UNEP

UNEP Policy Series

ECOSYSTEM MANAGEMENT

ISSUE NO. 4, JUNE 2011

Food and Ecological Security: Identifying synergy and trade-offs

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1. Status and trends of food security[1]

Food security is at the top of the global agenda. Almost half a century of growth in food production notwithstanding, 1 in 7 people today receive insufficient protein and energy from their diets. With the world's population and food consumption on the rise, the pressure on the food supply system is growing. Greater urbanization and income in countries in which meat consumption has traditionally been low have sparked an upsurge in demand for meat, putting more pressure on land. These trends in demographic dynamics and consumption patterns, combined with the threat of climate change and irreversible ecosystem service degradation, lead to increased uncertainty regarding current food production models. The delivery of ecosystem services[2] by agricultural ecosystems is becoming increasingly important, what with ever more land being put to agricultural use.[3]

The United Nations Secretary-General recently suggested that global food production needed to increase by half by 2030 to meet growing demand. Although in the longer term expanded demand and increased prices for agricultural commodities may represent an opportunity for agricultural and rural development, many constraints must be overcome if a significant supply response to changes in agricultural commodity prices is to be made without compromising but rather contributing to poverty alleviation and environmental sustainability.

Recent increases in food prices have caused worldwide concern as to whether demand will gradually outstrip supply and require a rapid expansion of food supply and an increase in efficient production, storage and delivery of food products. Accordingly, all States have swiftly increased their food security by stepping up food production, mostly through agricultural intensification. This requires higher levels of input (fertilizer, pesticides, water and new varieties of crops through plant breeding and genetic engineering) and decisions will have to be made regarding trade-offs between short-term gains and long-term impacts on ecosystems and their services.

The failure of supply to meet demand will result in higher food prices. Although this may benefit food producers, it will come at the detriment of consumers if income levels do not increase concomitantly. As societies are becoming progressively more urban in nature, food price hikes could lead to social and political instability, which would in turn hamper economic growth and development and efforts to alleviate poverty, especially because the poor food producers do not reap the benefits of any such price increases.

Recent increases in food prices has caused worldwide concern on whether demand will gradually outgrow supply and will require a rapid expansion of food supply, and an increase in efficient production, storage and delivery of food products.

1 In the present brief, the definition of "food security" provided by the Food and Agriculture Organization of the United Nations is used. According to that definition, food security exists when all people, at all times, have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.

2 "Ecosystem services", according to the Millennium Ecosystem Assessment (2005), are defined as the benefits that people obtain from ecosystems. These include: provisioning services, such as food, water, timber and fibre; regulating services, such as climate regulation, flood regulation and pollination; cultural services, such as aesthetic values, spiritual values and recreation; and supporting services, such as soil formation and nutrient cycling.

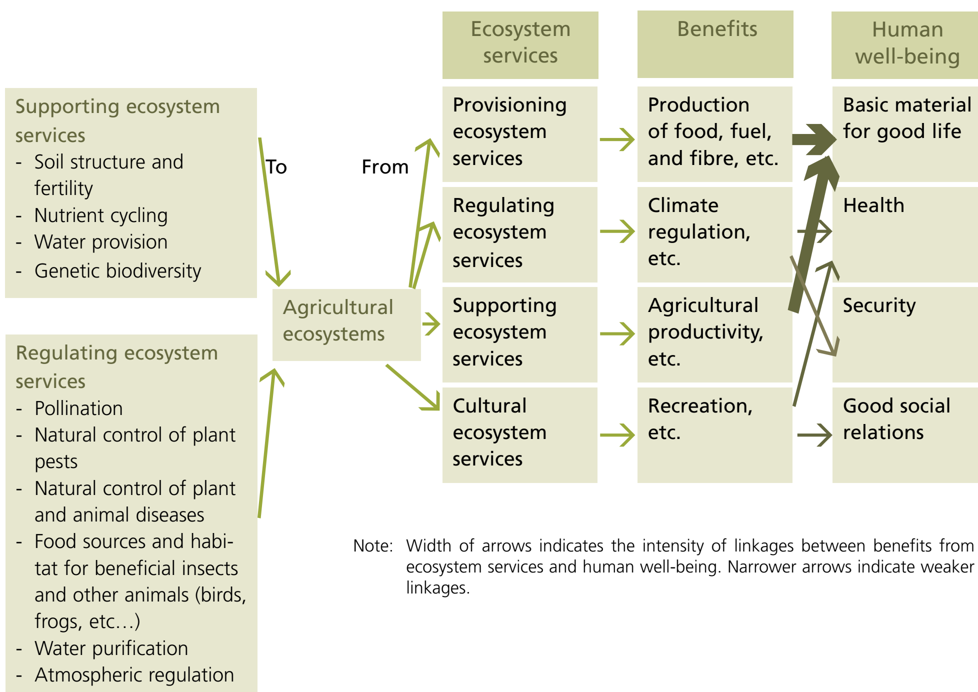
3 H. Charles J. Godfray and others, "Food security: the challenge of feeding 9 billion people", Science, vol. 327, No. 5967 (2010), p. 812

Furthermore, increased food production may include the intensification and expansion of agriculture through greater monocropping, intensive irrigation and use of transgenic crops, chemical fertilizers and pesticides. This puts pressure on cultivated ecosystems and, should the trend continue, will further degrade ecosystems' ability to provide services to society. Ecosystem management will therefore be key to successful environmental management and food security, given the relationship between food production systems and the continuation of ecosystem service delivery.

2. Impacts of accelerated food production on ecosystems and ecosystem services

While food security has improved around the world as a result of increased agricultural production and greater stability of supply, this has been accompanied by a significant decline in the state of ecosystems and the services that they provide. In fact, agriculture has been one of the major drivers of global environmental change, including through changes in land use, land cover and irrigation that affect the global hydrological cycle in terms of water quality and quantity.[4]

Figure 1: Ecosystem services to and from agriculture, and linkages between human well-being and benefits obtained from ecosystem services that are provided by agriculture.



Note: Width of arrows indicates the intensity of linkages between benefits from ecosystem services and human well-being. Narrower arrows indicate weaker linkages.

[4] Line J. Gordon and others, "Managing water in agriculture for food production and other ecosystem services", Agricultural Water Management, vol. 97, No. 4 (April 2010); United Nations Environment Programme, The Environmental Food Crisis: The Environment's Role in Averting Future Food Crises – A UNEP Rapid Response Assessment (2009).

Agricultural ecosystems are managed by humans in such a way as to optimize provisioning ecosystem services such as food, fibre and fuel. At the same time, the production of such services depends upon supporting and regulating ecosystem services, such as soil fertility and pollination. In addition to provisioning services and services in support of provisioning, agricultural ecosystems can provide other regulating and cultural services to communities, such as flood control and scenic beauty, recreation and tourism. The benefits obtained therefrom contribute to various aspects of human well-being, such as adequate livelihoods, sufficient nutritious food, health, secure resource access and security from disasters. If not managed correctly, however, agriculture can lead to reduced productivity or increased production costs as a result of problems such as pest damage, competition for water from other ecosystems, nutrient run-off and sedimentation of waterways.

These negative impacts have often engendered significant societal costs. They are increasingly affecting human well-being: for example, the quality of the water reaching downstream residents has declined, affecting their health, and in wetlands and coastal ecosystems have also suffered, affecting nutrient retention and local livelihoods. The harmful effects of the degradation of specific ecosystem services on human well-being are often borne disproportionately by the poor, contributing to growing inequities and disparities across groups of people. Furthermore, there is an increasing risk of ecosystem regime shifts, or non-liner, abrupt reorganizations of ecosystems from one relatively stable state to another, which might lead to catastrophic changes in ecosystem services. Evidence shows that changes in the quality and quantity of hydrological flows caused by agriculture can increase the risk of ecological regime shifts in aquatic systems, the soil and land-atmosphere interactions, which are often difficult to reverse. The declines in many ecosystem services caused by agriculture might also affect the supply of those services, such as pollination, which are of high importance to agriculture itself.[5]

Negative impacts of agriculture on various ecosystem services have often led to large societal costs that are increasingly being felt on human well-being, including, for example, declines in water quality for downstream residents affecting their health, and declines in wetlands and coastal ecosystems

Policymakers and practitioners involved in agricultural management therefore face the challenge of making certain that measures are in place to ensure that agricultural landscapes provide sufficient supporting and regulating ecosystem services, and that negative impacts on human well-being stemming from decline in the state of ecosystems are limited. To design appropriate policy measures and management approaches, however, there is a critical need sufficiently to understand the trade-offs that may occur between provisioning services and other ecosystem services, in addition to their impacts on human well-being and distribution between societal groups.[6]

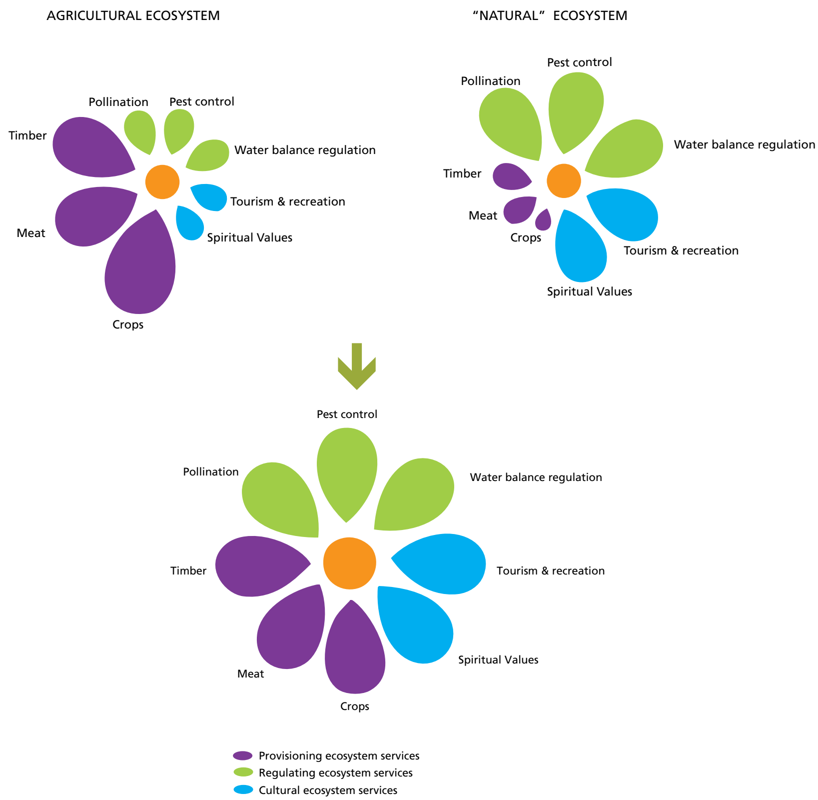
[5] Millennium Ecosystem Assessment, Millennium Ecosystem Assessment Synthesis Report (Washington, D.C.: Island Press, 2005), pp. 2–6; Gordon and others, "Managing water in agriculture for food production and other ecosystem services"; Alison G. Power, "Ecosystem services and agriculture: tradeoffs and synergies", Philosophical Transactions of the Royal Society B: Biological Sciences, vol. 365, No. 1554.

[6] Millennium Ecosystem Assessment, pp. 2–6; Gordon and others, "Managing water in agriculture for food production and other ecosystem services", pp. 512–519.

3. Trends in ecosystem services, especially from cultivated ecosystems

Intensified food production through agriculture is closely linked to ecosystem decline. The Millennium Ecosystem Assessment of 2005 highlighted trends of significant decline in many ecosystem services of high relevance to food security, such as those provided by cultivated ecosystems. According to the Assessment, within terrestrial ecosystems, more than half of major terrestrial biomes, such as temperate grasslands, Mediterranean forests, tropical dry

Figure 2: Agriculture generally increases provisioning ecosystem services at the expense of regulating and cultural ecosystem services that are often higher in less human-dominated ecosystems. Shifts can occur to develop agricultural systems that are designed to produce multiple ecosystem services and, where synergies exist among these services, trade-offs are reduced.[7]



forests, temperate broadleaf forests, tropical grassland and flooded grasslands had been converted primarily to agriculture by 1990. Globally, the rate of conversion to ecosystems has begun to slow, mainly because of reductions in the rate of expansion of cultivated land, and, in some regions, ecosystems are returning to conditions and species compositions

[7] Adapted from Gordon and others, "Managing water in agriculture for food production and other ecosystem services", pp. 512–519.

similar to their pre-conversion states. Rates of ecosystem conversion, however, remain high or are increasing for specific ecosystems and regions.

The Assessment also reported that the quantity of provisioning ecosystem services (e.g., food, water and timber) used by humans increased rapidly during the second half of the twentieth century, and continues to grow. Actions to increase the supply of those provisioning services have often brought about modifications to regulating services. For example, human activity, such as land-use changes, has affected the climate regulation services of ecosystems, contributing to increased carbon dioxide and other greenhouse gases. Other regulating services, such as erosion regulation, water purification and waste treatment, pest regulation and natural hazard regulation, have also declined. The Assessment also drew attention to some declines in cultural services, such as spiritual and religious values and aesthetic values.

4. How the twin objectives can be aligned

As described above, changes in one ecosystem service (e.g., increased food and timber production) can lead to changes in others as a result of such factors as increased water use, degraded water quality, land-use change and greenhouse-gas releases. A key challenge in managing ecosystem services is that they are not independent of one another: individual ecosystem services should be regarded as various elements of an interrelated whole or what might be termed a "bundle". Efforts to optimize a single ecosystem service often lead to negative changes in others. [8]

To design appropriate policies on and management approaches to food security issues, the trade-offs that may occur between provisioning ecosystem services and other types of ecosystem services should first be evaluated. In analysing these trade-offs, the three axes – spatial scale, temporal scale and reversibility – should be considered. "Spatial scale" relates to whether the effects of the trade-offs are felt locally, for example on-farm, or at a distant location. It relates particularly to the use of a provisioning service traded off against another ecosystem service, such as the impacts of increasing agricultural production through greater use of fertilizer in upstream areas, resulting in broad-scale effects on water quality in downstream areas. "Temporal scale" refers to the speed of trade-offs, such as how rapidly or slowly they take place. For example, management decisions tend to focus on the immediate provision of an ecosystem service (e.g., increased agricultural production), at the expense of the same ecosystem service or other services in future (e.g., longer-term loss of soil quality). "Reversibility" relates to the likelihood that the disturbed ecosystem services return to their original state when the disturbance ceases. In some cases, changes in some ecosystem services may be irreversible. Taking into account these important axes when performing trade-off analysis, including an analysis of the distributional effects of the trade-offs, will allow subsequent management decisions properly to consider the spatial complexities of ecosystems and to

Box 1: Irreversible Change in the Aral Sea Ecosystem[9]

Poorly designed and executed agricultural policies led to an irreversible change in the Aral Sea ecosystem. By 1998, the Aral Sea had lost more than 60% of its area and approximately 80% of its volume, and ecosystem-related problems in the region now include excessive salt content of major rivers, contamination of agricultural products with agrochemicals, high levels of turbidity in major water sources, high levels of pesticides and phenols in surface waters, loss of soil fertility, extinctions of species, and destruction of commercial fisheries.

[8] Jon Paul Rodriquez and others, "Trade-offs across space, time, and ecosystem services," Ecology and Society, vol. 11, No. 1 (2006), p. 28.

[9] Millennium Ecosystem Assessment, p. 47.

incorporate the long-term effects of preferring one ecosystem over another.[10]

Policies and management approaches that aim to minimize the effects of ecosystem service trade-offs can be developed based on a thorough understanding of the trade-offs. This will also allow policies and management approaches to foster synergies, whereby actions to conserve or enhance a particular component of an ecosystem or its services benefit other services or stakeholders. These synergetic approaches could include agroforestry that can meet human needs for food and fuel, restore soils and contribute to biodiversity conservation. An analysis of yields from agricultural ecosystems worldwide also indicates that, on average, agricultural systems that conserve ecosystem services by using practices such as conservation tillage, crop diversification, legume intensification and biological control perform as well as intensive, high-input systems. What is required is to incorporate within the food production system the positive and negative externalities of producing food, and identify what could be termed "win-win" strategies that can boost yield and increase sustainability.[11]

5. Policy Implications

On the basis of the above, the following key messages have been devised:

a. Increased production of food (provisioning services) often leads to significant declines in other types of ecosystem services, such as regulating and cultural services, which are critical in supporting sustainable food production. These trade-offs that may occur between provisioning services and other ecosystem services should be evaluated in terms of spatial scale, temporal scale and reversibility.
b. Trade-offs between ecosystem services often shift the costs of degradation from one group of people to another or defer costs to future generations. The spatial and temporal distribution of costs should therefore also be considered in designing policies and management approaches to tackling food security issues.
c. Changes to the quality and quantity of hydrological flows stemming from agriculture may increase the risk of ecological regime shifts in aquatic systems, the soil and land-atmosphere interactions, which may require greater management costs for restoration.
d. The need to mitigate ecosystem impacts and sustain the capacity of ecosystems for future generations makes necessary the introduction of appropriate regulatory frameworks at all levels that will control externalities affecting the capacity of ecosystems to sustain their food provisioning services.
e. The trade-offs between food production and the resulting impact on ecosystems should be identified and evaluated at all levels of decision-making.
f. A possible way to illustrate the trade-offs could be to express them in monetary units using a credible and robust valuation method.

[10] Jon Paul Rodriquez and others, "Trade-offs across space, time, and ecosystem services" p. 28; Power, "Ecosystem services and agriculture: tradeoffs and synergies", pp. 2959–2971.

[11] Jon Paul Rodriquez and others, "Trade-offs across space, time, and ecosystem services", p. 28; Power, "Ecosystem services and agriculture: tradeoffs and synergies", pp. 2959-2971; Godfray and others, "The future of the global food system", Philosophical Transactions of the Royal Society B: Biological Sciences, vol. 365, No. 1554 (2010), pp. 2769–2777; Harpinder S. Sandhu, Stephen D. Wratten and Ross Cullen, "Organic agriculture and ecosystem services", Environmental Science and Policy, vol. 13, No. 1 (February 2010), pp. 1–7.

g. Building georeferenced scenarios would provide useful analytical guidance and help policymakers to visualize the impact of alternative food security strategies on food production, ecosystems and poverty alleviation.
h. Sharing of information and communication between stakeholders from other disciplines and a multidisciplinary approach are needed to guarantee that decisions made account for both social benefits and environmental costs. In this regard, government officers delineating food security strategies need easily available information on the social and environmental impacts that a particular food security strategy might have.

Bibliography

Godfray, H. C. J., and others. The future of the global food system. Philosophical Transactions of the Royal Society B: Biological Sciences, vol. 365, No. 1554 (2010).

Godfray, H. C., and others. Food Security: The Challenge of Feeding 9 Billion People. Science, vol. 327, No. 5967 (2010).

Gordon, L. J., Finlayson, C. M. and Falkenmark, M. Managing water in agriculture for food production and other ecosystem services. Agricultural Water Management vol. 97, No. 4 (2010).

Government of India, 2010. Agricultural Statictics at a Glance. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture.

Millennium Ecosystem Assessment. Millennium Ecosystem Assessment Synthesis Report. Washington, D.C.: Island Press, 2005.

Power, A.G. Ecosystem services and agriculture: tradeoffs and synergies. Philosophical Transactions of the Royal Society B: Biological Sciences, vol. 365, No. 1554 (2010).

Rodriquez, J. P., and others. Trade-offs across space, time, and ecosystem services. Ecology and Society, vol. 11, No. 1 (2006).

Sandhu, H. S., Wratten, S. D. and Cullen, R. Organic agriculture and ecosystem services. Environmental Science and Policy, vol. 13 (2010).

United Nations Environment Programme. The Environmental Food Crisis: The Environment's Role in Adverting Future Food Crises – A UNEP Rapid Response Assessment. UNEP/GRID-Arendal, 2009.

Zhang, W., and others. Ecosystem services and dis-services to agriculture. Ecological Economics, vol. 64, No. (2007).

Box 2: Agricultural Production and Environmental Challenges in Punjab[12]

India province of Punjab is one of the fastest growing economies of the world, with 1.53% of natural geographical area of India, providing 55 - 65% of wheat and 35 - 40% of rice to the national pool annually. During the period from 1960 to 2008, the production of wheat has increased by nine times while rice production has gone up by forty eight times. This level of growth in food production had negative consequences in the agricultural ecosystem in Punjab state, as soil has become nutrient deficient, ground water table has gone down by a meter during 2003 – 2004, crop diversity has reduced and amounts of pollutants in soil as well as surface water have increased. The environmental crisis faced in Punjab, which may impact the sustainability of agricultural production deserves immediate national attention because of their increasing relative importance to national food security.

[12] India, Ministry of Agriculture, Agricultural statistics at a Glance (2010). Available from http://dacnet.nic.in/eands/latest_2006.htm.

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