The State of the World's Land and Water Resources for Food and Agriculture

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Introduction

The availability of land and water to supply national, regional and global food and agriculture production, under conditions of increased land and water scarcity and competition for these resources by different sectors, has attracted renewed attention following the recent rise in food prices, commodity price volatility and increased large-scale land acquisition. The buffering capacity of global agricultural markets to absorb supply shocks and stabilize agricultural commodity prices is mostly tied to the continued functioning of land and water systems particularly in agriculture dependent economies.

A recent FAO global study on the State of Land and Water Resources for Food and Agriculture, SOLAW, informs us that land and water resources currently allocated for food production are also under increasing pressure from competing demands for other uses. These include demands for urban expansion, the conservation of biodiversity, forestry, livestock production, aquaculture, as well as the cultivation of crops for the production of liquid bio-fuel. The negative impacts of climate change in some geographic regions place even additional pressures on land and water resources. The collective impacts of these pressures and resulting agricultural transformations have put some production systems at risk of breakdown of their environmental integrity and productive capacity.

Key Issues and Challenges

The world's cultivated area has grown by 12 percent over the last 50 years. The global irrigated area has doubled over the same period, accounting for most of the net increase in cultivated land (Figure 1). Meanwhile, agricultural production has grown between 2.5 and 3 times, thanks to significant increase in the yield of major crops.

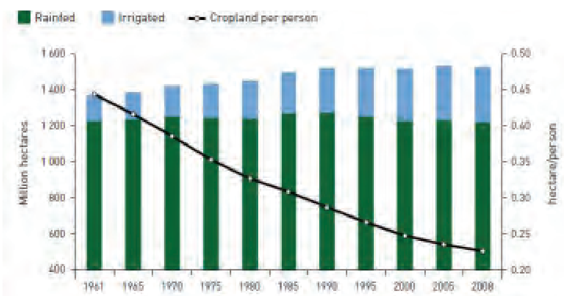

Figure 1. Evolution of land under irrigated and rainfed cropping (1961–2008)

However, global achievements in production in some regions have been associated with degradation of land and water resources, and the deterioration of related ecosystem goods and services (Figure 2). These include biomass, carbon storage, soil health, water storage and supply, biodiversity, and social and cultural services. In some of these areas, the accumulation of environmental impacts in key land and water systems has now reached the point where production and livelihoods are compromised. Agriculture already uses 11 percent of the world's land surface for crop production. It also makes use of 70 percent of all water withdrawn from aquifers, streams and lakes.

The distribution of land suitable for cropping is skewed against those countries which have most need to raise production (Table 1). Cultivated land area per person in low income countries is less than half that in high income countries and its suitability for agriculture is generally lower. This is a troubling finding given that the growth of demand for food production, as a function of population and income, is expected to be concentrated in low income countries. The main implication is that a global adjustment of agricultural production will need to be anticipated in order to compensate for these facts of geography.

Table 1. Share of world cultivated land suitable for cropping under appropriate production systems

Regions	Cultivated land (Mha)	Population (million)	Cultivated land per capita (ha)	Rainfed crops (%)		
				Prime Land	Good Land	Marginal Land
Low-income countries	441	2 651	0.17	28	50	22
Middle-income countries	735	3 223	0.23	27	55	18
High-income countries	380	1 031	0.37	32	50	19
Total	1 556	6 905	0.23	29	52	19

The tendency to locate high-input agriculture on the most suitable lands for cropping relieves pressure on land expansion and limits encroachment on forests and other land uses. The call for on-demand water services is rising and the global area equipped for irrigation continues to expand at a rate of 0.6 percent per year. Groundwater use in irrigation is expanding quickly, and almost 40 percent of the irrigated area is now reliant upon groundwater as either a primary source, or in conjunction with surface water. This pattern of intensification, through a concentration of inputs, has offset expansion of rainfed cultivation for staple cereals and established guaranteed supply chains for a wide range of agricultural products into urban centres.

Unsustainable management practices on small scale farms could also cause degradation (e.g. nutrient mining, erosion) as well as contribute to greenhouse gas emissions. Often, such practices are the result of unfavourable socio-economic conditions (e.g. insecure land tenure, lack of incentives, and lack of access to markets or appropriate technologies, use of marginal lands).

Typology of degradation of ecosystem benefits	Intervention options
Type 1 – High degradation trend or highly degraded lands	Rehabilitate if economically feasible; mitigate where degrading trends are high
Type 2 – Moderate degradation trend in slightly or moderately degraded land	Introduce measure to mitigate degradation
Type 3 – Stable land, slightly or moderately degraded	Preventive interventions
Type 4 – Improving lands	Reinforcement of enabling conditions which foster SLM

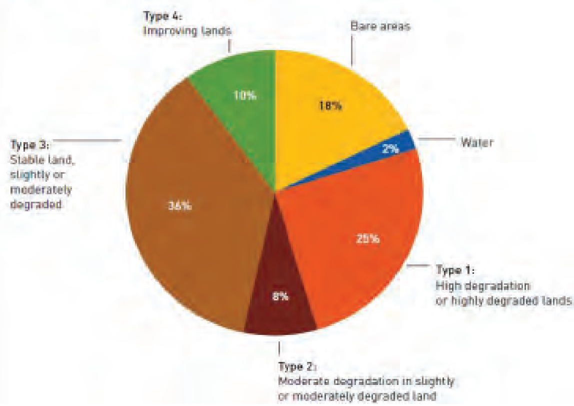

Figure 2. Status and trends in global land degradation

Groundwater abstraction has provided an invaluable source of ready irrigation water but has proved almost impossible to regulate. As a result, locally intensive groundwater withdrawals are exceeding rates of natural replenishment in key cereal producing locations.

- Major production systems at risk within some locations in Asia include:
- Irrigated rice-based systems in Southeast and Eastern Asia which are at risk due to land abandonment, loss of buffer role of paddy land, increasing cost of land conservation, health hazards due to pollution, and loss of cultural values of land;
- Tropical forest-cropland interface in Southeast Asia which are at risk due to cropland encroachment, slash and burn practices which lead to loss of ecosystems services of forests and land degradation; and
- Production systems located in deltas (e.g. Red river, Ganges/ Brahmaputra, Mekong) and coastal alluvial plains (e.g. Eastern China) which are at risk due to loss of agricultural land and groundwater, health-related problems, sea level rise, higher frequency of cyclones (Eastern and Southeast Asia), and increased incidence of floods and low flows.

By 2050, rising population and incomes are expected to demand 70 percent more production over 2009 levels. Increased production is projected to come primarily from intensification on existing cultivated land. A projected doubling of current production by 2050 in developing countries could be derived from already developed land and water resources. Possible conversion to crop production would require careful prior evaluation of the trade-off between production benefits and loss of their current ecological and socio-economic services. Competition for land and water will become stronger, within agriculture and with municipal and industrial demands. The economic, social and environmental trade-offs will also need to be evaluated and resolved if production is to meet rising demand. For this reason, a renewed emphasis on well informed basin planning and negotiated territorial planning among stakeholders will become essential.

Opportunities

The SOLAW report highlights the great diversity of local land and water conditions and the need to focus on those production systems where the current availability and access to suitable land and water resources are constrained, or where scarcity of land and water resources are further constrained by unsustainable agricultural practices, growing socio-economic pressures or climate change. Such situations occur locally within the nine major categories of global agricultural production systems mapped in SOLAW (Table 2).

More than four-fifths of agricultural production growth to 2050 is expected to come from increased productivity on currently used land. A variety of agronomic and technical approaches are available to achieve higher output, overcome constraints and manage risks. These will need to be accompanied and guided by increasingly effective and integrated land and water institutions.

Land productivity is generally low on rainfed croplands because of low inherent soil fertility, severe nutrient depletion and poor soil structure. Large fertilizer applications are unaffordable and too risky in many low-potential rainfed cropping systems. Sustainable land and water management techniques can greatly increase productivity through integrated soil fertility management, employing organic and inorganic nutrient sources and agronomic techniques such as plant diversity, agroforestry, crop rotation and maintenance of protective soil cover. Feasibility and risk assessments are needed to evaluate socio-economic constraints and formulate effective incentive packages for farmers to adopt appropriate management approaches and adapt techniques and practices to their specific farming situation.
Table 2: Land and water systems requiring priority attention (a broad typology)

GLOBAL PRODUCTION SYSTEMS	AREAS REQUIRING PRIORITY ACTION
RAINFED CROPPING Highlands	Densely populated highlands in poor areas: Himalaya, Andes, Central American highlands, Rift Valley, Ethiopian plateau, Southern Africa (Risks: erosion, land degradation, reduced productivity of soil and water, increased intensity of flood events, accelerated out-migration, high prevalence of poverty and food insecurity)
RAINFED CROPPING Semi-arid tropics	Smallholder farming in Western, Eastern and Southern Africa savannah region and in Southern India; agro-pastoral systems in the Sahel, Horn of Africa and Western India (Risks: desertification, reduction of the production potential, increased crop failures due to climate variability and temperatures, increased conflicts, high prevalence of poverty and food insecurity, out-migration)
RAINFED CROPPING sub-tropical	Densely populated and intensively cultivated areas, concentrated mainly around the Mediterranean basin (Risks: desertification, reduction of the production potential, increased crop failures, high prevalence of poverty and food insecurity, further land fragmentation, accelerated out-migration. Climate change is expected to affect these areas through reduced rainfall and river runoff, and increased occurrence of droughts and floods)
RAINFED CROPPING Temperate	Highly intensive agriculture in Western Europe (Risks: pollution of soils and aquifers leading to de-pollution costs, loss of biodiversity, and degradation of freshwater ecosystems)
	Intensive farming in United States, Eastern China, Turkey, New Zealand, Parts of India, Southern Africa, Brazil (Risks: pollution of soils and aquifers, loss of biodiversity, degradation of freshwater ecosystems, increased crop failure due to increased climate variability in places)
IRRIGATED Rice-based systems	South-eastern and Eastern Asia (Risks: land abandonment, Loss of buffer role of paddy land, increasing cost of land conservation, health hazards due to pollution, loss of cultural values of land)
	Sub-Saharan Africa ,Madagascar, Western Africa, Eastern Africa (Risks: Need for frequent rehabilitations, poor return on investment, stagnating productivity, large-scale land acquisition, land degradation)

IRRIGATED Other crops	**RIVER BASINS** Large contiguous irrigation systems from rivers in dry areas, including Colorado river, Murray Darling, Krishna, Indo-Gangetic plains, Northern China, Central Asia, Northern Africa and Middle East (Risks: increased water scarcity, loss of biodiversity and environmental services, desertification, expected reduction in water availability and shift in seasonal flows due to climate change in several places)
	AQUIFERS Groundwater dependent irrigation systems in interior arid plains: India, China, central USA, Australia, North Africa, Middle East and others (Risks: loss of buffer role of aquifers, loss of agriculture land, desertification, reduced recharge due to climate change in places)
RANGELANDS	Pastoral and grazing lands, including on fragile soils in Western Africa (Sahel), North Africa, parts of Asia (Risks: desertification, out-migration, land abandonment, food insecurity, extreme poverty, intensification of conflicts)
FORESTS	Tropical forest-cropland interface in South-eastern Asia, the Amazon basin, Central Africa, and Himalayan forests (Risks: cropland encroachment, slash and burn, leading to loss of ecosystems services of forests, land degradation)
Other locally important sub-systems	**DELTAS AND COASTAL AREAS:** Nile delta, Red river delta, Ganges/Brahmaputra, Mekong, etc. and coastal alluvial plains: Arabian peninsula, Eastern China, Bight of Benin, Gulf of Mexico (Risks: loss of agricultural land and groundwater, health-related problems, sea level rise, higher frequency of cyclones (Eastern and South-eastern Asia), increased incidence of floods and low flows)
	SMALL ISLANDS including Caribbean, Pacific islands (Risks: total loss of freshwater aquifers, increased cost of freshwater production, increased climate-change related damages (hurricanes, sea level rise, floods)).
	PERI-URBAN agriculture (Risk: pollution, health-related problems for consumers and producers, competition for land)

Several integrated rainfed production approaches, such as conservation agriculture, agroforestry and integrated crop-livestock systems, combine best management practices adaptable to the local ecosystem and culture and to market demand. Pesticide use and risks can be minimized by integrated pest management (IPM). Integrated soil fertility management, combined with rainwater harvesting and soil and water conservation on slopes could improve rainfed yields. However, risk and initially low profitability often inhibits adoption. The above-mentioned approaches have proven to be successful when they form part of a rural development and livelihoods improvement strategy which includes support services and better market access. Education, incentives and farmer field schools speed the transition to more productive and resilient land-use systems.

Additional irrigation water is likely to come from multi-purpose hydropower schemes. Small scale water storage projects are also expected to boost supply. Although some new groundwater development is anticipated, active management by users can improve water-use productivity where there is collective interest in maintaining aquifer function and services. A combination of improved irrigation scheme management, investment in modern technology, knowledge development and training can substantially increase water-use productivity and improve supply to the often poor tail-end users. The highest gains are possible in sub-Saharan Africa and parts of Asia.

Recycling and re-use of water is another option, but only with effective regulation can water be safely derived from drainage, saline and treated wastewater. On-site and off-site risks from salinization and water-logging require careful drainage planning, investment and management in many irrigation projects. Salt and water balance studies and a regulatory and monitoring system are required.

To raise land and water productivity on larger irrigation schemes, an integrated modernization package of infrastructure upgrades and management system improvements is required, together with an economic environment providing undistorted incentives, manageable risk, and market access. There is also scope for improving irrigation efficiency and productivity in small-scale and informal irrigation.[1] This requires mechanisms to ensure the availability of knowledge, technology and investment support, adapted to the local management practices and socio-economic context.

Many sustainable crop, livestock and agro-forestry management practices, which have long been recommended for ecological and economic reasons, increase resilience to climate change and extreme events and mitigate GHG emissions largely through carbon sequestration. The contribution of practices such as conservation agriculture, green manure, fodder crops, improved pasture and rangeland management and recycling of crop residues and animal wastes can make the agriculture sector more carbon-neutral.

Recommendations/Findings/Options/Questions

Principal recommendations are:

- Broad adoption of participatory and pluralistic approaches to land and water management, with growing devolution and local accountability.
- Increasing investment for improvement of essential public good infrastructure related to the whole market chain from production to consumer.
- Allocation of national and international dedicated funds to support sustainable land and water management in systems requiring priority attention linked to FAO strategic objectives on small farmers and Impact Focus Area on Water and Land Scarcity (IFA-WALS) and promotion of incentive programmes.
- Appraisal of ecosystem services including land and water audits developed to frame planning and investment decisions.
- A review of the mandates and activities of existing global and regional organizations for land and water to promote closer collaboration, if not integration.
- Promoting 'green economy' approach to assure improvements in human well being and social equity while reducing environmental risks through International trade agreements (e.g. improved use of WTO green fund) and contribution to sustainable agriculture overall.

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[1] Informal irrigation definition: http://www.ruaf.org/node/1486

- Cooperative frameworks and basin-wide management institutions should work together to optimize economic value and ensure equitable benefit sharing in international river basins.

To address the challenges for achieving improved food security and livelihood, the following need to be undertaken:

- Transforming existing agricultural practices to reduce pressure on land and water systems;
- Reducing negative impacts of production systems; increased food production is associated with poverty alleviation, food and livelihood security diversification and the maintenance of ecosystem services;
- Addressing as priority agricultural systems facing land and water-related constraints and monitoring of progress in redressing risks;
- Investment, economic and trade policies should favour sustainable agriculture and balanced rural development; and
- Implementing sustainable intensification through integrated planning and management approaches that can be scaled up from local levels to address constraints and mainstream climate change mitigation and adaptation simultaneously.

These systems at risk may simply not be able to contribute as expected in meeting human demands by 2050. The consequences in terms of hunger and poverty are unacceptable. Remedial action needs to be taken now. Appropriate levels of investments, access to novel mechanisms for financing, as well as development assistance needed to contribute to overcoming constraints to the adoption of sustainable management. Countries should give priority attention to reversing conditions which place their key production systems at risk.

Achieving increased production to address food security and poverty will require widespread adoption of sustainable land management practices. The potential exists to narrow notable gaps in crop yields, and to use irrigation water more productively. Greater attention should be paid not just to technical options to promote intensification. The adequacy of national policies and institutions, whether formal or traditional, is of equal importance.

The growing interdependence and competition on land and water resources in major river basins requires greater collaboration to ensure effective transboundary governance of these resources. Policies and other measures which slow the adoption of more sustainable practices, including distorted incentives should be revisited.