1 Introduction

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Abstract

This chapter sets the stage for our book on *Managing Water and Agroecosystems for Food Security*. It provides an introduction to the extent of food insecurity in the world and how this is further jeopardized by unsustainable food production. Water is a main constraint to sustainability because water use in agriculture has huge impacts on downstream ecosystems. Furthermore, degraded ecosystems are less capable of sustaining water flows. In this book the authors take an ecosystem approach to freshwater management for sustainable agroecosystems and food security, with an emphasis on technical options. They show how water and ecosystems can be managed in such a way that they are mutually supportive and contribute to sustainable food security and wealth.

Background

The global food shortages and soaring food prices of the 2000s led to increased attention to food security worldwide. Rising food prices are continuously aggravated by population growth and climatic factors. Globally, about 870 million people, mostly from developing countries, are undernourished (FAO *et al*., 2012). Most of these people live in countries that are not self-sufficient in food production, in particular in South Asia and sub-Saharan Africa, where agricultural productivity is often low. This is due to factors such as limited soil nutrient availability, the occurrence of pests and diseases, and spells of minimal or no precipitation or irrigation during critical growing periods. Poor agricultural practices have aggravated land degradation so that it is now seriously limiting food production (Bossio and Geheb, 2008).

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Fisheries and aquaculture, which are major sources of protein in many developing countries, provided more than 2.9 billion people with at least 15% of their average per capita animal protein intake in 2006 (FAO, 2009b), but these too are threatened by ecosystem degradation caused by overfishing, habitat destruction, pollution, invasive species and the disruption of river flow by dams. These pressures have caused a severe decline in fish species diversity and production, particularly in inland fisheries, thus threatening an important food and nutrition source for low-income rural men, women and children (UNEP, 2010). Beef, poultry, pork and other meat products provide one third of humanity's protein intake but also consume almost a third (31%) of the water used in agriculture globally (Herrero *et al.*, 2009).

Agriculture and ecosystem services are interrelated in various ways. Agroecosystems generate beneficial ecosystem services such as the production of food, feed and fibre, but they also generate biodiversity, carbon storage, water services, soil retention and aesthetic benefits (Wood *et al.*, 2000; UNEP, 2007). In return, agroecosystems receive beneficial ecosystem services from other ecosystems, such as pollination and a supply of fresh water. However, ecosystem services from non-agricultural systems may be affected by agricultural practices and, in turn, dysfunctional ecosystem services have further impacts on agroecosystems and their production systems, thereby threatening food security (Hassan *et al.*, 2005; Millennium Ecosystem Assessment, 2005a, 2005b; Nellemann *et al.*, 2009).

These various environmental pressures on, and negative trends in, food production are further threatened by climate change (see Chapter 2 for more detailed discussion). Increases in the magnitude and frequency of drought and floods are expected to lead to higher spatial and temporal variability in production and lower overall food production, especially in sub-Saharan Africa (Parry *et al.*, 2007).

Feeding a world population of over 9 billion people in 2050 will require the raising of overall food production by some 70% over the period from 2005–2007 to 2050 (nearly 100% in low-income countries) (FAO, 2009a), in addition to the putting in place of global and national mechanisms to ensure equitable access. Obviously, food security is not only a matter of food production but also an issue of equity and secure access to the means of production and to food products (FAO, 2010). Thus, food security is the product of many variables, which include: physical factors such as climate, soil type and water availability; the management of these factors and of other natural resources (water, land, aquatic resources, trees and livestock), at the level of fields, landscapes and river basins; and losses and waste along the value chain (see Chapter 2). Food security requires supporting policies to ensure more equitable access to food, while agroecosystems have to be managed in a more sustainable way so as to increase long-term food security and livelihood benefits while minimizing or reversing environmental deterioration.

The understanding of linkages between ecosystems, water and food production is important to the health of all three, and managing for the sustainability of these connections is becoming increasingly necessary to help in improving global food security (Molden, 2007). Changes in the global water cycle, caused largely by human pressures, are seriously affecting ecosystem health and human well-being (Millennium Ecosystem Assessment, 2005c; WWAP, 2012; see Chapter 5). For example, in key parts of the tropics, agriculture has continued to expand into forest and woodland areas (Gibbs *et al.*, 2010), where it has caused reduced tree cover and soil compaction, which have led to reduced infiltration and higher runoff of rainwater, often causing severe erosion, salinization or other degradation processes (Ong and Swallow, 2003; Falkenmark *et al.*, 2007). Ecosystem degradation therefore threatens the regulation of ecosystem services such as water quality and water flow. Likewise, water is a key driver of several ecosystem functions, including biomass and crop yields, as well as of various supporting and regulatory ecosystem services (Keys *et al.*, 2012).

To address the significant sustainability issues in agriculture, particularly that of water use, the agricultural sector needs the development and implementation of a functioning ecosystems approach to water management

and food security. This in turn helps to increase productivity, i.e. it produces more, and better, food without further increase in the use of land, water and other valuable inputs, particularly in sub-Saharan Africa and other vulnerable regions. Global assessments suggest that despite the planetary limits to resource availability, it is feasible to achieve sustainable agricultural production while simultaneously meeting other human needs, although this requires significant changes in policy and approach (Foley *et al*., 2011). Increased water productivity is crucial to achieving sustainable food security (Fisher and Cook, 2010).

Potential of Ecosystem Approach

The challenges to food security can be addressed by managing agriculture as ecosystems that require certain water flows and provide essential ecosystem services, supported by appropriate policy and institutions. In practical terms this would mean improving agricultural management across scales (from field to landscape or basin level), linking to downstream aquatic ecosystems, and creating and managing multifunctional agroecosystems (Gordon *et al.*, 2010). In this book, we define agroecosystems as a set of human practices, aimed at food production – and embedded in and part of its own ecosystem – that has certain ecosystem needs, functions and services, and that interacts with other natural and human-made ecosystems (see Chapter 3). Agroecosystem management is then the management of natural resources and of other inputs for the sustainable production of food and of other provisioning, cultural, regulatory and supporting ecosystem services (see Chapter 4).

One of the shaping characteristics of an agroecosystem is its climate, which helps to determine the length of the available growth period (LEAD, 1999). In tropical areas four zones are distinguished: arid, semi-arid, sub-humid and humid. In temperate regions and highlands the mean monthly temperature is the main determinant of the climate. The particularly fragile arid zone and its challenges are discussed in more detail in Chapter 6. Wetlands are found across all zones and provide many high-value ecosystem services, which is why they are increasingly exploited for, and threatened by, food production (see Chapter 7).

While a paradigm shift towards an ecosystems-based approach to water and food security has begun (UNEP, 2011; Frison, 2012; Keys *et al*., 2012; Landscapes for People, Food and Nature Initiative, 2012; WLE, 2012), it is vitally important to continue the application of this to what we already know and to encourage innovations in the approach. Hence, in this volume the authors show how ecosystems and water can be managed in such a way that they mutually support food production, thereby contributing to sustainable food security. The book illustrates the three-way interdependence between ecosystems, water management and food security (Fig. 1.1). By looking at the world as a range of interlinked ecosystems (from naturally pristine to the highly intensive agriculture of crops, livestock, fish and trees) and recognizing the variety of ecosystem services, the improved management of water and ecosystems together has the potential to bring long-term food security.

The book is structured to systematically show the relationships between ecosystems, water and food security, and to elaborate an ecosystem approach to sustainable agriculture. It contains chapters on the drivers of food security (Chapter 2) and provides solid analyses on ecosystems, agroecosystems, ecosystem services and their valuation (Chapters 3 and 4). Next, there is an analysis of the role of water in agriculture as well as analyses of water use and scarcity (Chapter 5). This is followed by discussions of the specific challenges in drylands (Chapter 6) and wetlands (Chapter 7); each of these chapters provides more insight into the reasons why an integrated ecosystem approach is required and what this should entail, giving practical recommendations for those vulnerable ecosystems. A discussion of the contributions that can be made by increased water productivity to a better joint management of agroecosystems and water follows in the next chapter (Chapter 8). Subsequently, Chapter 9 presents various approaches to the enhancement of ecosystem services in agriculture, with many concrete examples, while

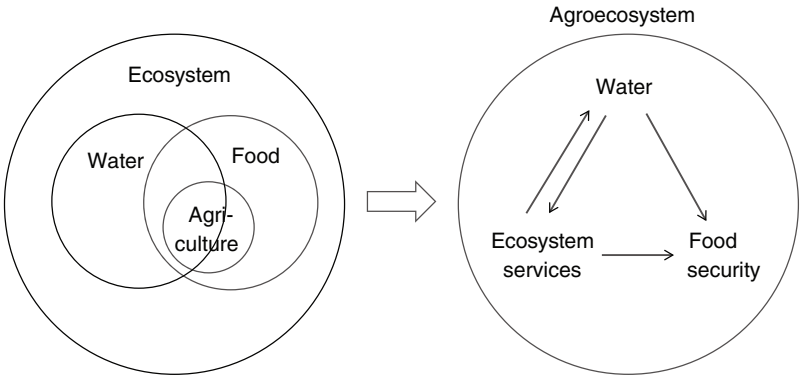

Fig. 1.1. Water and food as dimensions of ecosystems (left), with agriculture as a subset of food (production), and the role of water for food security and other ecosystem services in an agroecosystem (right).

Chapter 10 provides more detail of the ecosystem approach to water management. Finally, the last chapter (Chapter 11) ends the book with a synthesis that embeds the key recommendations into a landscape approach, links this to ongoing initiatives and identifies knowledge gaps for further research.

Conclusions

With a growing global population expected to reach around 9 billion in 2050, and the increasing impacts of climate change, the sustainable use of water and ecosystems for food security is a great challenge. It has become increasingly important to gain a better understanding of the functioning of terrestrial and aquatic ecosystems, and their interrelations with the availability and quality of water. This calls for a shift in the management of ecosystems and the water within them for food security. Ecosystems need to be safeguarded and the resources within used wisely, as they are the backbone of all environmental services needed in achieving food security and are often of direct importance to low-income countries and marginal groups.

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