SAVE AND GROW

A POLICYMAKER'S GUIDE TO THE SUSTAINABLE INTENSIFICATION OF SMALLHOLDER CROP PRODUCTION

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Foreword

The Green Revolution in agriculture, which swept much of the developing world during the 1960s, saved an estimated one billion people from famine. Thanks to high-yielding crop varieties, irrigation, agrochemicals and modern management techniques, farmers in developing countries increased food production from 800 million tonnes to more than 2.2 billion tonnes between 1961 and 2000. Intensive crop production helped to reduce the number of undernourished, drive rural development and prevent the destruction of natural ecosystems to make way for extensive farming. Those achievements came at a cost. In many countries, decades of intensive cropping have degraded fertile land and depleted groundwater, provoked pest upsurges, eroded biodiversity, and polluted air, soil and water. As the world population rises to a projected 9.2 billion in 2050, we have no option but to further intensify crop production. But the yield growth rate of major cereals is declining, and farmers face a series of unprecedented, intersecting challenges: increasing competition for land and water, rising fuel and fertilizer prices, and the impact of climate change.

The present paradigm of intensive crop production cannot meet the challenges of the new millennium. In order to grow, agriculture must learn to *save*. Consider, for example, the hidden cost of repeated ploughing. By disrupting soil structure, intensive tillage leads to loss of nutrients, moisture and productivity. More farmers could save natural resources, time and money if they adopted conservation agriculture (CA), which minimizes tillage, protects the soil surface, and alternates cereals with soil-enriching legumes. Those simple practices help to reduce crops' water needs by 30 percent and the energy costs of production by up to 60 percent. In trials in southern Africa, they increased maize yields six-fold. Combining CA with precision irrigation produces more crops from fewer drops. Farmers can reduce the need for fertilizers by adopting "precision placement", which doubles the amount of nutrients absorbed by plants. By using insecticides wisely, they can save pest predators and disrupt the cycle of pest resistance. Economizing on agrochemicals and building healthy agro-ecosystems would enable low-income farm families in developing countries – some 2.5 billion people – to maximize yields and invest the savings in their health and education.

This new paradigm of agriculture is sustainable crop production intensification (SCPI), which can be summed up in the words "save and grow". Sustainable intensification means a productive agriculture that conserves and enhances natural resources. It uses an ecosystem approach that draws on nature's contribution to crop growth – soil organic matter, water flow regulation, pollination and natural predation of pests – and applies appropriate external inputs at the right time, in the right amount. "Save and grow" farming systems offer proven productivity, economic and environmental benefits. A review of agricultural development in 57 low-income countries found that ecosystem farming led to average yield increases of almost 80 percent. Conservation agriculture, which is practised on more than 100 million hectares worldwide, contributes to climate change mitigation by sequestering in soil millions of tonnes of carbon a year.

SCPI represents a major shift from the homogeneous model of crop production to knowledge-intensive, often location-specific, farming systems. Its application will require significant support to farmers in testing new practices and adapting technologies. Governments will need to strengthen national programmes for plant genetic resources conservation, plant breeding and seed distribution in order to deploy improved crop varieties that are resilient to climate change and use nutrients, water and external inputs more efficiently. Fundamental changes are also required in agricultural development strategies. Policymakers must provide incentives for adoption of SCPI, such as rewarding good management of agro-ecosystems. Developed countries should support sustainable intensification by increasing considerably the flow of external assistance to, and investment in, agriculture in the developing world.

Sustainable intensification of smallholder crop production is one of FAO's strategic objectives. Our aim over the next 15 years is to assist developing countries in adopting "save and grow" policies and approaches. This book provides a toolkit of adaptable farming systems, technologies and practices, and explores the policies and the institutional arrangements that will support the large-scale implementation of SCPI.

Jacques Diouf
Director-General
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Overview

1. The challenge

To feed a growing world population, we have no option but to intensify crop production. But farmers face unprecedented constraints. In order to grow, agriculture must learn to save.

The Green Revolution led to a quantum leap in food production and bolstered world food security. In many countries, however, intensive crop production has depleted agriculture's natural resource base, jeopardizing future productivity. In order to meet projected demand over the next 40 years, farmers in the developing world must double food production, a challenge made even more daunting by the combined effects of climate change and growing competition for land, water and energy. This book presents a new paradigm: sustainable crop production intensification (SCPI), which produces more from the same area of land while conserving resources, reducing negative impacts on the environment and enhancing natural capital and the flow of ecosystem services.

2. Farming systems

Crop production intensification will be built on farming systems that offer a range of productivity, socio-economic and environmental benefits to producers and to society at large.

The ecosystem approach to crop production regenerates and sustains the health of farmland. Farming systems for SCPI will be based on conservation agriculture practices, the use of good seed of high-yielding adapted varieties, integrated pest management, plant nutrition based on healthy soils, efficient water management, and the integration of crops, pastures, trees and livestock. The very nature of sustainable production systems is dynamic: they should offer farmers many possible combinations of practices to choose from and adapt, according to their local production conditions and constraints. Such systems are knowledge-intensive. Policies for SCPI should build capacity through extension approaches such as farmer field schools, and facilitate local production of specialized farm tools.

3. Soil health

Agriculture must, literally, return to its roots by rediscovering the importance of healthy soil, drawing on natural sources of plant nutrition, and using mineral fertilizer wisely.

Soils rich in biota and organic matter are the foundation of increased crop productivity. The best yields are achieved when nutrients come from a mix of mineral fertilizers and natural sources, such as manure and nitrogen-fixing crops and trees. Judicious use of mineral fertilizers saves money and ensures that nutrients reach the plant and do not pollute air, soil and waterways. Policies to promote soil health should encourage conservation agriculture and mixed crop-livestock and agroforestry systems that enhance soil fertility. They should remove incentives that encourage mechanical tillage and the wasteful use of fertilizers, and transfer to farmers precision approaches such as urea deep placement and site-specific nutrient management.

4. Crops and varieties

Farmers will need a genetically diverse portfolio of improved crop varieties that are suited to a range of agro-ecosystems and farming practices, and resilient to climate change.

Genetically improved cereal varieties accounted for some 50 percent of the increase in yields over the past few decades. Plant breeders must achieve similar results in the future. However, timely delivery to farmers of high-yielding varieties requires big improvements in the system that connects plant germplasm collections, plant breeding and seed delivery. Over the past century, about 75 percent of plant genetic resources (PGR) has been lost and a third of today's diversity could disappear by 2050. Increased support to PGR collection, conservation and utilization is crucial. Funding is also needed to revitalize public plant breeding programmes. Policies should help to link formal and farmer-saved seed systems, and foster the emergence of local seed enterprises.

5. Water management

Sustainable intensification requires smarter, precision technologies for irrigation and farming practices that use ecosystem approaches to conserve water.

Cities and industries are competing intensely with agriculture for the use of water. Despite its high productivity, irrigation is under growing pressure to reduce its environmental impact, including soil salinization and nitrate contamination of aquifers. Knowledge-based precision irrigation that provides reliable and flexible water application, along with deficit irrigation and wastewater-reuse, will be a major platform for sustainable intensification. Policies will need to eliminate perverse subsidies that encourage farmers to waste water. In rainfed areas, climate change threatens millions of small farms. Increasing rainfed productivity will depend on the use of improved, drought tolerant varieties and management practices that save water.

6. Plant protection

Pesticides kill pests, but also pests' natural enemies, and their overuse can harm farmers, consumers and the environment. The first line of defence is a healthy agro-ecosystem.

In well managed farming systems, crop losses to insects can often be kept to an acceptable minimum by deploying resistant varieties, conserving predators and managing crop nutrient levels to reduce insect reproduction. Recommended measures against diseases include use of clean planting material, crop rotations to suppress pathogens, and eliminating infected host plants. Effective weed management entails timely manual weeding, minimized tillage and the use of surface residues. When necessary, lower risk synthetic pesticides should be used for targeted control, in the right quantity and at the right time. Integrated pest management can be promoted through farmer field schools, local production of biocontrol agents, strict pesticide regulations, and removal of pesticide subsidies.

7. Policies and institutions

To encourage smallholders to adopt sustainable crop production intensification, fundamental changes are needed in agricultural development policies and institutions.

First, farming needs to be profitable: smallholders must be able to afford inputs and be sure of earning a reasonable price for their crops. Some countries protect income by fixing minimum prices for commodities; others are exploring "smart subsidies" on inputs, targeted to low-income producers. Policymakers also need to devise incentives for small-scale farmers to use natural resources wisely – for example, through payments for environmental services and land tenure that entitles them to benefit from increases in the value of natural capital – and reduce the transaction costs of access to credit, which is urgently needed for investment. In many countries, regulations are needed to protect farmers from unscrupulous dealers selling bogus seed and other inputs. Major investment will be needed to rebuild research and technology transfer capacity in developing countries in order to provide farmers with appropriate technologies and to enhance their skills through farmer field schools.

Contents

Chapter 1

The challenge

To feed a growing world population, we have no option but to intensify crop production. But farmers face unprecedented constraints. In order to grow, agriculture must learn to save

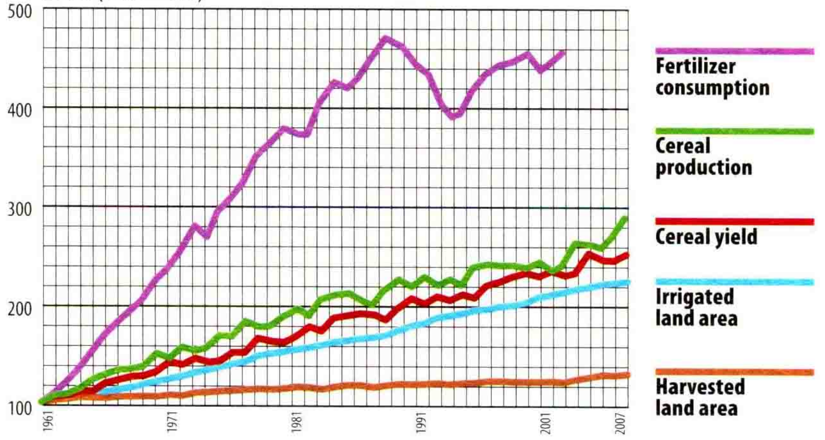
The history of agriculture can be seen as a long process of intensification[1], as society sought to meet its ever growing needs for food, feed and fibre by raising crop productivity. Over millennia, farmers selected for cultivation plants that were higher yielding and more resistant to drought and disease, built terraces to conserve soil and canals to distribute water to their fields, replaced simple hoes with oxen-drawn ploughs, and used animal manure as fertilizer and sulphur against pests.

Agricultural intensification in the twentieth century represented a paradigm shift from traditional farming systems, based largely on the management of natural resources and ecosystem services, to the application of biochemistry and engineering to crop production. Following the same model that had revolutionized manufacturing, agriculture in the industrialized world adopted mechanization, standardization, labour-saving technologies and the use of chemicals to feed and protect crops. Great increases in productivity have been achieved through the use of heavy farm equipment and machinery powered by fossil fuel, intensive tillage, high-yielding crop varieties, irrigation, manufactured inputs, and ever increasing capital intensity[2].

The intensification of crop production in the developing world began in earnest with the Green Revolution. Beginning in the 1950s and expanding through the 1960s, changes were seen in crop varieties and agricultural practices worldwide[3]. The production model, which focused initially on the introduction of improved, higher-yielding varieties of wheat, rice and maize in high potential areas[4,5] relied upon and promoted homogeneity: genetically uniform varieties grown with high levels of complementary inputs, such as irrigation, fertilizers and pesticides, which often replaced natural capital. Fertilizers replaced soil quality management, while herbicides provided an alternative to crop rotations as a means of controlling weeds[6].

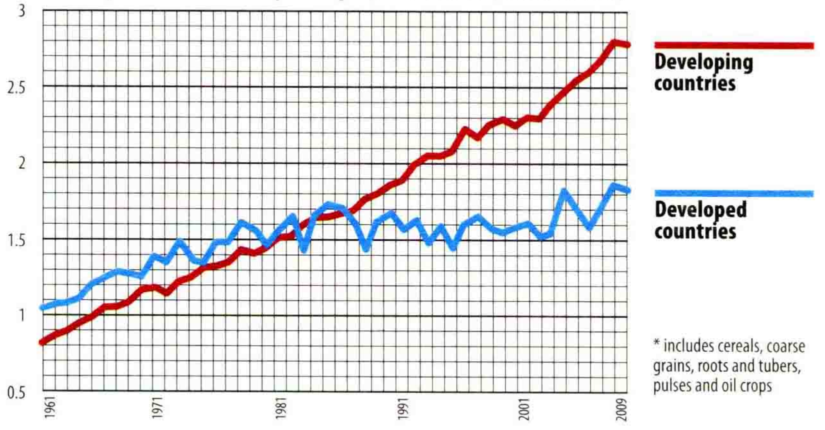
The Green Revolution is credited, especially in Asia, with having jump-started economies, alleviated rural poverty, saved large areas of fragile land from conversion to extensive farming, and helped to avoid a Malthusian outcome to growth in world population. Between 1975 and 2000, cereal yields in South Asia increased by more than 50 percent, while poverty declined by 30 percent[7]. Over the past half-century, since the advent of the Green Revolution, world annual production of cereals, coarse grains, roots and tubers, pulses and oil crops has grown from 1.8 billion tonnes to 4.6 billion tonnes[8]. Growth

Indicators of global crop production intensification, 1961-2007
Index (1961=100)



FAO. 2011. FAOSTAT statistical database (http://faostat.fao.org/).

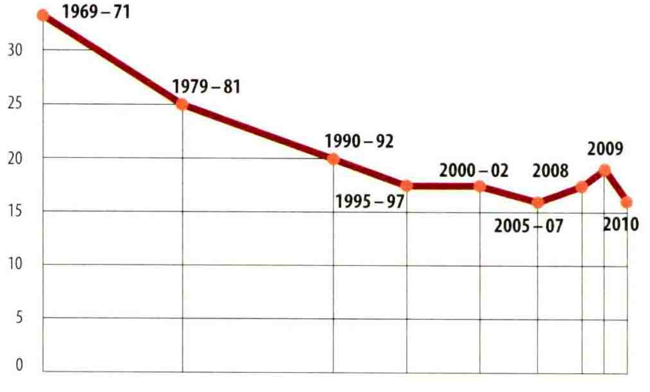
World production of major crops*, 1961-2009 (billion tonnes)



* includes cereals, coarse grains, roots and tubers, pulses and oil crops

FAO. 2011. FAOSTAT statistical database (http://faostat.fao.org/).

Undernourished in developing world population, 1969-71 to 2010
(percent)



FAO. 2010. *The State of Food Insecurity in the World: Addressing food insecurity in protracted crises*. Rome.

in cereal yields and lower cereal prices significantly reduced food insecurity in the 1970s and 1980s, when the number of undernourished actually fell, despite relatively rapid population growth. Overall, the proportion of undernourished in the world population declined from 26 percent to 14 percent between 1969-1971 and 2000-2002[9].

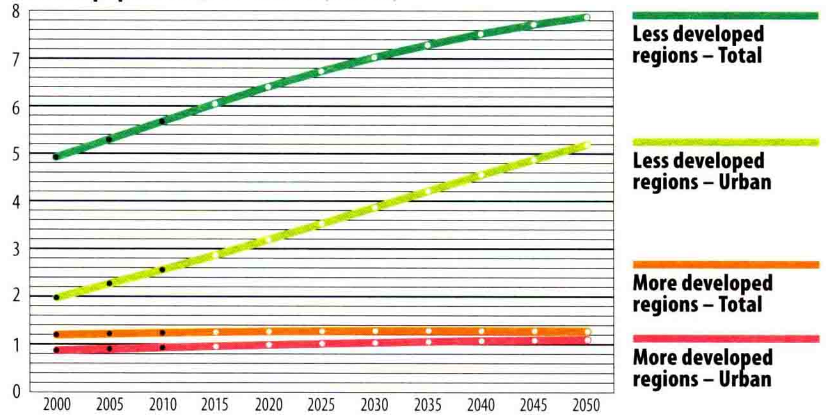
A gathering storm

It is now recognized that those enormous gains in agricultural production and productivity were often accompanied by negative effects on agriculture's natural resource base, so serious that they jeopardize its productive potential in the future. "Negative externalities" of intensification include land degradation, salinization of irrigated areas, over-extraction of groundwater, the buildup of pest resistance and the erosion of biodiversity. Agriculture has also damaged the wider environment through, for example, deforestation, the emission of greenhouse gases and nitrate pollution of water bodies[10, 11].

It is also clear that current food production and distribution systems are failing to feed the world. The total number of undernourished people in 2010 was estimated at 925 million, higher than it was 40 years ago, and in the developing world the prevalence of undernourishment stands at 16 percent[12]. About 75 percent of those worst affected live in rural areas of developing countries, with livelihoods that depend directly or indirectly on agriculture[13]. They include many of the world's half a billion low-income smallholder farmers and their families who produce 80 percent of the food supply in developing countries. Together, smallholders use and manage more than 80 percent of farmland – and similar proportions of other natural resources – in Asia and Africa[14].

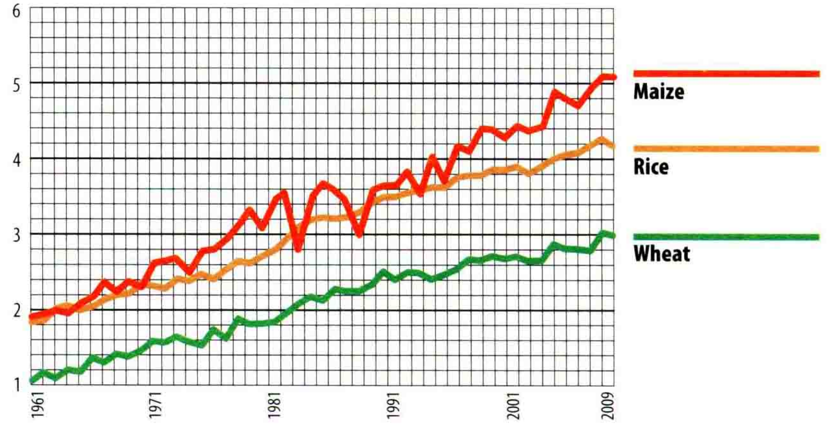
Over the next 40 years, world food security will be threatened by a number of developments. The Earth's population is projected to increase from an estimated 6.9 billion in 2010 to around 9.2 billion in 2050, with growth almost entirely in less developed regions; the highest growth rates are foreseen in the least developed countries[15]. By then, about 70 percent of the global population will be urban, compared to 50 percent today. If trends continue, urbanization and income growth in developing countries will lead to higher meat

World population, 2000-2050 (billions)



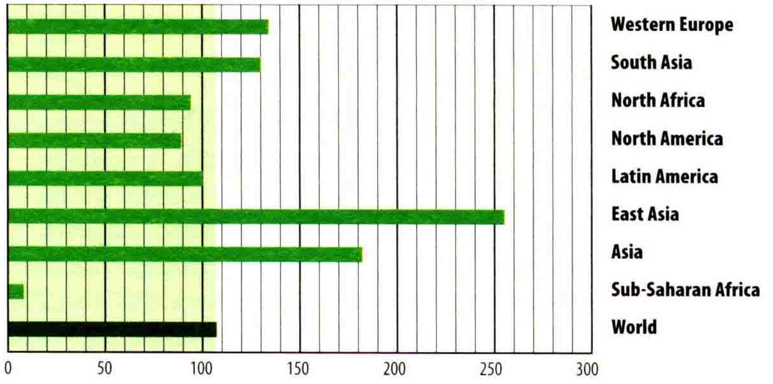
United Nations.
World urbanization prospects, the 2009 revision population database
(http://esa.un.org/wup2009/unup/).

Global average yields of major cereals, 1961-2009 (t/ha)



FAO. 2011.
FAOSTAT statistical database
(http://faostat.fao.org/).

Average rates of mineral fertilizer use, 2008/09
(kg of nutrients per ha)



IFDC,
derived from FAOSTAT
statistical database
(http://faostat.fao.org/).

consumption, which will drive increased demand for cereals to feed livestock. The use of agricultural commodities in the production of biofuels will also continue to grow. By 2020, industrialized countries may be consuming 150 kg of maize per head per year in the form of ethanol – similar to rates of cereal food consumption in developing countries[16].

Those changes in demand will drive the need for significant increases in production of all major food and feed crops. FAO projections suggest that by 2050 agricultural production must increase by 70 percent globally – and by almost 100 percent in developing countries – in order to meet food demand alone, excluding additional demand for agricultural products used as feedstock in biofuel production. That is equivalent to an extra billion tonnes of cereals and 200 million tonnes of meat to be produced annually by 2050, compared with production between 2005 and 2007[10].

In most developing countries, there is little room for expansion of arable land. Virtually no spare land is available in South Asia and the Near East/North Africa. Where land is available, in sub-Saharan Africa and Latin America, more than 70 percent suffers from soil and terrain constraints. Between 2015 and 2030, therefore, an estimated 80 percent of the required food production increases will have to come from intensification in the form of yield increases and higher cropping intensities[17]. However, the rates of growth in yield of the major food crops – rice, wheat and maize – are all declining. Annual growth in wheat yields slipped from about 5 percent a year in 1980 to 2 percent in 2005; yield growth in rice and maize fell from more than 3 percent to around 1 percent in the same period[18]. In Asia, the degradation of soils and the buildup of toxins in intensive paddy systems have raised concerns that the slowdown in yield growth reflects a deteriorating crop-growing environment[4].

The declining quality of the land and water resources available for crop production has major implications for the future. The United Nations Environment Programme (UNEP) has estimated that unsustainable land use practices result in global net losses of cropland productivity averaging 0.2 percent a year[19]. Resource degradation reduces the productivity of inputs, such as fertilizer and irrigation. In the coming years, intensification of crop production will be required increasingly in more marginal production areas with less reliable pro-