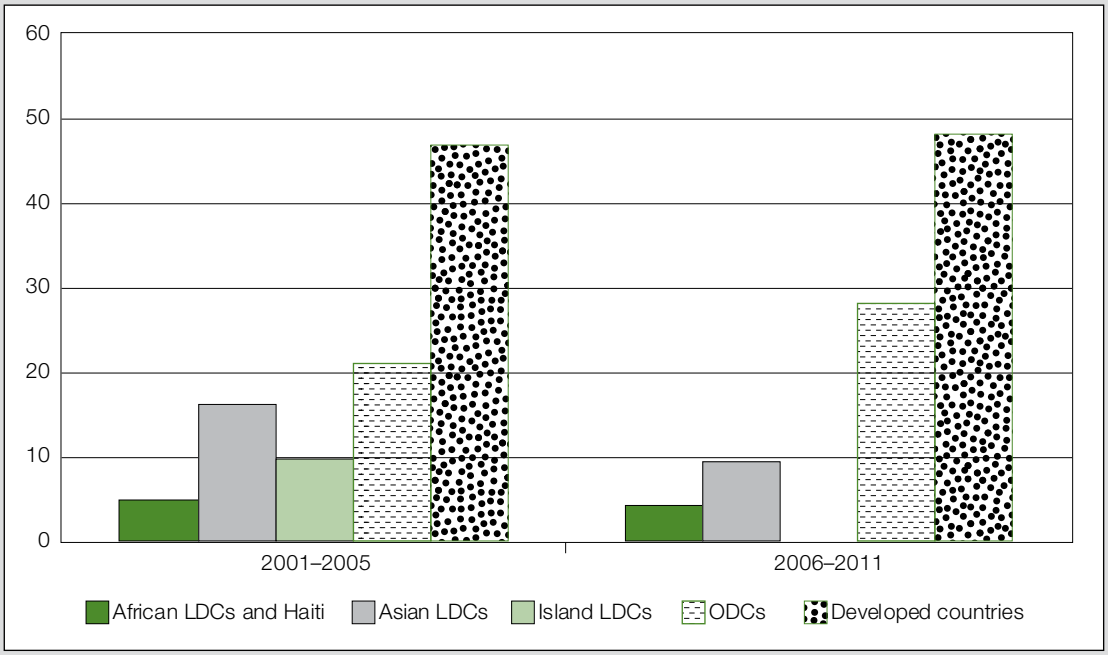
Public spending (in both LDCs and other countries) has a significant influence on agricultural productivity not only through outlays on knowledge-building (e.g. agricultural R&D, extension services and education), but also through its investment in physical infrastructure. Irrigation systems and roads may be required to make a technology profitable to implement, and physical access to input and output markets provides incentives to farmers' productive upgrading. Similarly, the presence of storage facilities and physical marketing facilities offers an incentive for productivity enhancement. Moreover, public investment in these areas is a precondition for private investment in agriculture and stimulates the latter (Zepeda, 2001). The "soft" (institutional) infrastructure and public policies also contribute to fostering or hindering the growth of the sector's productivity. In some cases reforms in pricing policy or the marketing system may have changed the incentive structure and helped boost productivity growth.

Public investment is a precondition for private investment in agriculture and stimulates the latter.

Road density is much lower in LDCs than in ODCs and developed countries. In African LDCs and Haiti, and in Asian LDCs, it corresponds to just 15 per cent and 33 per cent, respectively, of the level of ODCs (chart 2.11). Sub-Saharan Africa's present road density, at 201 km/1000 km^2, is less than a third of that of India in 1950 (703 km/1000 km^2). Even Rwanda, the continent's most densely populated country, does not have the road density of India in 1950. Today's gap is even wider: India's road density is 32 times that of Ethiopia and 255 times that of Sudan (Staatz and Dembélé, 2007).

Public investment in rural roads had the largest positive impact on agricultural productivity growth as compared with other explanatory variables, according to a study of country- and regional-level public expenditure in rural India (Fan, Hazell and Thorat, 1999). Other studies of the effect of road connectivity on input use, crop output and household income have suggested that isolation — defined as travel time during the dry season from a rural community to the nearest urban centre — entails lower agricultural productivity, increased

Chart 2.11. Road density by country groups, 2001–2011
(Kilometers of road/square kilometer of land)



Source: World Bank, World Development Indicators database (http://data.worldbank.org/data-catalog/world-development-indicators).

Isolation entails lower agricultural productivity, increased transport and transaction costs, increased insecurity, and a reduction in per capita consumption.

transport and transaction costs, increased insecurity, and a reduction in per capita consumption. These studies are based on household data for Ethiopia (Chamberlin et al., 2007) and Madagascar (Stifel and Minten, 2008). They observe that the distance to a passable road and the cost of transporting rice significantly decrease the use of fertilizer in rice production. Controlling for soil fertility, they demonstrate that crop yields for the three major staples in Madagascar — rice, maize and cassava — are lower in isolated areas.

Analyses of the long-run relationship between market access and agricultural production in Democratic Republic of the Congo and sub-Saharan Africa more generally show that agricultural production is highly correlated with proximity to urban markets (as measured by time travel), rather than with physical distance to the market (Ulimwengu et al., 2009; and Dorosh et al., 2010, respectively). In other words, reducing travel time to major cities has significant effects on agricultural productivity in sub-Saharan Africa.

Reducing travel time to major cities has significant effects on agricultural productivity.

In allocating public investment in infrastructure, the choice has to be made between a transport corridor development strategy and a rural feeder road strategy. It has been found that investments in corridors have a limited effect on smallholders and agricultural production. A study of corridors in Mozambique and United Republic of Tanzania suggests that these routes are likely to be "corridors of power" that benefit relatively few, rather than "corridors of plenty", with 90 per cent of smallholders likely to be left out of value chains. Therefore, additional opportunities and support should be provided to smallholders to help them benefit from corridors by linking those large infrastructure developments to the upgrading of feeder roads and storage facilities (Byiers and Rampa, 2013). This is confirmed by Dercon and Hoddinott (2005), who argue that low-quality feeder roads raise more poor people out of poverty for every dollar spent than high-quality trunk roads, making them a win-win strategy for growth and poverty alleviation.

With regard to soft infrastructure, the importance of policy reform in producing higher returns in agriculture is increasingly recognized. An example of the relation between policy reform and productivity is the implementation of China's

"responsibility system" in 1980–1981, which linked productivity to material reward and resulted in increased crop yields "for every major crop" (Wiens, 1983). Lin (1992) calculated that 42–47 per cent of the growth in agricultural output between 1978 and 1984 was attributable to that system. In another example, price reforms implemented in Egypt in 1986 contributed to increased yields of wheat, maize and rice from 1987 to 1993 (Khedr, Ehrich and Fletcher, 1996). Bevan, Collier and Gunning (1993) show how agricultural production in United Republic of Tanzania accelerated after price controls and export taxes were removed in 1984. These are examples of the long-term process of structural transformation, in which typically net resource transfers from agriculture to other economic sectors are initially high, but are subsequently gradually reduced through changes in tax and other policies and regulatory mechanisms (Timmer, 1988).[11] This evolution tends to change the incentives structure for farmers and to favour agricultural productivity growth.

The dearth of farmers' access to credit institutions and financial markets constitutes a major obstacle to their risk-taking, their adoption of new technologies and their improvements to productivity.

Another form of institutional development that encourages productivity growth is the development of credit institutions and financial markets (including credit and insurance). The dearth of farmers' access to these mechanisms, or the deficient quality of the supply of the services that are available to them, constitute major obstacles to their risk-taking, their adoption of new technologies and their improvements to productivity. Well-functioning, easily accessible markets for credit, for example, help farmers purchase productivity-enhancing inputs. Unfavourable social outcomes are more likely when these conditions are not in place.

Agricultural land titling tends to lead to larger average plot sizes, where economies of scale may be achieved.

Assigning property rights is viewed as a means of promoting development through the efficient and responsible use of resources (North, 1994). In the case of agriculture, it is argued that tenure security is an incentive for investment and that land property rights can be used as collateral for credit. In keeping with this view, many LDCs have adopted policies to title agricultural land, especially since the 1990s. However, this has also had unintended consequences. It tends to lead to larger average plot sizes, where economies of scale may supposedly be achieved. It also tends to result in large numbers of landless peasants. After titling and the creation of land markets, peasants often view the sale of small plots as an opportunity. However, becoming landless, and with limited opportunities for wage labour in rural areas, these ex-farmers have frequently been forced to emigrate to cities (Bouquet, 2015). Another mechanism of loss of access to land has often been the use of land as collateral in credit operations undertaken by farmers. This has happened a number of times in connection with microcredit operations, where farmers have not been able to service their debt because of the high interest rates which this type of credit typically entails.

4. Agroecological conditions and climate change

Farmers tend to underinvest in equipment, land improvement and human capital.

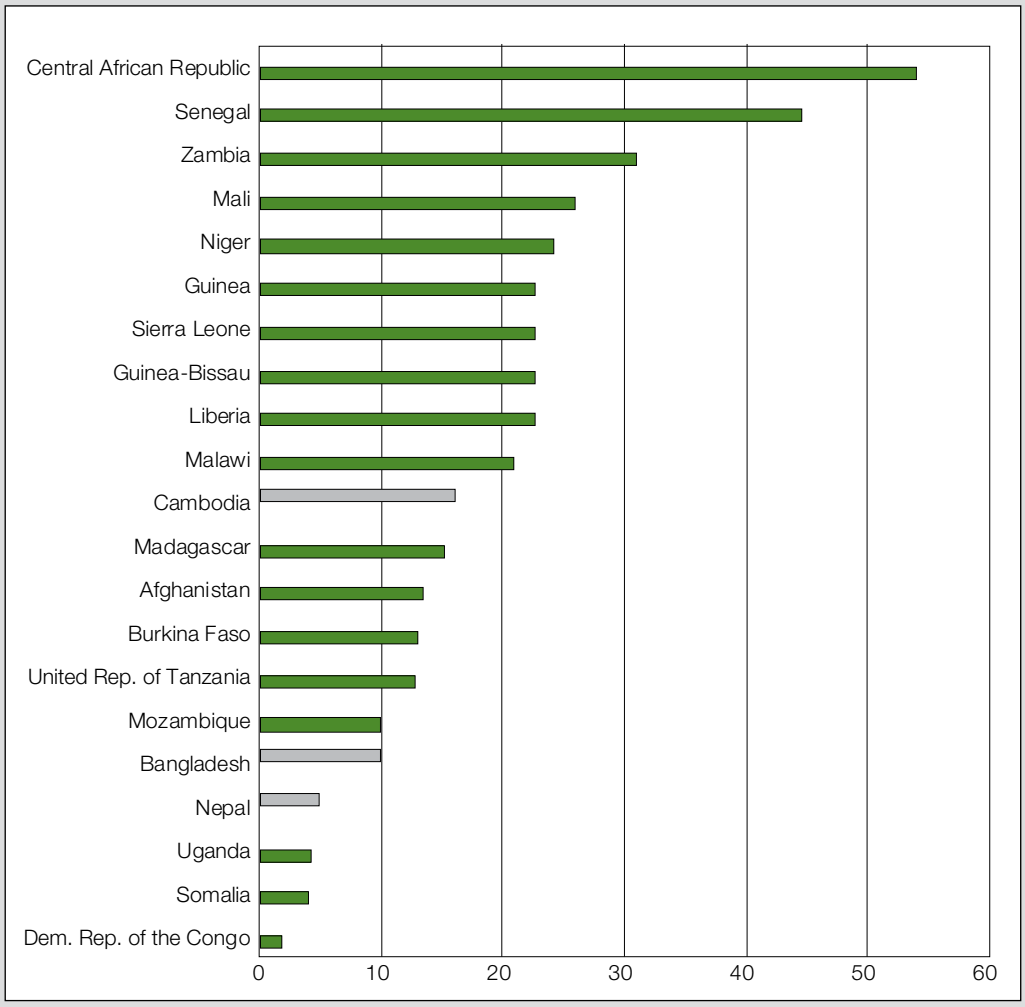
The natural fertility of soils is a major determinant of land productivity, as are the other agroecological conditions under which farmers produce. Farmers' investment decisions and agricultural practices can enhance or alternatively deplete the natural fertility of the soil. The irreversibility of investment in agriculture means that once investment is made, it is impossible — or at least very difficult — to redirect it to uses other than that originally planned. While this is common to any form of physical investment, it occurs much more frequently in agriculture than in other sectors. Allied with the inherent uncertainties of investment, this means that farmers tend to underinvest in equipment, land improvement and human capital. In any given year, net agricultural investment is likely to be negative (depreciation is higher than gross investment (Zepeda, 2001)). This is particularly true in LDCs, where low income and limited financial market development render access to insurance especially difficult for farmers. Therefore, in the absence of investment in land regeneration and low fertilizer

use, land quality tends to deteriorate. This has an adverse long-term impact on land productivity.

Agricultural output is projected to decline by the late twenty-first century even under the most optimistic scenario.

These factors will likely be affected by climate change and its related developments, such as temperature increases, changes in precipitation, decreased predictability of rainy seasons and increased frequency of extreme weather events (Keane et al., 2009). Their effects will vary considerably even within countries, ranging from agricultural areas that are lost to those that are gained, and from yield decreases to increases in different areas/crops. For low-income countries, estimates of changes in yield due to climate change between 2000 and 2050 range from -0.51 to -3.37 per cent for maize, from +1.61 to -9.79 per cent for rice and from -10.09 to -18.0 per cent for wheat (Nelson et al., 2010). In aggregate terms, agricultural output is projected to decline by the late twenty-first century even under the most optimistic scenario. The latter assumes carbon fertilization, which means that an increased concentration of carbon dioxide in the atmosphere (associated with climate change) can to some extent have a positive effect on crop productivity, since it stimulates photosynthesis and reduces loss of water by plants. Agricultural production is projected to contract in all 21 LDCs for which data are available, but in proportions that vary widely from less than 5 per cent in Democratic Republic of the Congo, Nepal, Somalia and Uganda to more than 40 per cent in Central African Republic and Senegal (Chart 2.12). The negative impact is generally much greater in African

Chart 2.12. Estimated loss in agricultural output by the 2080s, selected LDCs
(Per cent of agricultural output in 2003)



Source: UNCTAD secretariat elaboration, based on data from Cline (2007).
Note: Estimates include carbon fertilization, where an increased concentration of carbon dioxide in the atmosphere acts as a stimulus to crop productivity.

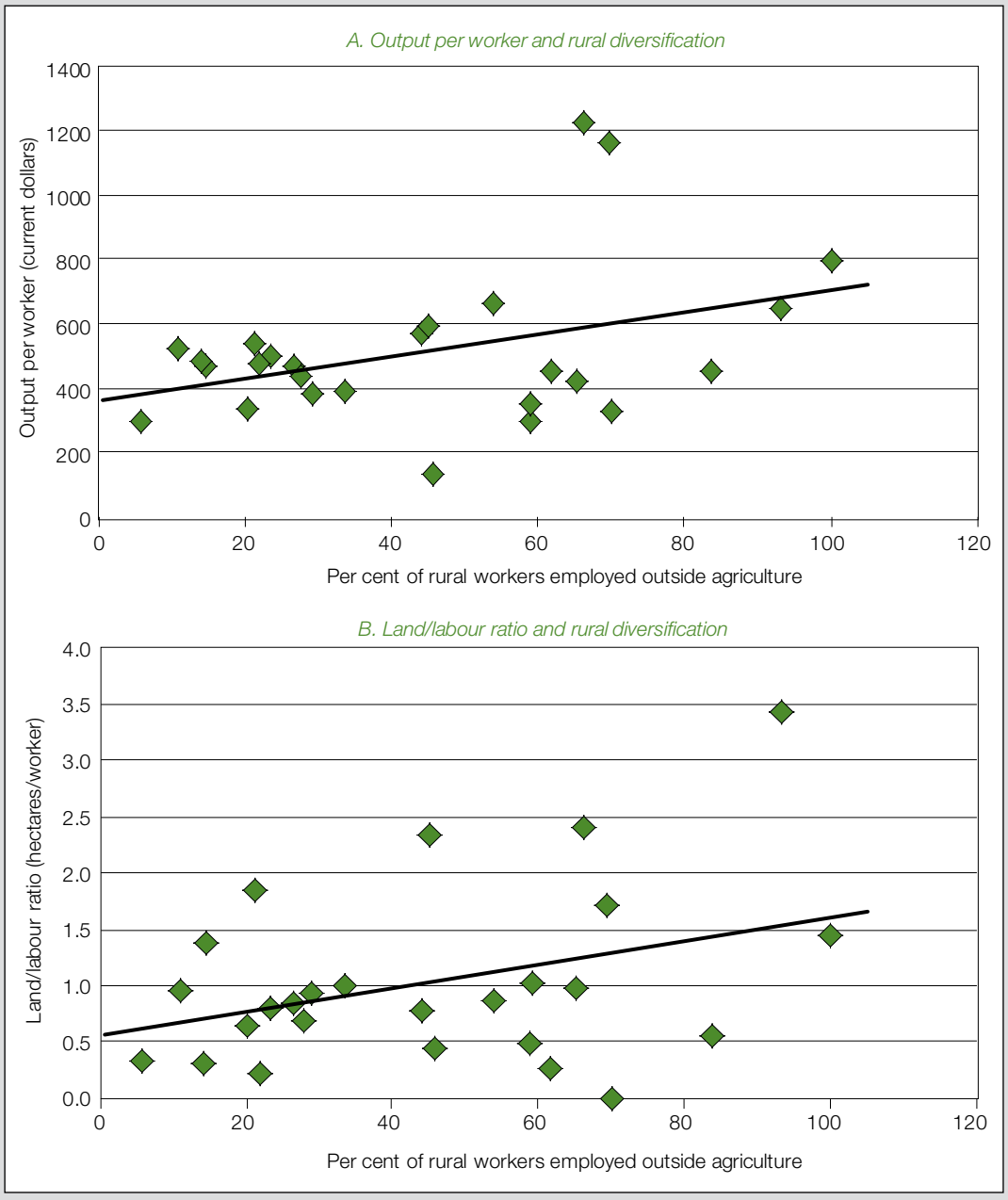
than in Asian LDCs. Considering that the agricultural labour force is projected to continue increasing in all of these countries, climate change is expected to cause a contraction of labour productivity (*ceteris paribus*) of even greater proportions.

The negative impact of climate change on agricultural production is generally much greater in African than in Asian LDCs.

5. Rural diversification

Rural diversification (discussed in Chapter 3) is a key driver and facilitator of productivity growth and upgrading in agriculture. The rise in off-farm income provides an additional source of financing for agricultural investment and technological upgrading, and the development of off-farm activities increases the supply of important inputs and services for agriculture, while also boosting demand growth for agricultural production. Improved vertical coordination is critical to achieving the timely flow of productivity-enhancing inputs to farmers and of quality agricultural raw materials to agro-industry. At the same time, production must be closely aligned with the rapidly evolving demands of consumers. Structural change in farming and agro-industry are thus closely interrelated (Staatz, 2011).

Chart 2.13. Agricultural productivity, land/labour ratios and rural diversification in selected LDCs



Source: UNCTAD secretariat calculations, based on data from FAO, FAOSTAT database (http://faostat.fao.org/) and DHS Program database (www.dhsprogram.com) (both accessed May 2015).

More diversified rural economies tend to register higher levels of labour productivity in the agricultural sector.

More diversified rural economies tend to register higher levels of labour productivity in the agricultural sector, as shown by the positive correlation (around 0.4) between rural diversification and labour productivity in the agricultural sector for a sample of 26 LDCs in all geographical regions (chart 2.13A).[12]

The increases in labour productivity related to rural diversification, however, are not associated with increases in land productivity. There is, in fact, no sign of positive correlation between land productivity and percentage of employment outside the agricultural sector. More diversified rural economies employ fewer workers, on average, in agriculture and are therefore characterized by relatively higher land/labour ratios (chart 2.13B). This relatively lower utilization of land may in part explain why the improvements in labour productivity are not reflected in higher yields per hectare.

E. Summary

The main points raised in this chapter are:

- LDC agriculture employs land and labour intensively, but makes limited use of other inputs (fertilizers, irrigated water, machinery), which results in low levels of productivity.
- Increasing land and labour productivity in agriculture is critical to structural transformation, poverty reduction and food security.
- Agricultural productivity declined across all LDC subgroups in the 1980s, and has exhibited strong growth only in Asian LDCs since 2000, allowing them to overtake the African and island LDCs.
- Labour productivity in agriculture in LDCs (with sectoral production measured by value added) is 18.7 per cent of that in ODCs and 1.8 per cent that in developed countries, and these gaps have widened progressively over time.
- Land productivity has risen much faster in LDCs than labour productivity, starting to converge with developed countries but not with ODCs, and the gaps are much narrower.
- Land/labour ratios have declined for all LDC geographical subgroups.
- Total factor productivity in LDC agriculture stagnated from the 1960s to the 1980s, but started to increase in the 1990s and accelerated after 2000, especially in Asian LDCs.
- Major drivers of increasing agricultural productivity are use and quality of inputs, development and adoption of high-yield varieties, education, public investment in infrastructure and diversification into non-farm activities.
- Well integrated national and international efforts towards technology generation and innovation diffusion can make a major contribution to raising agricultural productivity.
- Public policies can greatly contribute to enhancing agricultural productivity through spending on R&D, extension services, education, and physical and institutional infrastructure.
- Climate change is likely to have a negative effect on agricultural productivity in most LDCs.

Notes

1 As used in this chapter, "agriculture" refers to agriculture, forestry and fisheries, unless otherwise specified.

2 Conflicts of land use are bound to arise when land becomes scarcer and extensive expansion of agricultural production (which has been the practice especially in African LDCs) becomes more difficult.

3 For the classification of LDCs according to geographical/structural criteria, see page xiii.

4 Data on productivity trends and developments in individual countries are provided in the annex to this chapter.

5 For the classification of LDCs according to export specialization, see page xiii.

6 Between 2015 and 2100, the populations of 33 countries, most of them LDCs, have a high probability of at least tripling. Among them, the populations of Angola, Burundi, Democratic Republic of Congo, Malawi, Mali, Niger, Somalia, Uganda, United Republic of Tanzania and Zambia are projected to increase at least fivefold by 2100. The concentration of population growth in the poorest countries will make it harder for their governments to eradicate poverty and inequality; combat hunger and malnutrition; expand education enrolment and health systems; improve the provision of basic services; and implement other elements of a sustainable development agenda to ensure that no one is left behind (UN/DESA, Population Division, 2015).

7 A study of the competitiveness of commercial agriculture compared the on-farm per-unit production costs for several agricultural products produced in the Guinea-Savannah regions of Africa with production costs for the same products in Brazil and Thailand. It showed that while African farm-level costs were comparable to those in Brazil and Thailand, this "competitiveness" was based on: (1) soil mining (the depletion of soil nutrient reserves, leading to soil degradation); and (2) extremely low returns to labour, reflecting few alternative employment opportunities for workers — hardly a model for poverty reduction (World Bank, 2009).

8 The proportion of land under irrigation in sub-Saharan Africa is currently less than a quarter of that of India in 1961, at the dawn of its green revolution. Increasing the percentage of irrigated land in sub-Saharan Africa to the Indian levels of 1960 would cost approximately $114 billion.

9 The capital intensity of the agriculture of developed countries is significantly higher than that of developing countries, including both LDCs and ODCs. The former use 54.5 machines per hectare, five times as many as in ODCs.

10 In the case of India, public investment in research accounts for over half of agricultural growth, while extension contributes about one third and infrastructure accounts for very little growth. Internal rates of return were estimated at 218 per cent for public research, 177 per cent for public extension and 95 per cent for private research expenditures (Evenson and McKinsey Jr., 1991).

11 In developed countries, this process has typically gone furthest, to the point where other economic sectors transfer net resources to agriculture.

12 Data on rural diversification are extracted from several demographic and health surveys (DHS). Diversification is measured by the share of rural labour force working outside the agricultural sector. For labour productivity, for each country in the sample the most recent DHS available and the corresponding level of output per worker for the same year are used.

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Annex table 2.1. Total economically active population in agriculture in LDCs and other country groups, 1980–2012, selected years
(Thousand workers)

	1980	1990	2000	2010	2012
Afghanistan	3 004	2 513	4 013	5 431	5 809
Angola	2 533	3 323	4 336	6 021	6 582
Bangladesh	25 196	31 416	32 457	32 622	32 154
Benin	814	1 150	1 478	1 723	1 769
Bhutan	134	160	169	308	335
Burkina Faso	2 737	3 535	4 703	6 519	7 194
Burundi	1 839	2 546	2 879	4 117	4 435
Cambodia	2 404	2 979	3 956	5 046	5 313
Central African Republic	862	1 030	1 168	1 239	1 272
Chad	1 298	1 871	2 441	3 090	3 234
Comoros	99	127	161	206	222
Democratic Republic of the Congo	7 320	9 071	11 063	13 381	14 117
Djibouti	119	191	230	268	282
Equatorial Guinea	67	108	142	175	187
Eritrea[a]	631	867	1 173	1 694	1 853
Ethiopia[a]	12 487	17 166	24 226	33 255	36 089
Gambia	227	333	436	588	649
Guinea	1 952	2 479	3 480	4 176	4 470
Guinea-Bissau	283	338	402	468	498
Haiti	1 662	1 783	1 977	2 251	2 323
Kiribati	8	10	10	11	11
Lao People's Democratic Republic	1 172	1 505	1 891	2 443	2 656
Lesotho	243	291	328	335	344
Liberia	541	562	724	905	955
Madagascar	3 248	4 125	5 374	7 384	8 102
Malawi	2 523	3 401	3 939	4 946	5 375
Mali	1 622	1 795	2 162	2 780	2 989
Mauritania	431	442	584	777	841
Mozambique	5 050	5 217	7 119	8 885	9 544
Myanmar	12 445	15 521	18 441	20 325	20 929
Nepal	5 200	6 301	8 245	10 804	11 535
Niger	1 742	2 234	3 116	4 341	4 839
Rwanda	2 141	2 866	3 363	4 450	4 821
Sao Tome and Principe	21	24	27	35	38
Senegal	1 890	2 381	3 036	3 977	4 373
Sierra Leone	899	1 098	1 038	1 296	1 337
Solomon Islands	67	91	119	148	157
Somalia	1 781	1 797	2 045	2 520	2 720
South Sudan[b]	-	-	-	-	1792
Sudan[b]	4 434	5 005	6 252	7 450	6025
Timor-Leste	203	249	238	338	358
Togo	714	939	1 119	1 346	1 430
Tuvalu	1	1	1	1	1
Uganda	4 902	6 603	8 442	11 202	12 197
United Republic of Tanzania	7 806	10 556	13 549	16 928	18 346
Vanuatu	26	30	33	38	39
Yemen	1 075	1 330	1 871	2 191	2 214
Zambia	1 501	2 210	2 658	3 246	3 536
LDCs (total)	**127 354**	**159 570**	**196 614**	**241 680**	**256 291**
African LDCs and Haiti	76 299	97 313	124 982	161 733	174 520
Asia LDCs	50 630	61 725	71 043	79 170	80 945
Island LDCs	425	532	589	777	826
Other develping countries	**761 358**	**933 492**	**998 179**	**1 037 298**	**1 041 515**
Developed countries	**40 080**	**31 751**	**22 338**	**15 998**	**14 455**

Source: UNCTAD secretariat calculations, based on data from FAO, FAOSTAT database (accessed August 2015).
Notes: *a* Estimates for 1980 and 1990; *b* Data prior to 2011 are for former Sudan.

Annex table 2.2. Agricultural labour productivity in LDCs and other country groups, 1980–2013, selected years

	Sectoral production measured by value added (2005 thousand dollars / worker)					Sectoral production measured by final output value (2004–2006 international dollars / worker)				
	1991	*2000*	*2010*	*2012*	*2013*	*1980*	*1990*	*2000*	*2010*	*2013*
Afghanistan	1 354.3	674.9	686.1	702.2	748.7	779.8	797.8	620.1	613.0	593.3
Angola	821.9	521.5	1 424.2	1 544.0	1 531.3	314.5	249.1	309.1	608.5	681.9
Bangladesh	280.1	315.3	480.8	520.9	534.6	338.9	339.4	452.0	649.3	692.9
Benin	776.5	946.9	953.7	1 015.0	1 055.3	584.0	678.4	972.6	1 073.6	1 321.8
Bhutan	1 024.5	1 081.7	952.3	886.0	988.4	580.7	636.1	597.8	452.0	427.0
Burkina Faso	228.4	302.7	538.7	563.5	583.1	209.9	291.6	299.4	383.1	368.0
Burundi	247.9	193.1	211.1	210.0	212.1	419.7	399.4	337.0	295.5	328.5
Cambodia	351.0	370.4	569.3	611.2	622.7	282.2	394.6	462.8	705.1	822.5
Central African Republic	436.1	482.6	446.9	460.3	283.0	500.9	516.2	654.5	745.3	782.3
Chad	451.1	444.0	556.8	571.7	529.5	512.5	430.5	437.4	464.0	489.3
Comoros	1 475.8	1 377.1	1 308.3	1 342.3	1 365.0	397.7	401.1	378.6	351.3	325.0
Democratic Republic of the Congo	261.5	205.3	188.1	189.8	194.1	445.5	484.6	340.3	292.8	305.0
Djibouti	..	..	..	..	..	214.1	267.1	201.0	240.8	259.5
Equatorial Guinea	571.4	1 350.1	1 954.8	1 724.7	1 653.5	407.3	362.7	275.3	265.9	261.5
Eritrea[a]	139.1	118.1	102.0	99.5	101.8	265.2	205.4	150.2	139.8	132.5
Ethiopia[a]	154.9	181.7	256.1	282.9	299.1	326.7	253.1	215.0	303.2	297.9
Gambia	431.6	476.2	512.3	398.9	425.2	283.0	220.0	271.7	275.8	179.7
Guinea	204.4	217.1	184.3	199.9	206.7	407.0	401.7	410.3	453.8	459.0
Guinea-Bissau	672.0	650.7	593.1	599.0	573.9	336.8	442.1	519.1	622.9	675.2
Haiti	1 096.6	601.0	481.8	465.9	481.9	562.4	505.3	467.9	467.0	481.6
Kiribati	..	..	..	..	..	1 491.4	1 206.4	1 709.6	2 447.7	2 516.0
Lao People's Democratic Republic	310.3	410.7	462.5	474.0	482.3	366.1	430.6	562.9	650.4	742.5
Lesotho	347.1	359.1	373.8	356.2	381.5	441.8	426.8	386.0	411.9	404.6
Liberia	613.8	712.7	1 130.1	1 365.2	1 478.8	584.7	453.2	544.4	435.6	414.5
Madagascar	230.2	207.8	173.9	166.5	151.5	619.9	574.2	470.7	458.2	421.0
Malawi	289.2	354.8	313.2	307.2	315.6	323.9	282.5	457.0	567.5	640.2
Mali	917.7	841.6	935.1	944.0	858.2	634.9	787.2	798.8	1 245.2	1 162.1
Mauritania	1 757.3	1 271.5	1 358.3	1 361.5	1 453.2	666.4	758.9	662.2	628.6	619.9
Mozambique	234.2	232.9	389.1	404.2	411.5	229.8	214.5	223.4	321.2	319.3
Myanmar	146.5	232.0	579.1	598.8	694.4	413.0	360.9	513.7	846.2	811.4
Nepal	245.2	259.4	316.9	334.2	332.9	339.5	445.3	452.8	449.9	484.4
Niger	592.8	484.5	632.0	661.4	638.8	551.8	450.5	488.2	711.0	592.6
Rwanda	265.0	253.9	313.5	327.6	326.9	425.0	381.3	361.4	482.4	523.8
Sao Tome and Principe	..	..	..	..	..	673.9	508.3	914.0	760.7	763.6
Senegal	652.6	690.5	548.9	511.4	463.2	282.6	354.4	379.6	419.5	318.6
Sierra Leone	905.9	418.0	769.8	839.1	882.1	386.3	386.2	305.2	821.2	909.6
Solomon Islands	1 338.3	1 007.5	1 306.1	1 304.2	1 359.5	873.4	704.5	705.5	767.5	772.9
Somalia	..	..	..	..	..	725.5	813.2	704.1	665.5	692.5
Sudan[b]	1 655.5	2 594.9	3 424.6	2 895.8	2 900.9	846.3	762.8	1 137.5	1 199.8	1 315.0
Timor-Leste						439.7	420.1	439.0	418.0	373.0
Togo	599.9	592.5	591.3	482.4	469.5	474.3	484.9	538.0	617.6	569.4
Tuvalu						829.3	527.4	799.3	936.4	912.3
Uganda	377.4	451.7	483.2	468.5	462.7	470.3	513.0	517.0	506.3	468.4
United Republic of Tanzania	317.3	334.2	423.0	434.0	436.4	369.9	366.6	318.8	451.6	497.7
Vanuatu						1 976.9	2 270.8	1 826.5	2 082.8	2 114.9
Yemen	682.9	1 008.7	2 070.2	1 856.4	1 787.0	548.7	568.8	593.7	837.2	838.3
Zambia	607.8	521.0	570.8	723.9	656.5	351.7	332.3	324.5	544.1	549.5
LDCs (total)	**350.5**	**376.9**	**507.5**	**516.6**	**525.1**	**412.9**	**400.2**	**433.3**	**544.1**	**553.5**
African LDCs and Haiti	387.1	406.7	498.4	498.3	498.9	429.3	408.9	403.0	478.3	485.6
Asia LDCs	293.9	327.3	522.9	552.2	578.8	386.4	384.9	485.2	678.2	699.7
Island LDCs	1 410.8	1 206.5	1 307.3	1 325.0	1 362.5	624.6	587.5	598.0	593.1	565.5
Other develping countries	**1 156.7**	**1 440.5**	**2 463.4**	**2 776.8**	**2 876.3**	**622.6**	**751.8**	**1 010.5**	**1 348.9**	**1 459.0**
Developed countries	**13 696.3**	**18 494.0**	**27 427.4**	**27 397.7**	**29 484.7**	**10 618.6**	**14 738.7**	**22 883.2**	**33 704.8**	**38 367.5**

Source: For sectoral production mesured by value added: UNCTAD secretariat calculations, based on data from UNTAD, UNCTADStat database for value added (accessed in August 2015), and ILO, WESO 2015 database for labour (accessed in August 2015).
For sectoral production mesured by final output value: UNCTAD secretariat calculations, based on data from FAO, FAOSTAT database (accessed August 2015).

Notes: *a* Estimates for 1980 and 1990; *b* Data prior to 2011 are for former Sudan. Data are unavailable for South Sudan.

Annex table 2.3. Agricultural land productivity in LDCs and other country groups , 1980-2012, selected years
(2004–2006 international dollars / hectare)

	1980	1990	2000	2010	2012
Afghanistan	61.6	52.7	65.9	87.8	92.9
Angola	13.9	14.4	23.4	62.8	56.5
Bangladesh	855.0	1026.7	1560.7	2292.1	2398.4
Benin	234.5	343.7	449.9	537.7	571.8
Bhutan	188.4	224.2	190.6	267.7	284.0
Burkina Faso	65.4	107.7	144.1	206.9	217.6
Burundi	369.6	482.0	519.6	663.7	552.2
Cambodia	256.0	263.8	383.8	629.2	730.0
Central African Republic	87.3	106.2	148.5	181.8	192.8
Chad	13.8	16.7	22.0	28.9	33.0
Comoros	358.0	398.0	420.4	469.9	451.7
Democratic Republic of the Congo	126.9	169.3	147.1	152.1	163.8
Djibouti	19.6	39.3	28.9	37.9	43.0
Equatorial Guinea	81.7	117.3	117.1	158.3	171.1
Eritrea[a]	13.6	14.8	23.4	31.2	32.5
Ethiopia[a]	87.1	98.2	169.9	282.6	293.8
Gambia	114.1	125.0	214.6	263.7	212.3
Guinea	55.9	70.4	105.8	132.5	142.1
Guinea-Bissau	68.9	103.3	128.2	178.9	201.9
Haiti	584.2	564.2	547.4	562.1	591.6
Kiribati	314.0	309.3	502.8	791.9	807.1
Lao People's Democratic Republic	267.2	390.4	575.0	667.6	791.1
Lesotho	46.8	53.5	54.2	59.3	54.2
Liberia	122.8	102.2	151.0	148.2	151.3
Madagascar	55.9	65.2	62.5	81.7	87.2
Malawi	213.4	227.8	380.6	493.7	556.0
Mali	32.1	44.0	44.7	84.3	85.6
Mauritania	7.3	8.5	9.7	12.3	13.2
Mozambique	24.6	23.5	33.0	57.1	59.2
Myanmar	495.0	537.2	876.2	1373.0	1323.2
Nepal	432.1	677.0	878.6	1178.0	1457.9
Niger	31.3	30.5	41.1	70.2	67.1
Rwanda	530.5	581.6	727.9	1172.7	1328.1
Sao Tome and Principe	382.5	290.4	503.6	548.9	536.3
Senegal	60.4	95.1	131.6	175.5	157.3
Sierra Leone	127.5	150.1	112.7	270.8	281.9
Solomon Islands	991.8	942.8	1104.6	1061.6	1103.9
Somalia	29.4	33.2	32.7	38.0	40.3
Sudan[b]	34.0	31.1	54.1	65.6	65.2
Timor-Leste	319.9	329.0	310.0	379.8	376.9
Togo	111.6	142.7	165.8	226.8	233.5
Tuvalu	414.7	263.7	399.7	520.2	496.5
Uganda	215.9	283.2	348.9	403.3	395.8
United Republic of Tanzania	87.5	113.8	127.1	204.1	216.6
Vanuatu	401.6	448.2	344.4	423.2	415.7
Yemen	25.1	32.0	46.9	77.8	80.5
Zambia	26.6	35.3	38.3	75.4	82.6
LDCs (total)	**70.4**	**83.1**	**109.5**	**160.8**	**166.4**
African LDCs and Haiti	49.9	59.0	73.6	107.3	111.0
Asia LDCs	215.8	254.9	370.5	559.6	586.0
Island LDCs	406.5	417.3	430.6	509.6	506.7
Other develping countries	**187.0**	**251.0**	**343.5**	**477.0**	**505.1**
Developed countries	**348.9**	**391.4**	**439.3**	**499.3**	**496.1**

Source: UNCTAD secretariat calculations, based on data from FAO, FAOSTAT database (accessed August 2015).
Notes: *a* Estimates for 1980 and 1990; *b* Data prior to 2011 are for former Sudan. Data are unavailable for South Sudan.

Annex table 2.4. Land/labour ratio in LDCs and other country groups, 1980–2012, selected years (Hectares/worker)					
	1980	1990	2000	2010	2012
Afghanistan	12.67	15.14	9.41	6.98	6.67
Angola	22.66	17.27	13.21	9.70	9.26
Bangladesh	0.40	0.33	0.29	0.28	0.28
Benin	2.49	1.97	2.16	2.00	2.11
Bhutan	3.08	2.84	3.14	1.69	1.59
Burkina Faso	3.21	2.71	2.08	1.85	1.73
Burundi	1.14	0.83	0.65	0.45	0.45
Cambodia	1.10	1.50	1.21	1.12	1.10
Central African Republic	5.74	4.86	4.41	4.10	4.03
Chad	37.10	25.82	19.92	16.03	15.67
Comoros	1.11	1.01	0.90	0.75	0.73
Democratic Republic of the Congo	3.51	2.86	2.31	1.93	1.88
Djibouti	10.93	6.80	6.96	6.35	6.14
Equatorial Guinea	4.99	3.09	2.35	1.68	1.55
Eritrea[a]	19.47	13.90	6.42	4.48	4.22
Ethiopia[a]	3.75	2.58	1.27	1.07	1.04
Gambia	2.48	1.76	1.27	1.05	0.96
Guinea	7.29	5.70	3.88	3.42	3.30
Guinea-Bissau	4.89	4.28	4.05	3.48	3.35
Haiti	0.96	0.90	0.85	0.83	0.77
Kiribati	4.75	3.90	3.40	3.09	3.09
Lao People's Democratic Republic	1.37	1.10	0.98	0.97	0.95
Lesotho	9.45	7.98	7.12	6.94	6.70
Liberia	4.76	4.44	3.60	2.94	2.88
Madagascar	11.10	8.81	7.54	5.61	5.27
Malawi	1.52	1.24	1.20	1.15	1.10
Mali	19.78	17.90	17.85	14.77	14.28
Mauritania	91.56	89.72	68.07	51.11	48.43
Mozambique	9.33	9.14	6.76	5.62	5.36
Myanmar	0.83	0.67	0.59	0.62	0.61
Nepal	0.79	0.66	0.52	0.38	0.36
Niger	17.63	14.79	11.87	10.13	9.60
Rwanda	0.80	0.66	0.50	0.41	0.40
Sao Tome and Principe	1.76	1.75	1.81	1.39	1.34
Senegal	4.68	3.72	2.88	2.39	2.13
Sierra Leone	3.03	2.57	2.71	3.03	3.10
Solomon Islands	0.88	0.75	0.64	0.72	0.69
Somalia	24.71	24.51	21.55	17.51	16.66
South Sudan	-	-	-	-	16.44
Sudan[b]	24.91	24.56	21.05	18.29	64.92
Timor-Leste	1.37	1.28	1.42	1.10	1.09
Togo	4.25	3.40	3.24	2.72	2.75
Tuvalu	2.00	2.00	2.00	1.80	1.80
Uganda	2.18	1.81	1.48	1.26	1.20
United Republic of Tanzania	4.23	3.22	2.51	2.21	2.28
Vanuatu	4.92	5.07	5.30	4.92	4.92
Yemen	21.83	17.76	12.65	10.76	10.65
Zambia	13.22	9.42	8.46	7.22	6.94
LDCs (total)	**5.87**	**4.82**	**3.96**	**3.38**	**3.30**
African LDCs and Haiti	8.60	6.93	5.47	4.46	4.31
Asia LDCs	1.79	1.51	1.31	1.21	1.19
Island LDCs	1.54	1.41	1.39	1.16	1.14
Other develping countries	**3.3**	**3.0**	**2.9**	**2.8**	**2.8**
Developed countries	**30.4**	**37.7**	**52.1**	**67.5**	**72.7**

Source: UNCTAD secretariat calculations, based on data from FAO, FAOSTAT database (accessed August 2015).
Notes: *a* Estimates for 1980 and 1990; *b* Data prior to 2011 are for former Sudan.

Annex table 2.5. Growth rate of agricultural total factor productivity, 1960–2011
(Annual averages, per cent)

	1960s	1970s	1980s	1990s	2000s	2010sa
Afghanistan	1.7	0.7	-0.1	1.8	-1.8	-1.9
Angola	-2.0	-4.0	-1.0	3.5	4.9	-2.6
Bangladesh	-0.2	-0.3	0.1	1.5	2.8	-0.2
Benin	-1.5	1.4	1.3	1.6	2.9	5.6
Bhutan	0.6	-0.6	-0.3	1.5	-0.7	1.7
Burkina Faso	-0.4	-1.6	1.4	0.6	0.1	0.6
Burundi	-0.9	-1.7	1.0	-0.7	-1.2	-5.0
Cambodia	-0.6	-5.2	4.2	1.4	4.8	6.3
Central African Republic	-1.5	0.3	0.9	1.8	0.0	2.9
Chad	-1.7	-0.5	0.7	0.1	-0.5	3.8
Comoros	-0.1	0.0	1.1	-1.0	0.4	1.4
Democratic Republic of the Congo	-0.7	-0.8	0.9	-0.2	-1.0	-1.9
Djibouti	1.8	1.5	0.3	0.5	0.7	0.2
Equatorial Guinea	-1.0	-5.4	0.4	0.3	2.1	3.1
Ethiopia[b]	-1.0	0.4	-0.7	-0.8	2.3	3.1
Gambia	-0.9	-4.5	-1.4	-0.3	-1.9	5.2
Guinea	-0.1	0.1	1.9	-1.6	0.7	0.2
Guinea-Bissau	-2.9	-0.8	2.8	0.8	1.7	1.6
Haiti	0.4	0.4	-0.5	-1.6	0.9	0.8
Lao People's Democratic Republic	0.3	-0.4	1.7	1.2	2.1	4.2
Lesotho	-0.1	0.6	-1.1	1.3	0.5	2.5
Liberia	-0.6	-0.5	-0.5	1.1	-1.4	-3.7
Madagascar	-0.9	0.3	0.7	-0.2	1.9	0.2
Malawi	0.2	0.7	-0.7	4.3	1.9	0.6
Mali	-1.3	1.8	1.7	1.0	1.9	-5.4
Mauritania	-0.3	-0.4	0.2	-0.2	0.6	4.7
Mozambique	0.0	-2.3	0.6	2.3	0.2	4.6
Myanmar	-1.8	1.1	0.4	2.3	6.4	0.6
Nepal	-0.1	-1.2	2.1	-0.2	2.1	1.5
Niger	-1.8	-0.9	-0.2	1.7	2.5	-1.0
Rwanda	1.0	1.5	-0.3	0.3	-0.3	14.4
Sao Tome and Principe	1.1	-3.3	-2.1	5.0	0.8	2.0
Senegal	-3.3	-0.3	1.0	-1.1	1.8	5.2
Sierra Leone	-0.6	0.0	1.0	-0.8	3.5	2.6
Solomon Islands	-1.9	1.4	0.2	1.3	2.7	0.9
Somalia	0.3	1.6	-0.7	1.6	0.7	3.0
Sudan[c]	-1.3	0.8	-0.8	1.3	1.1	-3.8
Timor-Leste	0.8	-0.5	-0.4	-2.5	-0.1	0.4
Togo	-0.9	-1.7	-1.9	2.5	1.0	4.5
Uganda	2.6	0.6	1.1	-0.7	-1.8	-0.6
United Republic of Tanzania	-0.3	0.7	0.9	0.1	1.3	0.6
Vanuatu	-2.0	1.4	-0.8	0.0	-1.0	4.8
Yemen	-3.1	1.6	1.1	1.3	3.6	3.6
Zambia	0.9	1.5	0.3	1.0	3.5	7.1
LDCs (total)	**-0.6**	**-0.6**	**0.3**	**0.8**	**1.4**	**1.8**
African LDCs and Haiti	-0.7	-0.5	0.3	0.7	1.2	1.7
Asia LDCs	-0.4	-0.7	1.2	1.4	2.8	2.3
Island LDCs	-0.3	-0.5	-0.5	0.8	0.7	1.9
Other develping countries	**0.8**	**0.8**	**0.6**	**2.0**	**1.5**	**0.9**
Developed countries	**0.8**	**1.1**	**1.6**	**2.3**	**2.2**	**0.6**

Source: UNCTAD secretariat calculations, based on data from Fuglie and Rada (2014).
Notes: *a* Average growth in 2010–2011; *b* Prior to 1994, refers to former Ehtiopia; *c* Refers to former Sudan.
Data are unavailable for Kiribati, South Sudan and Tuvalu.