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Articulation agriculture, public health and environment for the management of risks associated with the food production in the Americas:

Institutional experiences for the management of environmental risks associated with food production

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SUMMARY

The challenge of "greening" global food production to feed 9 billion people by 2050 in a sustainable manner has emerged as a top priority for national and international action. Public, private and civil institutions will need to strengthen collaborative approaches and develop the required knowledge, technologies and systems. This paper identifies a wide range of tools including innovative policy changes, mandatory regulations, economic instruments, incentives and private sector initiatives that will be needed to foster sustainable production systems for large and small scale application in a wide range of ecological and socio-economic settings. New information and communications technologies and innovative partnerships between private and non-governmental organizations offer important opportunities to amplify the power of knowledge and consumer choice. Progress should be tracked by rigorous evaluation and adjustments made as lessons are learned. Public institutions will have opportunities in the wake of Rio +20 to support journeys with their partners along these paths to a sustainable future.

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INTRODUCTION

"New challenges for ensuring food safety and food security for 9 billion people" (the forecast world population by 2050) was ranked third amongst 21 emerging environmental issues in a recent UNEP report[i]. Only cross-cutting issues of governance and human resource development to ensure global sustainability were ranked higher. While dealing with the combined challenges of climate change, competition for land from other uses, water scarcity[ii], possible shortfalls of fertilizer[iii] and perturbation of the nitrogen cycle[iv], food producers will need to strengthen the long term ecological foundation of the world's food supply and reduce the sector's environmental footprint to avoid making the situation worse. This paper examines a broad range of approaches that can be used by the public, private and civil sectors to reduce the environmental impacts of food production.

BACKGROUND

The agriculture and fisheries sectors have long been concerned with the social, economic and environmental sustainability of food production. The collapse of Mayan civilization is a reminder that agricultural intensification without ensuring ecological resilience[v] can lead to disaster, including an inability to adapt to moderate changes in climatic conditions[vi].

In the modern era, sustainable agriculture and rural development are part of Agenda 21 from the 1992 United Nations Conference on Environment and Development[vii] that is being reviewed this year. Also this year the OAS 42nd General Assembly resolved:

> *"…to promote and strengthen, within the countries of the region, the development of public policies, programs, and incentives to reduce the pressures of food production on ecosystems that are fragile and unsuitable for agricultural activities; avoid soil degradation, water pollution, use of agrochemicals and substances that are harmful to the environment and to human health; promote services for universal access to farming technologies, technical assistance, health, and safety; and promote processes for risk management, natural disaster emergency plans, and climate change adaptation plans for food security."*[viii]

CURRENT SITUATION

The United Nations Environment Programme (UNEP) reported that current farming practices use over 40% of global freshwater, contribute to over 13% of greenhouse gas (GHG) emissions and contribute to millions of cases of pesticide poisoning including thousands of deaths annually[ix]. Capture fisheries, aquaculture fisheries and crop production all face controversial issues. In calling attention to a global crisis in land use Jonathon Foley describes in compelling text and videos the impacts of agriculture on ecosystem degradation, freshwater decline, nutrient pollution and GHG emissions[x]. Exploring the case of livestock production, a report by the UN Food and Agriculture Organization (FAO) drew attention to significant impacts on land, water, the atmosphere and biodiversity[xi,] sparking healthy debate about the challenges of assessing and managing these issues, especially GHG emissions[xii, xiii]. A World Bank study also identified the need for changes in livestock production, including in developed countries that face growing pressures regarding health and ethical considerations[xiv].

Important work to address such issues and strengthen sustainable food production has been performed by many countries with the support of international agencies and donors. Private sector and non-governmental organizations have also contributed through partnerships with producers in building capacity and green value chains.

Recent reports from OECD[xv] and UNEP[xvi, xvii] observe that i) while food production can cause environmental harm it can also, if properly managed, provide beneficial ecosystem services, ii) improvements have been made but progress has been uneven, and iii) care must be taken with broad policy generalizations given the ecological, social and economic differences amongst and within countries.

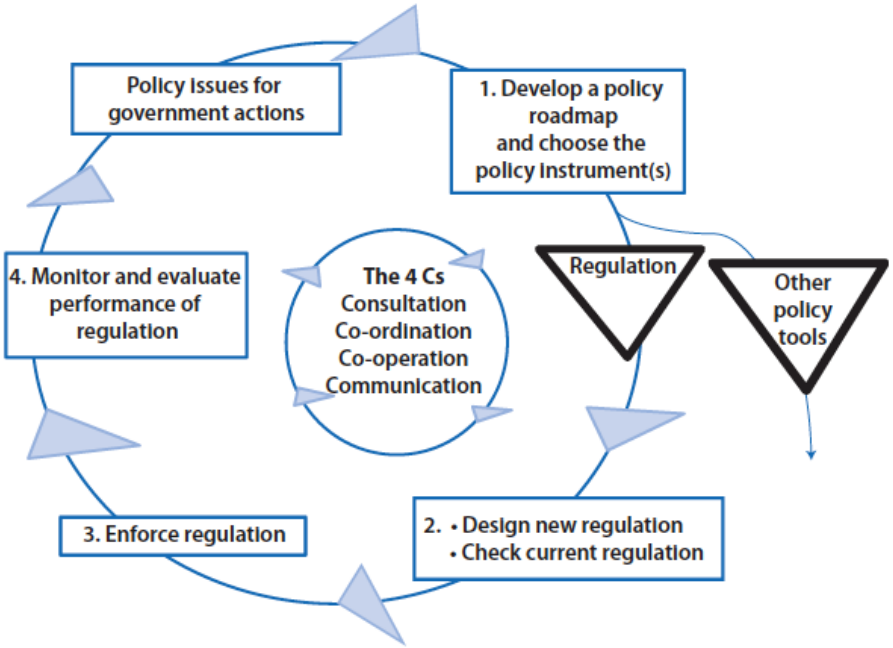
INSTITUTIONAL APPROACHES TO THE MANAGEMENT OF ENVIRONMENTAL RISKS

Given the scale and complexity of their environmental issues, food producing sectors need all available tools: knowledge; appropriate technologies; control measures ranging from voluntary measures to command and control regulations; market-based instruments; and incentives to adopt sustainable production methods. Actions are required at all levels from public, private and civil organizations. The daunting challenge of working with an estimated 525 million small farms may be the most effective strategy to increase sustainable food production[xviii], although large-scale production dominates international food and feed markets. Monitoring and evaluation of results at all scales is essential.

In making policy and regulatory choices many countries use a life cycle approach that starts with the identification and analysis of issues and then continues through the design of policy or regulatory instruments, their deployment and enforcement, followed by monitoring and evaluation leading to possible adjustments (Figure 1).

Environmental impact assessments and cost-benefit analyses are important tools to support decisions that balance social, environmental and economic values. Instruments ranging from mandatory to 'voluntary', including market forces and information, may be used to change the behaviour of industries and consumers (Figure 2). Developing strategic approaches requires collaboration of technical experts (familiar with the risks and measures that might be taken), economists and policy experts to assess the social and economic implications of possible actions[xix].

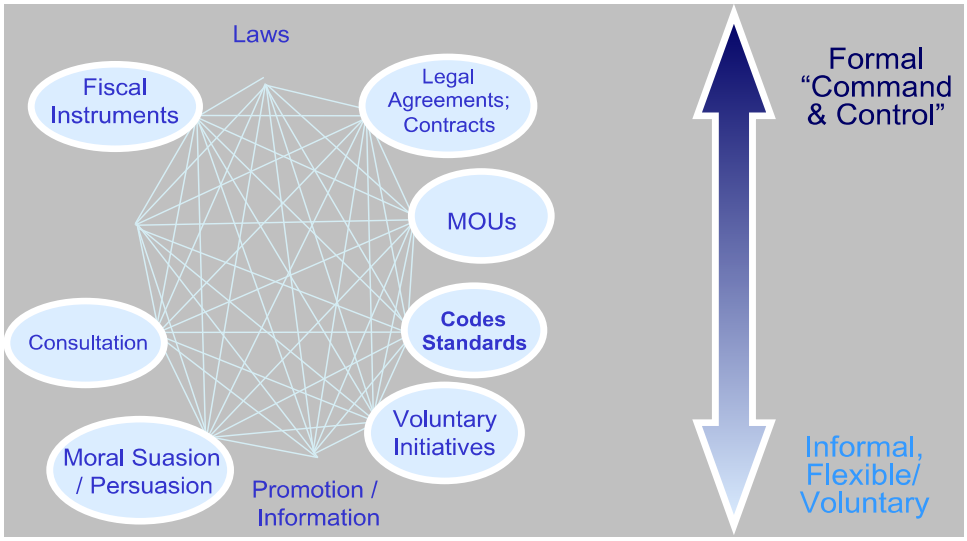
Figure 1. Lifecycle approach to policy and regulation[xx, 1]



Source: OECD Secretariat.

[1] Figure 1 courtesy of OECD Secretariat

Figure 2. An Array of Regulatory Instruments[2]



There are no simple solutions and generalisations are fraught with risk. OECD member countries use a mix of policy instruments to fit their varied circumstances[xxi]. Let us consider what we have in the "tool box" using some instructive examples.

a) Knowledge

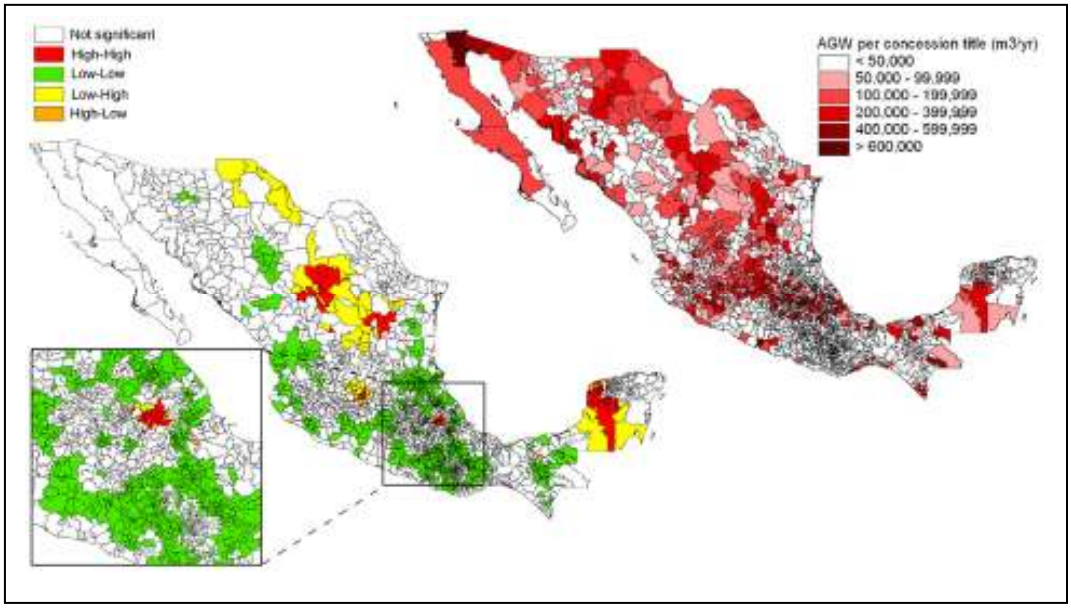
Adequate funding for research, monitoring and policy analysis to support sustainable agriculture must be a high priority of all funding agencies. Research, development and extension work is needed to address emerging issues such as two identified by a UNEP foresight study[1]: i) new understandings of complex water/land interactions, and ii) the need to protect water quality for inland fisheries threatened by agricultural runoff and municipal effluent. The link between land cover or cropping systems and groundwater levels as well as dry-land salinity has been well documented and lends itself to close collaboration with producers and legislators in efforts towards integrated land management to balance and optimize both production and ecosystem services[xxii].

Information alone can be a powerful regulatory tool. For example mandatory, publicly accessible inventories of pollutant releases[xxiii] have had a powerful regulatory effect in open economies where public disclosure becomes an important environmental management tool.

As Mexico grapples with a serious and likely ongoing drought[xxiv], a timely example of providing knowledge to decision makers can be found in water maps of Mexico[xxv, xxvi] (Figure 3) that provide municipality level data to determine if over-exploitation of groundwater can be addressed through reallocations of concessions or must be limited by demand management.

[2] Figure 2 courtesy of Treasury Board of Canada Secretariat.

Figure 3. Water Maps of Mexico



The top map of Mexico with all its 2,429 municipalities shows large groundwater titles in the north and center of the country. The bottom map compares the ratio of ground to surface water use in any one municipality with that of its ten nearest neighbors. In red areas both the municipality and its neighbors use much groundwater so that regional substitution is not an option and groundwater depletion must be managed through reducing demand. In green areas, municipalities and their nearest neighbors use relatively little ground water and pressure on the resource is low. In yellow and orange areas, neighboring municipalities have very different uses of ground and surface waters; therefore, opportunities exist for managing the water supply through transfers or adjustment of water allocations. Reproduced under creative commons license from IAI (2011).

b) Resource Conserving and Information Technologies and Systems

There are many sources of information on appropriate technologies and systems. A complete review is beyond the scope of this report, but consider for example water management lessons from Israel and Italy[xxvii], commodity specific experiences documented by the World Wildlife Fund[xxviii] and the evolution over centuries of integrated production systems in China[xxix]. The latter cases illustrate the power of applying agro-ecological and social sciences as well as traditional knowledge and methods. Resource-conserving methods were shown to increase average yields by an average of 79% while improving critical environmental services across 286 projects in 57 developing countries[xxx].

New technologies such as geographic information systems, global positioning systems, cellular phones as well as DNA and chemical testing offer opportunities to strengthen the product tracking and auditing systems needed to improve confidence in such certification systems[xxxi]. There are already some examples of the use of such technologies to trace product from boat and farm to the end consumer.

c) Collaboration across disciplines, communities and countries

Reducing the environmental footprint of agriculture requires multi-disciplinary and even multi-national efforts. Cross-disciplinary work engaging a broad community of interests is illustrated by efforts to build watershed-wide solutions to the eutrophication problems facing Lake Winnipeg[xxxii], a problem spanning almost the entire

Canadian Prairies[xxxiii]. A similar approach may be needed to address watershed problems in South America's La Plata Basin that are thought to arise from large scale conversion of forest and grassland to soya production[xxxiv]. In the case of developing nations, management at the landscape level will be essential to prevent damaging land cover changes and losses in productivity and ecosystem functions. The Ibero-American Model Forest Network seeks to address this need for 26 landscapes in 14 countries of Latin America, the Caribbean and Spain through projects to improve farmer livelihoods, increase food production and conserve forest resources[xxxv, xxxvi].

d) National and sub-national laws and regulations

The power of law is widely relied upon to prevent serious pollution from pesticides, herbicides, or livestock waste[xxxvii]. While powerful, the effectiveness of this approach may be limited by the institutional capacity and will to develop appropriate controls and enforce sanctions. Capacity is often limited, especially in developing countries. The willingness and ability of regulators to exercise authority is a complex issue as shown by a study of business regulatory agencies in Australia that found negotiated solutions to be the dominant mode of action[xxxviii]. The agriculture sector presents considerable political and logistical challenges that impede regulated solutions, including numerous small and non-point sources of pollution. Proposals to control of the use of antimicrobials in North American agriculture are instructive. A US court recently decided to prohibit the use of antimicrobials for livestock growth promotion, pointing out that US Food and Drug Administration (FDA) had failed to implement actions that it identified as needed in 1977[xxxix, xl]. The FDA subsequently requested voluntary actions[xli]. In Canada recommendations to strengthen regulations governing the use of antimicrobials in food animals were made by an expert advisory committee in 2002[xlii], but a nearly decade later most have yet to be addressed[xliii]. These gaps may to some extent have been offset by initiatives by the veterinary profession, the livestock sector and the food industry through prudent use guidelines and emerging private standards. However work remains to be done, as is likely the case elsewhere in the Americas.

e) Promoting beneficial practices

In 2003 Agriculture and Agri-Food Canada (AAFC), in partnerships with the Provincial and Territorial governments, launched joint programs to provide producers with information, tools and resources to assist them to develop and implement environmental farm plans (EFP) and to promote the adoption of Beneficial Management Practices (BMP). In this case producer participation was voluntary, not driven by value-chain standards or cross-compliance requirements discussed later in this paper. The focus varied amongst provinces depending on the nature of their agriculture and issues, and included work in agroforestry, biodiversity, irrigation and crop diversification, soil and land conservation as well as water supply and quality[xliv]. Following an audit of the early program[xlv] AAFC strengthened its efforts to demonstrate the effectiveness of the EFP and BMP programs using Agri-Environmental Indicators developed in collaboration with Environment Canada[xlvi, xlvii]. While much remains to be done, some early findings are that i) that the most commonly adopted BMPs were for management and storage of nutrients, ii) BMPs to reduce soil erosion and protect wildlife habitat were not as widely adopted, and iii) most funding was directed to areas of moderate to high risk.

A comprehensive report on agricultural systems for the 21st century by the U.S. National Research Council[xlviii] advocated that incremental efforts of this kind are needed, but should be complemented by transformative multi-disciplinary approach that would bring a systems perspective to agricultural research. It also called for an understanding of how many social, technical and economic variables affect farmer's choices – an understanding that will require investments in social sciences such as behavioural economics.

f) Greening the Value Chain: Private or Public Standards and Certification

Recent years have seen the development of promising standards and certification regimes in the forestry, fisheries and agriculture sectors (e.g. GlobalG.A.P.[xlix] and the Sustainable Agriculture Network[l]) to meet growing demands for products from sustainable production systems. An OECD review of certification regimes for capture and aquaculture fisheries identified that most costs are borne by primary producers who are "standard takers"; there is no price premium as the economic benefit is primarily sustained market access[li]. The report examined the role that governments might play in areas of credibility to avoid fears of "green washing" and to improve harmonisation to reduce "eco-label noise" that can result from a proliferation of standards that may confuse consumers.

Over the past year concerns have arisen over the reliability of eco-labelling for capture fisheries by the Marine Stewardship Council and Friends of the Sea[lii, liii]. The very existence of this research and oversight indicates that these certification systems are being monitored and may be adjusted as required. Both reports conclude that an imperfect regime is better than none at all.

The Sustainable Agriculture Initiative (SAI) is a food industry platform to support the development of sustainable agriculture that includes many of the world's largest private corporations amongst its 30 members[liv]. SAI commissioned a major Benchmark Study "with the aim of investigating and comparing some of the most influential agricultural production standards worldwide"[lv] and is engaged in a "review on carbon foot-printing methodologies to enable the global dairy sector to tackle a consistent methodology project"[lvi]. Many SAI members have their own certification regimes.

The Global Reporting Initiative (GRI), a not for profit multi-stakeholder network, offers a leading framework for sustainability reporting[lvii]. Its work is gaining some traction in the agricultural sector with exploratory work for Australia's cotton sector[lviii] and in Brazil where InpEV, the National Institute for Processing Empty Containers, a nonprofit organization that represents the Crop Protection Industry, has filed GRI sustainability reports most recently for 2010[lix].

What is the appropriate role for Governments in value-chain standards?

Private sector initiatives raise several issues for government to consider regarding sovereignty, accountability and governance. Key questions for public and consumer confidence in private standards are: i) how rigorous are the standards? ii) can the results be measured? iii) is there formal verification of the results by an independent third party?, and iv) how transparent is the process? The challenge of harmonization to avoid confusion in the market place is being addressed for the fisheries sectors by FAO with the development of guidelines for eco-labelling and certification[lx, lxi]. Other policy questions for governments include:

1. How far should countries go in developing national standards? There are several examples of national certification standards – for example as France's Agriculture Biologique[lxii] built upon EU regulations. Uruguay established a Certified Natural Meat Program under a "non-state public institution" to assure the traceability of animals and products from ranch to harvest, fabrication and packaging, ii) that no hormones, growth promotants, sub-therapeutic antibiotics or animal protein feeds (except maternal milk) are used, and iii) that the animals are grass-fed and not confined[lxiii]. This certification program has been recognized by the United States Department of Agriculture and the European Union[lxiv].
2. Can government recognition of private initiatives improve environmental performance can assure the public of the integrity of such systems? Environment Canada has had successful experiences with a *Policy Framework for Environmental Performance Agreements*[lxv] that sets out criteria to assure the effectiveness, credibility, transparency and efficiency of such initiatives.

3. How can green value chain benefits be extended to "small holders" and developing countries while avoiding green protectionism that has been a concern in the agriculture[lxvi] fisheries[lxvii] and Forestry[lxviii] sectors? Amongst other things this will require both capacity building[lxix] as well as appropriate and affordable certification regimes of the sort offered by Fair Trade International[lxx] with its regional producers' affiliate Coordinadora Latinoamericana y del Caribe de Comercio Justo (CLAC)[lxxi].
4. A further question is "who should pay?". Implementation costs are disproportionately borne by the primary producer, at least initially, and benefits are spread throughout the value chain. Is financial support warranted? Should retailers to pay the verification fees for participants? For developing countries, a case may be made for adapted certification schemes that consider the realities of their production and aim to avoid the worst impacts, such as pollution associated with shrimp farming in fragile coastal environments[lxxii].

g) Partnerships between governments, industry and non-governmental organizations

Strategic partnerships are being established by leading firms in the private sector. For example, the World Wildlife Fund has partnered with businesses from producers to retailers for many agricultural commodities in the agriculture[lxxiii] and fisheries sectors[lxxiv]. A recently formed Global Roundtable for Sustainable Beef brings together leading corporations and non-governmental organizations to improve sustainable production[lxxv].

The Alberta Livestock and Meat Agency is building a "One Health" agenda[lxxvi] that is moving beyond a focus on zoonotic diseases to consider the environmental footprint of the full value chain, including slaughter and meat processing operations. This includes an innovative partnership with Alberta's Clean Air Strategic Alliance[lxxvii] on a plan to address air quality for confined feeding operations.

h) Economic instruments

Proponents of green production criticize subsidies that artificially reduce the costs of inputs such as fuel, pesticides and fertilizers, and seek to reduce trade barriers that prevent markets from products of sustainable systems[lxxviii]. They encourage reforms in ownership of lands and fishing rights to reduce "tragedy of the commons" effects[lxxix] that continues to plague too many food production systems.

Agriculture and fisheries sectors would face higher input prices under economy wide measures such as a carbon tax or a cap and trade scheme on greenhouse gas (GHG) emissions. While there would be likely be positive effects in terms of reduced GHG emissions and reduced use of fuel, pesticides and fertilizers, complex questions arise about the net impact of such taxes on other environmental objectives and the feasibility of implementation in a sector with many non-point sources of GHG emissions[lxxx]. Important lessons may be learned from early experiences with a carbon markets in Costa Rica[lxxxi] and carbon taxes in the Canadian Provinces of British Columbia and Quebec. In regions undergoing significant land use change, accounting for carbon budgets in soil and vegetation will be critical, and will raise questions on the accounting base line and cut-off dates for historical contributions of land-cover change to atmospheric CO2.

<u>Environmental Cross Compliance</u>

Requirements for compliance with agri-environmental objectives in order to access agricultural support payments, or "environmental cross-compliance" (ECC), has been used since the mid 1980s in the USA, became compulsory in the EU with the 2003 reforms of the Common Agriculture Policy, and is used in various forms in a number of other OECD countries[lxxxii]. The design and implementation of such policies once again raises complex questions involving trade-offs between income support and environmental objectives, leading an

OECD working party to conclude that further study is needed of the cost-efficiency and effectiveness of such policies[lxxxiii].

Payment for eco-system services

Work in Colombia, Costa Rica and Nicaragua funded by the UN Global Environmental Facility clearly demonstrated the effectiveness of modest payments made directly to farmers for environmental services – in this case by adopting integrated silvo-pastoral grazing systems[lxxxiv, lxxxv].

"The environmental benefits associated with the project include a 71% increase in carbon sequestration, increases in bird, bat and butterfly species and a moderate increase in forested area. Milk production and farm income also increased by more than 10 and 115% respectively. Herbicide use dropped by 60%, and the practice of using fire to manage pasture is now less frequent." [lxxxvi]

Environmental Stewardship in the UK is an agri-environment plan that offers payments to farmers and land managers for effective land management to protect and enhance the environment and wildlife[lxxxvii]. It offers several levels of participation depending on the extent of the environmental serves to be provided.

On the other hand the effectiveness of payments for ecosystem services and of protection measures may be overestimated, since they support the conservation of areas that may not be under pressure of land use conversion. Evaluating the application such payments in the context of road access, infrastructure and topography can bring considerable refinement[lxxxviii].

i) International agreements and protocols

Evolving trade rules are a major instrument to drive industries and governments to strengthen their management of environmental issues. Although environmental issues are not currently subject to the Sanitary and Phytosanitary (SPS) rules of the World Trade Organization (WTO), the WTO Trade and Environment Committee has considered a proposal to establish "border tax adjustments to address competitiveness and leakage issues that may develop" as some countries fail to take sufficiently stringent measures to deal with green house gas emissions[lxxxix]. It is reasonable to expect that environmental impacts of food production sector could be the subject of similar proposals in the future. Where environmental and health safety issues are not yet fully defined, future rules will require much work and transparency of evidence. Thus while WTO SPS disciplines can be effectively applied for issues such as anti-microbial or pesticide residues that affect health or food safety, costly disputes have arisen when the evidence for harm was contentious, as in the cases of growth promoting hormones and genetically modified organisms (GMOs).

In support of the United Nations Framework Convention on Climate Change the Inter-American Institute for Cooperation on Agriculture (IICA) is working to summarize knowledge and experience regarding climate change in Latin America and the Caribbean[xc] and is assisting eight countries in Central America to prepare for international negotiations on biodiversity, biosafety and climate change[xci].

Other international environmental accords that require action by the agriculture and fisheries sectors are the Cartagena biosafety protocol for GMOs, the Stockholm Convention on Persistent Organic Pollutants (including several pesticides), the Rotterdam Convention and its regime for Prior Informed Consent for trade in hazardous substances (including pesticides) and the Montreal Protocol for Ozone Depleting Substances (such as the fumigant methyl bromide).

j) Most issues require use of multiple tools

A 2011 OECD review cites the use by the Governments of the Netherlands[xcii] and Korea[xciii] of policies ranging from traditional regulations to incentives and market-based approaches and investments in technology to reduce pollution and energy use and identifies opportunities to reduce waste in the food chain through innovation, efficient resource use and investments through the supply chain including infrastructure[xciv].

The issue of antimicrobial resistance offers an example of the need for multiple approaches at local, national and international levels. Resistant microbes are beginning to have medical impacts. Agricultural use accounts for three quarter of antimicrobial use and is largely uncontrolled in much of the world. Meanwhile anti-microbial resistance has become a global concern[xcv]. The FAO, Codex Alimentarius, OIE and WHO have jointly developed international scientific guidance and standards[xcvi, xcvii] and the OIE recently announced a global conference on the issue to be held in March 2013[xcviii]. The WHO Global Principles[xcix] and the OIE International Standards on Antimicrobial Resistance[c] call for effective national controls on the licencing, manufacture, sale, distribution and use of antimicrobials in food producing animals as well as for monitoring of such usage and the resulting impacts. To meet these norms requires a range of measures including command and control regulations, formulation and adoption of prudent use guidelines and stewardship protocols for both veterinarians and producers. Monitoring should be performed for the emergence of resistant organisms, including a focus on concentrated livestock feeding operations[ci, cii]. Monitoring the use is also valuable as done in Europe by reporting antimicrobial sales in "mg/population corrected unit" (mg per live weight of all farm animals) for international benchmarking. This approach for use in humans revealed remarkable differences between European countries that correlated with resistance in human pathogens[ciii, civ].

ASSESSING AND EVALUATING IMPACTS OF POLICIES

The evaluation step of the policy cycle (Figure 1) is challenging but essential for success. The state of work at OECD is summarized in their Green Growth Studies Food and Agriculture report[cv]. Again the private sector is making a significant contribution, for example through the work of SAI work on indicators[cvi]. Food producers can expect ongoing pressures for documentation of life-cycle footprints as consumer and community awareness and expectations grow. The benefits and challenges of carbon foot-printing for the food value chain have been explored in a draft report from FAO[cvii] that echoes points made above regarding the need for credibility and to avoid a confusing proliferation of labels. To meet the need to reflect system-wide effects Gerbens-Leenes et al[cviii] developed a method to express the performance of a production system with three indicators: the total land, energy and water requirement per kilogram of available food.

In the case of regulations, a *Regulatory Impact Analysis*[cix] is recommended by OECD early in the process to define anticipated benefits as well as the economic and social business and consumer impacts. Periodic evaluations may then be needed once measures have been implemented.

Building capacity in the fields of behavioural economics[cx], social psychology and communications will help to understand what measures are effective in motivating primary producers and others in the value chain, including consumers, to invest in environmentally friendly practices and products. This will vary greatly in different settings thus requiring context-specific studies. Lessons could perhaps be learned from experiences with programmes to reduce smoking and improve fitness in many countries.

CONCLUSIONS AND RECOMMENDATIONS

The focus of national leaders on Rio +20 offers an opportunity to take steps that will increase the productivity and reduce the ecological footprints of food production. These should include measures to:

1. Improve policies to support green food production by i) eliminating environmentally harmful subsidies, ii) rewarding ecosystem services and environmentally friendly food production practices and iii) linking these policies to trade[cxi] as conditions that should be required as new trade agreements are negotiated.
2. Improve capacity to monitor and evaluate progress and impacts with refined indicators ranging from very specific (e.g. anti-microbial usage) to broad indices of land, water and energy footprints. Improved transparency will help – by providing the public with information on the use of agricultural chemicals, the release of pollutants and the sectors' footprint indicators. Given their importance, the adequacy of systems for monitoring and evaluation warrants ongoing attention from national Auditors General.
3. Support funding for applied research and development specifically for inter-disciplinary teams and networks; ensure a focus on emerging issues through science policy dialogues; and strengthen science/policy linkages through new mechanisms of science governance to deliver timely, pertinent advice to decision makers.
4. Share knowledge and lessons learned amongst countries and sectors and promote North-South and South-South partnerships to build sustainability and innovation[cxii].
5. Engage and support small holders – for example to meet national or private standards through adequate knowledge, technologies and incentives – to facilitate equitable market access. Access to such certification systems at reasonable cost may actually be a prime candidate for subsidies, if environmental BMPs are to spread.
6. Take advantage of new developments in: i) private sector/NGO cooperation, ii) eco-footprint analysis, iii) social media and iv) traceability using mobile information technology to links consumers to sustainability and eco-footprint information.

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