

# **Changes in Global Agriculture: A Framework for Diagnosing Ecosystem Effects and Identifying Response Options**

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## **Summary**

We propose a framework for diagnosing the ecosystem effects of changing global agriculture and identifying appropriate response options and interventions beyond the farm level.

The diagnostic framework is intended for use by practitioners who face the complex task of understanding the national and regional implications of changing global agriculture and formulating actions to respond to it or intervene proactively.

At this stage, the framework is a simplified linear representation of a multi-faceted system defined by human development (poverty reduction), agriculture, and the environment. With its strong focus on agricultural trade liberalization the paper assumes a macro-economic viewpoint. General descriptions, categories and examples are provided to stimulate thinking and inform actions undertaken by practitioners.

The framework considers the policy and institutional context of global agricultural change as well as private sector initiatives as the *indirect drivers* of ecosystem effects. The ‘on the ground’ socio-economic changes caused by these indirect factors (scale effects, structural effects, infrastructure expansion, urbanisation, etc), are treated as the *direct drivers* of ecosystem change. That is, structural socio-economic changes are the direct drivers of ecosystem change. Changes in ‘on-the-ground’ agricultural practices moderate the direct driver effects. The assessment of changes in ecosystem services informs the selection of appropriate interventions and responses.

Given the importance of temporal and physical scales, uncertainties, cultural context, equity issues, etc, a one-size-fits-all approach cannot possibly yield insights with the level of detail required for on-the-ground action. To articulate realistic actions for specific commodities, countries, and regions, formalisation of the key processes and feedbacks in the system is required.

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# 1. Introduction

## Background

WWF-MPO's "From Negotiations to Adjustment" activity seeks to facilitate dialogue around the options available to developing countries seeking to adjust to the environmental consequences of agricultural trade liberalization, domestic agricultural reform, and associated changes in global agriculture<sup>1</sup>. The project focuses on ecosystem effects at the landscape scale (as opposed to on-farm effects). With its emphasis on future response options, "From Negotiations to Adjustment" is an effort at strategic planning. The three pilot countries chosen for the first phase of the project are Brazil, Kenya, and Vietnam.

## Objective of this paper

This framing paper is part of a set of papers commissioned under the "From Negotiations to Adjustment" activity. It aims to outline a framework for *cataloguing and diagnosing* the ecosystem effects of changes in global agriculture as well as *cataloguing and identifying* suitable response options (reactive) and interventions (proactive). The terms of reference emphasise that the framework has to be:

- immediately accessible to on-the-ground decision makers, environmental and social practitioners, etc., and
- allow additions as experience grows and the number of participants expands.

Therefore, special effort has been made to highlight generic forces and processes (i.e., applicable to any country or region), and to avoid speculative, theoretical, and/or academic interpretations.

The paper presents a simplified and practical environmental perspective on a multi-faceted issue (changing global agriculture) with linkages to many other themes and issues (trade, poverty alleviation, population growth, climate change, etc) as well as a practical entry point for on-the-ground decision making.

## A systems approach

The centrepiece of this paper is a systems diagram (Figure 1) which was conceived in close cooperation with WWF-MPO. The diagram is based on an extensive literature review and expert interviews. Particular attention was paid to the OECD's Pressure-State-Response framework and its successors<sup>2</sup> (Driving Force-State-Response) and Driving Force-Pressure-State-Impact-Response (DPSIR) frameworks), the UN's Millennium Ecosystem Assessment<sup>3</sup>, and an earlier framework for assessing the effects of trade liberalization on biodiversity developed by the International Institute for Sustainable Development<sup>4</sup>.

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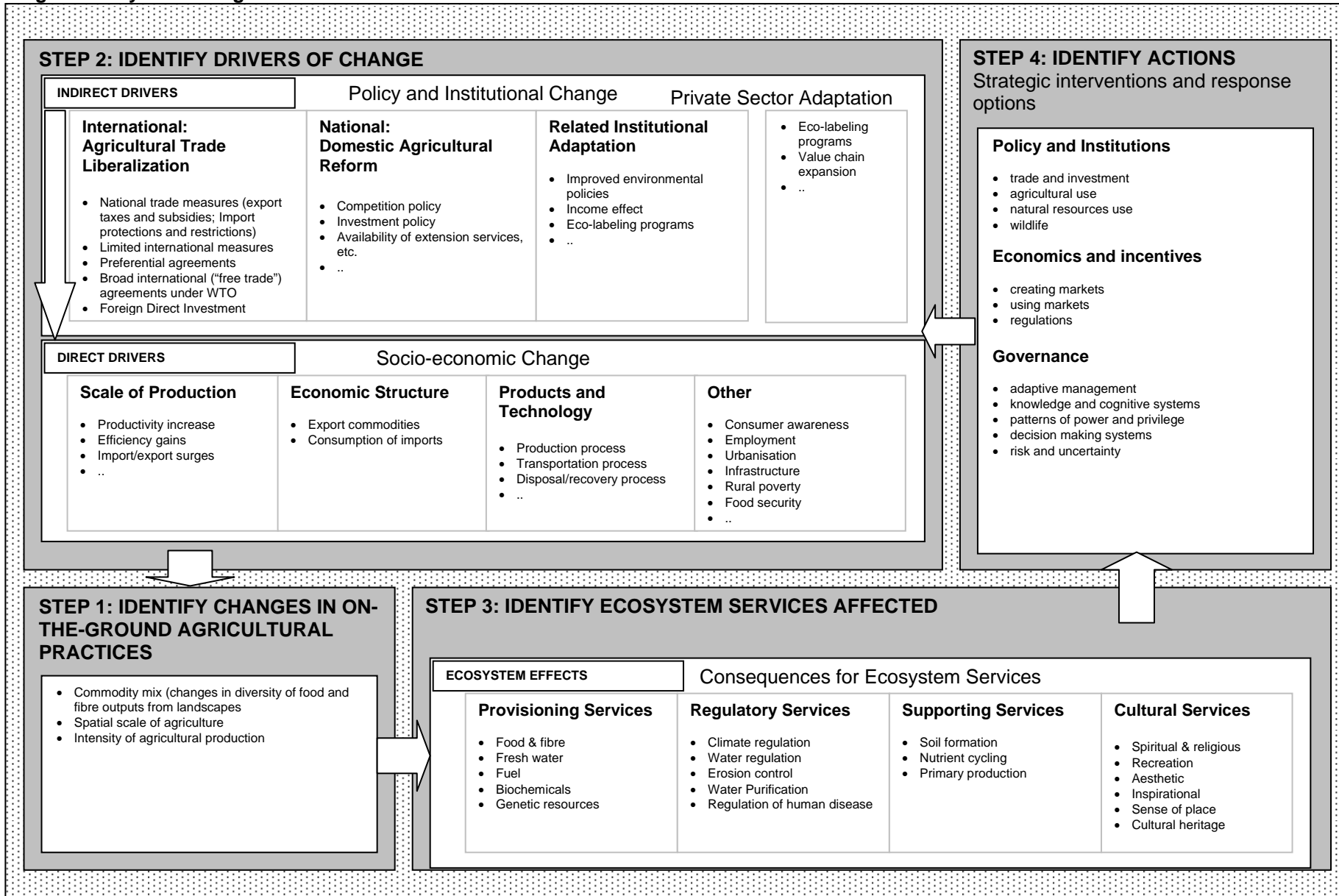
<sup>1</sup> WWF-MPO 2004

<sup>2</sup> OECD 1993

<sup>3</sup> Millennium Ecosystem Assessment 2003

<sup>4</sup> Conway 1998

Figure 1 – Systems Diagram



Understanding the factors that change ecosystems and the services they provide is essential because the interventions and response options will affect those very factors. This is reflected in the framework (Figure 1) by a focus on drivers and their links to response options and interventions. This paper adopts the driver definitions as employed in the Millennium Ecosystems Assessment report “*Ecosystems and Human Well-being*”:

a driver is any factor that changes an aspect of an ecosystem. Direct drivers unequivocally influence ecosystem processes, whereas indirect drivers operate more diffusely, often altering one or more direct drivers.

Both indirect and direct drivers often operate synergistically, and there is increasing belief<sup>5</sup> that synergies and feedbacks are the really important impacts and that their joint effects will dwarf the separate effects. However for practical reasons the framework currently ignores synergies and feedbacks between drivers.

### **Structure of this paper**

Chapter 2 places global agriculture in the broader perspective of human development, poverty reduction, and the environment. Chapter 3 (Figure 1, Step 1) categorized and describes the on-the-ground changes in agricultural practices. Chapter 4 (Figure 1, Step 2) discusses the drivers of change at two levels: the policy and institutional<sup>6</sup> context of global agriculture (direct drivers), which indirectly drives ecosystem change, and the ‘on the ground’ socio-economic effects of changes in the institutional and policy domain. Chapter 5 (Figure 1, Step 3) focuses on the services and goods that ecosystems provide and how they are affected by the changes identified in Step 1. Chapter 6 discusses response options and interventions and explains how ecosystem and other indicators can be used to inform their selection. Chapter 7 suggests further steps towards a comprehensive decision support tool.

## **2. Agriculture, Development, and the Environment**

### **Agricultural production**

The practice of agriculture is the process of modifying natural ecosystems to provide goods and services for people through the nurturing of domesticated species of plants and animals<sup>7</sup>. Agriculture has played a central role in the progress and development of the human species, enabling the world’s population to expand far beyond what would have been possible without changing natural ecosystems. Agriculture is the dominant global land use. In developing countries it generates about 12 percent of GDP, more than 50 percent of total employment, and 13 percent of merchandise exports<sup>8</sup>. Present-day agricultural production systems have some diversity depending on the mix of annual crops, perennial crops and livestock, management, and irrigation practices.

### **Poverty and development**

Agriculture also underpins the social and community dimensions of human life: it provides its practitioners with a source of income and living, as well as a sense of

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<sup>5</sup> Millennium Ecosystem Assessment 2003

<sup>6</sup> This paper adopts the view that policies are implemented through institutions

<sup>7</sup> McNeely & Scherr 2003

<sup>8</sup> Maret, date unknown

identity and belonging. Investing in the agricultural sector of developing countries has the potential to reduce poverty and slow down urbanization, and is therefore deemed to be a key development mechanism.

### **Agriculture and the environment**

Agriculture inevitably impacts on the environment in which it is practised. Many current agricultural practices carry high costs to both producers and society, which reduces the long-term viability of farming. Intensively farmed agricultural lands are subject to regular disturbance of the soil and are dominated by introduced species. Trends in agricultural land use have been towards greater land expansion and intensification. Land conversion has mostly halted in developed countries, but clearing and conversion continues to take place in the developing world. Expansion for agricultural use is competing with other land uses or is moving into marginal areas, which further stresses the environment. Agriculture already accounts for 70 percent of water consumption worldwide, of which 50 percent is extracted from unsustainable sources. Furthermore, ever-increasing inputs of chemicals and fertilizers pose a threat to the natural areas surrounding farmlands.

### **A joined-up approach**

WWF is moving towards a “joined-up” approach to agriculture, poverty and the environment, recognizing the complex relationships and potential synergies between agriculture, poor people, and the environment.

Depending on one’s point of view<sup>9</sup>, agriculture can drive environmental improvement and at the same time contribute to poverty reduction. In other words, improving the environment and reducing poverty can be objectives, and agricultural change the means to achieve them<sup>10</sup>. Likewise, agricultural practice can harm the environment and increase poverty. To assess the potential of agricultural change as a driver of environmental improvement (the objective of WWF-MPO’s “From Negotiations to Adjustment” activity), an insight in the changes in agricultural practices, ecosystem services, policy and institutional context (indirect drivers) and socio-economic changes (direct drivers) is required.

We suggest the following process framework to assist with understanding the national and regional implications of changing global agriculture and formulating actions to respond to it or intervene proactively. Steps 1-3 provide a means of cataloguing and diagnosing the impact of agricultural changes on ecosystem services. Step four provides a means of developing responses.

### **3. Step 1: On-the-ground Changes in Agricultural Practices**

For practitioners in the field, there are many signals to read from the agricultural practices in their area. These can be categorized as:

- Changes in the *diversity* of outputs from landscapes - what is produced (e.g., food and fibre)? Is there a significant change in the *mix* of commodities? Are any new commodities dominating or emerging?

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<sup>9</sup> Cleetus 2004

<sup>10</sup> Roe *et al.* 2005

- Changes in the spatial *scale* of agricultural production – over what area of land does production take place? Is agriculture moving into marginal areas? Or is land taken out of production, e.g. because of the introduction of new technologies, varieties, or urbanisation?
- Changes in the *intensity* of production – what intensity of inputs is used (e.g., water, agro-chemicals, fossil fuel, labour, rotation frequency) and is this intensity changing? Are there any ‘novel’ inputs? What is the relation of the change in intensification to the spatial scale of production (e.g., expansion and intensification or contraction *because of* intensification, with the abandonment of marginal lands as a result?)

Conceptually, we suggest the impact of agriculture can be summarized as a function (f) of the crop(s) times the scale of the cropping system times the intensity:

$$\text{Impact} = f(\text{Crop} * \text{Scale} * \text{Intensity})$$

For example, beef production across 10,000 ha of rangeland with only fencing and watering points as inputs has a far different impact than beef production on 100 ha of feedlots dependent on 5,000 ha of irrigated forage crops, which in turn are dependent on fertilisers, herbicides, and pesticides.

#### **4. Step 2: Drivers of Change**

##### **Indirect Drivers: Policy and Institutional Change**

##### **Agricultural trade liberalization and investment<sup>11</sup>**

The on-going process of global integration known as “globalization” has economic, political, cultural, and technical dimensions. Economic integration largely takes place through trade, foreign investment, and capital flows. The policy and institutional context of global trade in agricultural commodities<sup>12</sup> (Figure 1, Step 2) is dominated by the collection of agreements and ongoing negotiations administered under the World Trade Organization (WTO). Countries can adopt different types of trade policies<sup>13</sup>:

- At the national level, a government can impose unilateral tariffs and non-tariff barriers. Tariffs are imposed on imports of goods, especially those benefiting from subsidies in the exporting country and goods sold below their fair market value. Non-tariff barriers are quotas, laws, regulations, investment rules, standards, etc, intended to restrict imports and foreign investment.
- Limited international measures involve two or more countries (sectoral agreements) or producers and consumers of a particular commodity (commodity agreements) and aim to avoid trade disputes between competitors as well as volatile market price swings and earnings.

<sup>11</sup> This section draws heavily on Panayotou 2000

<sup>12</sup> See, for example, UNEP/ETB 2005

<sup>13</sup> This section draws heavily on Conway 1998



- Countries can also set up so-called preferential agreements, which are tariff concessions specifying which products apply under which conditions.
- Trade liberalization agreements (“free trade” agreements) are broad international agreements involving two or more countries which set broadly applicable rules applicable to both tariff and non-tariff barriers. Through the rule frameworks they establish, free trade agreements have the biggest potential indirect impact on ecosystems.
- Foreign Direct Investment (FDI). The interlinkages between trade and foreign direct investment have become a much-discussed topic<sup>14</sup>. The sheer size of the flows makes FDI difficult to ignore. Estimates suggest that over the period 1973-1995, the value of annual FDI global outflows increased by a factor 12. Second, FDI is one of the main forces feeding the ongoing integration process of the world economy. According to the WTO, the increased importance of foreign-owned production, together with the more or less steady rise in the trade-to-GDP ratio, are “tangible evidence of globalization”.

Because of the many trade restrictions that are currently effective, further trade liberalization has tremendous potential to change the face of global agriculture, both in the developed and the developing world. In theory, free trade maximizes the efficiency of resource allocation because it channels economic activities to least-cost producers. Theoretically, free trade also maximizes social welfare if all relevant social costs are properly accounted for. However, social cost accounting poses considerable conceptual and practical difficulties, and from the ecosystem resilience literature it is well known that “efficient” resource use can still be unsustainable<sup>15</sup>.

### **Domestic agricultural reform**

International trade policies and domestic agricultural reform (Figure 1, Step 2) have very similar effects on the environment<sup>16</sup>. In addition, ratifying international trade agreements can trigger or accelerate domestic agricultural policy reform. Domestic agricultural reform can take place through:

- Changes in national competition policy, implemented through export taxes and subsidies and/or other import protections and restrictions;
- Changes in national investment policy and associated incentives;
- Availability of extension services, rural credit, guaranteed markets and other support services to small farmers.

Domestic agricultural reform typically results in changing agricultural import/export patterns which potentially lead to intensification and/or extensification of agriculture and their associated environmental effects.

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<sup>14</sup> Maechler 2000

<sup>15</sup> Walker *et al.* 2004

<sup>16</sup> Lankoski, 1997

Development goals (e.g., Poverty Reduction Strategy Papers<sup>17</sup>) can also have a profound effect on domestic agricultural policies.

### **Related institutional adaptation**

Institutional adaptations related, but not immediately linked to agriculture include:

- Improved environmental policies (e.g., National Environmental Standards) in response to new trade agreements, Multilateral Environmental Agreements, etc;
- Increased budgetary resources for environmental protection due to increased wealth and welfare (income effect);
- Eco-labeling programs to differentiate products in the marketplace based on how they are produced. Eco-labeling gives credibility to claims that products are better for the environment, are cheaper to maintain, and are cleaner to recycle than otherwise similar products or services. Both governments and the private sector can be involved in eco-labeling programs<sup>18</sup>. Government involvement in eco-labeling schemes can improve the programme's economic stability, legal protection and credibility, provide more dependable, long-term resources, overcome high start-up and compliance monitoring costs, allow for the incorporation of international standards, provide better accountability and technical expertise, and ensure public involvement in setting new standards.

### **Private sector adaptations**

- As explained above, both governments and the private sector can be involved in eco-labeling programs. Private-sector programs are less vulnerable to shifting political priorities and budget constraints, can set more stringent standards than government agencies, and can put pressure on overseas companies to comply with environmental regulations.
- Many farmers are increasingly recognizing the value-chain<sup>19</sup> of their produce and are capturing portions of the value added beyond the farm gate (e.g., by processing, packaging and marketing). The importance of value-added agriculture is growing because of the increasing difference in the prices that farmers receive for their products and prices paid by consumers.

### **Direct Drivers: Socio-Economic Change**

The categories and examples described in the previous section capture the policy and institutional (macro-economic) context of global agricultural change. These indirect drivers operate diffusely and simultaneously affect the 'on the ground' socio-economic situation (Figure 1, Step 2). The latter changes are treated as the direct drivers of ecosystem change. That is, structural socio-economic changes are considered to be the direct drivers of ecosystem change.

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<sup>17</sup> Poverty Reduction Strategy Papers are prepared by the member countries through a participatory process involving domestic stakeholders as well as external development partners, including the World Bank and International Monetary Fund.

<sup>18</sup> Source: [http://www.bsdglobal.com/markets/eco\\_labeling.asp](http://www.bsdglobal.com/markets/eco_labeling.asp)

<sup>19</sup> Porter 1985

Table 1 summarizes the links between indirect drivers (policy/institutions, private sector initiatives) and direct drivers of environmental degradation.

*Table 1 Summary of the links between indirect drivers (policy/institutions, private sector initiatives) and direct drivers of environmental degradation.*

	Policy and Institutions			Private Sector Initiatives
	Trade liberalization	Domestic Agricultural Reform	Related Adaptation	
Scale	✓	✓		
Structure	✓	✓		✓
Products	✓	✓	✓	✓
Other	✓	✓		

Trade liberalization, domestic agricultural reform and related institutional adaptations as well as private sector initiatives impact on the socio-economic setting of countries and regions through a number of channels<sup>20</sup>:

### **Scale of Production**

Trade liberalization tends to stimulate economies and lead to increased production of export commodities and/or consumption of imports. Production processes can intensify due to greater availability of capital, technology, and inputs. Expanding the scale of economic activity typically makes it more efficient.

### **Economic structure**

Change in the policy/institutional domain can change the structure of an economy. Structural effects are shifts in economic activity from one sector to another. Typically, these shifts maximize a country's comparative advantage. The most obvious mechanism is a sudden shift to "booming" industries (e.g., flowers, ornamental plants). Consolidation of the agricultural value chain can also affect economic structures because small processing and packaging businesses may fail or be absorbed by the larger farms leading to further concentrations of wealth.

### **Products and technology**

Product effects emerge when agricultural reform affects the agricultural commodities themselves as opposed to the producing industries. Product effects are triggered by changes in the way commodities are produced, transported, consumed, and disposed of. These processes largely depend on the availability of new technologies<sup>21</sup>. Product effects are relatively easy to assess, hence most assessments of the environmental effects of trade tend to gravitate towards the product or product/sector level (e.g. agriculture, forestry, and mining).

### **Other socio-economic changes**

Global agricultural change can boost economic growth and increase welfare. This may change consumers' attitudes towards the environment (income effect). Furthermore, a greater exposure to global markets can affect the choice patterns of consumers and producers, and give rise to "green" export markets (e.g., organic produce). Changes in economic structure may also lead to increases in infrastructure

<sup>20</sup> OECD 1994; Conway 1998; Panayotou 2000

<sup>21</sup> Panayotou 2000

(e.g., roads, ports). Significant changes in a country's agricultural sector can increase rural poverty and decrease employment and food security. If more land is allocated to grow export commodities, small landholders may be wedged out of their trade and leave for the city (urbanization, migration).

### **5. Step 3: Ecosystem Effects**

The economic and structural effects described in the previous section directly drive ecosystem change (Figure 1, Step 3). Diagnosing ecosystem changes driven by global agricultural change requires a clear definition of environmental effects is required. In the context of this paper, the term "environment" is too vague because it implicitly encompasses a multitude of scales, uses and functions of landscapes, soils, flora, fauna, species, etc. A useful approach, formulated by the Millennium Ecosystem Assessment<sup>22</sup>, is to place human well-being at the central focus for assessment (while recognizing that biodiversity and ecosystems also have intrinsic value). The usefulness of this approach comes from the fact that humans make natural resource management decisions based on the perceived well-being they derive from ecosystems.

Two key concepts define the approach, ecosystems and ecosystem services.

An *ecosystem* is a dynamic complex of plant, animal and micro-organism communities and the non-living environment interacting as a functional unit. Humans are an integral part of ecosystems.

Although sustainable farming depends on ecosystems, the changing face of global agriculture has significant potential to degrade them. The *ecosystem services* concept confronts this paradox<sup>23</sup>. Ecosystem services are the benefits people obtain from ecosystems. They comprise the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life<sup>24</sup>.

Thinking about ecosystems as providers of services is a new approach. It moves people beyond the angst of agriculture replacing native species and vegetation communities. Agriculture simplifies natural systems by 'channelling' solar energy, soil and water through a limited number of agricultural plants and animals, and this has an effect on native species and vegetation communities.

The question is whether an intensified agricultural system, producing few products over a large area, provides a total of more or fewer services to people. An intensified cropping system may provide more rice, but does it provide enough clean water, fish, produce few non-assimilated pollutants, provide enough recreational opportunities and preserve local culture?

The ecosystem services framework provides a holistic approach to agricultural landscapes. The framework is neither focused 'just' on agriculture, nor 'just' on nature conservation. Rather, the ecosystem services concept examines the impact of

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<sup>22</sup> Millennium Ecosystem Assessment 2003

<sup>23</sup> Abel *et al.* 2003

<sup>24</sup> Daily 1997; Kremen 2005

agricultural changes *across all human values* derived from ecosystems that support human existence and well being.

The direct drivers listed in Chapter 4 can affect ecosystem services in many different ways through changes in agricultural practices on the ground. Key determinants are the geographical location and scale, agricultural commodity and their production and transport processes as well as the magnitude of change in the driver; ignoring these factors merely yields general mechanisms. Table 2 provides a diagnostic matrix to assist in identifying how three categories of agricultural change can affect four broad classes of ecosystem services.

Table 2 Socio-economic changes and their links to ecosystem services.

	Diversity of agricultural production	Spatial scale of agricultural	Intensity of agricultural production
<b>PROVISIONING SERVICES: products obtained from ecosystems</b>			
Food			
Fresh Water			
Fuelwood			
Fiber			
Biochemicals			
Genetic resources			
<b>REGULATING SERVICES: benefits obtained from regulation of ecosystem processes</b>			
Climate			
Diseases			
Water			
<b>SUPPORTING SERVICES: services necessary for the production of all other ecosystem services</b>			
Soil formation			
Nutrient cycling			
Primary production			
<b>CULTURAL SERVICES: nonmaterial benefits obtained from ecosystems</b>			
Recreation/tourism			
Educational			
Cultural heritage			

## 6. Step 4: Interventions and Response Options

Decision-making processes and institutions that affect agriculture operate across geographical and institutional scales<sup>25</sup>. The decision-making processes that directly and indirectly affect the environment through the practice of agriculture provide the “hooks” for interventions and response options (Figure 1). That is, the interventions and response options are mirrored by the direct and indirect drivers of global agricultural change. The relevance of these options in specific situations depends on the local “signals” given by the changes in ecosystems (Figure 1, link between Step 3 and Step 4).

The implementation of interventions and response options is strongly dependent on the objectives, and institutional status of the actors involved; NGO’s like WWF focus on the environment and partake in international negotiations as institutional partners, whereas individual farmers influence decisions affecting their lands at a much smaller institutional scale (landcare groups, cooperative societies, etc)

<sup>25</sup> Millennium Ecosystem Assessment 2003

Interventions can be interpreted as pro-active as they seek to change the outcomes of the policy processes that influence agricultural impacts on the environment. Responses are reactive in the sense that they accept agricultural change as a given and seek ways to adapt national or regional agriculture to the consequences of these changes.

When identifying interventions and response options it may be tempting to immediately focus on policy/institutional interventions, and/or practice responses without first challenging the basic premises, moderating between different stakeholders, or coordinating among goals. Without going through these steps, proposed interventions are likely to sit well outside established and/or agreed goals and norms, and thus will make no sense to decision makers. Mainstreaming of objectives into the agricultural and development agendas should therefore be an important first step.

The impacts of global agricultural change on the environment can be moderated by influencing the decision-making processes in the policy/institutional domain, the private sector, the (national) socio-economic domain, and at the farm level. The latter category will not be discussed because this paper aims to identify options beyond the farm level.

*Table 3 Interventions and response options and their relevance to the different driver categories.*

	Policy and institutional interventions	Economic incentives	Governance
<b>Indirect drivers</b>			
Agricultural trade liberalization			
Domestic agricultural reform			
Related institutional adaptation			
Private sector initiatives			
<b>Direct drivers</b>			
Scale of production			
Economic structure			
Products and technology			
Other Socio-economic			

Table 3 provides a diagnostic matrix to assist in identifying how institutional, economic and governance arrangements can affect indirect and direct drivers of agricultural change. Examples of policies and institutional arrangements that may be appropriate to populating this matrix include:

- Complementary trade agreements (e.g., the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreements);
- Special and differential treatment agreements;
- Agreements on social and environmental issues (e.g., the Convention on International Trade in Endangered Species (CITES));

- Special safeguard mechanisms - contingency restrictions on imports taken temporarily to deal with special circumstances such as a sudden surge in imports;
- “Green boxes” - production-decoupled subsidies that are environmentally friendly;
- Foreign direct investments subject to environmental and social requirements;
- Regulation of environmental hazards and unsustainable practices (substance emissions, water extraction, etc), using standards, bans, permits, quota, etc;
- Protection of subsistence farming, its local markets as well as existing assets and management capacity of (and investment opportunities for) the rural poor.
- Land use planning and zoning to protect vulnerable areas, rehabilitate degraded lands and retire marginal lands;

Examples of economic incentives include:

- Using and creating markets by subsidy reduction, environmental taxes, deposit-refund systems, targeted subsidies, property rights, offset systems, etc<sup>26</sup>;
- Payment for environmental services;
- Certification and eco-labeling.

Examples of governance measures include:

- Promote agricultural livelihood diversification;
- Promote best management practices based on social criteria and equity;
- Base regulatory structures and permitting schemes, investment, insurance and purchases screens on best management practices;
- Promote a shift from highly sectoral resource management approaches to more integrated approaches;
- Promote community resource management;
- Funding for pro-environment agricultural and natural resource research;
- Promote conservation and alternative rural finance programs;
- Promote social- and equity based best management practices;
- Incorporate market and non-market values in resource management and investment decisions;
- Enhance human and institutional capacity for assessing the consequences of ecosystem change;
- Engage the public via information disclosure, community pressure, and public participation;
- Promote consideration of equity and vulnerability when developing response options and considering trade-offs;
- Align response options at the level of governance where they can be most effective;
- Promote assessment of irreversible risk and irreversible thresholds;
- Value chain evaluation.

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<sup>26</sup> World Bank 1997; Whitten *et al.* 2003

## 7. What's Next?

### Substantiating the framework

The framework presented in this paper (Figure 1) inter-relates different “boxes” with different conceptual premises. The categories provided for the direct drivers, private sector initiatives (none so far), socio-economic changes, ecosystem services, and interventions are provisional and may change as experience grows. The framework explains the links between direct drivers, indirect drivers and ecosystem effects in terms of cause and effect. However, the link between ecosystem services and response options is complicated and needs to be further developed.

The range of response options and interventions that can be applied to a particular problem will depend on its economic, environmental, and social nature, its spatio-temporal and institutional scale, the capacity of the decision-maker or actor to change, and many other factors<sup>27</sup>. In order to use Table 1 and Table 2 to derive environmental signals to inform the identification of actions, information on the specific region (soil type, dry or wet climate, proximity of wetlands, etc), management (fertilizer inputs), etc would be needed as well as information on the relative magnitude of the change in ecosystem services. For example, Table 2 indicates that changes in economic scale (a direct driver of ecosystem change) impacts on the regulation of climate. In a practical context, this could apply to the introduction of high-input cash crops in a traditional agricultural setting which increases the emissions of nitrogen and carbon to the atmosphere and thereby impacts on the global climate. One way to substantiate Table 2 is to use models of agriculture-environment interactions<sup>28</sup>. Many different approaches exist, e.g. environmental risk mapping, life cycle analysis, environmental impact assessment, multi-agent systems, multiple goal linear programming, and agro-environment indicators<sup>29</sup>.

In addition, the framework could be enhanced by adding more instances (examples) of the categories. Adding examples will challenge the rationale of the framework and at the same time make it more valuable for practitioners in the field.

### Feedbacks

Feedbacks in the agriculture/environment/development system can be positive or negative, and partial or complete. That is, regulating or banning agricultural does not necessarily generate better environmental outcomes, and neither does investment in agriculture guarantee better social outcomes. If positive feedbacks exist, policy reform and other inventions may benefit from synergies (win-win situation), whereas there will be trade-offs (win-lose situation) if negative feedbacks exist. With partial positive feedbacks, synergies may exist between two compartments (e.g., better social and environmental outcomes), but a trade-off may exist between the synergetic compartments and the remaining realm (win-win-lose situation). The nature of the feedbacks strongly depends on local geography, production systems, commodities, and institutional arrangements. Making these complex trade-offs is a triple bottom line “balancing act” in which the planet, the people, and the environment are simultaneously at stake<sup>30</sup>. Knowledge of processes and their dynamics in all three

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<sup>27</sup> Millennium Ecosystem Assessment 2003

<sup>28</sup> Antle 2005

<sup>29</sup> Payraudeau & Van Der Werf 2005

<sup>30</sup> Foran *et al.* 2005



compartments as well as clearly stated objectives (e.g. sustainable development) are required to make informed decisions about adopting intervention strategies and response options.

### ***Further Reading***

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