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SHAPING AGRICULTURAL POLICIES IN THE ANTHROPOCENE ERA: WHAT CAN WE LEARN FROM THE DPSIR FRAMEWORK?

Guillaume Lhermie

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SUMMARY

The global agricultural sector often doesn't get the attention it deserves, usually because of its secondary economic importance and because no major structural shifts in demand for agricultural commodities are expected. However, there is considerable variation between high-income and developing countries.

If the world is to meet the UN's Sustainable Development Goals, seven of which are closely related to agriculture, then the effects of agricultural production on local cultures, societies and environments need careful consideration. Applying the driver-pressure-state-impact-response (DPSIR) framework helps in understanding interactions between actors and sectors, and overall in better designing agricultural policies.

The DPSIR framework is a holistic approach to policy created by the European Environment Agency that facilitates the identification and description of processes and interactions in human-environmental systems. DPSIR recognizes agriculture as being multi-functional. The agricultural sector not only produces food, it also provides ecosystem services like pollination, pest control, soil conservation and biodiversity.

Drivers such as food production, recreation and tourism, fulfil human needs but put pressure on the environment. Pressures are physical changes in the environment in response to drivers. These can range from land-use shifts to disease outbreaks to climate change.

States are the sum of societal, economic and environmental functions measured with indicators. Measurements include a vast range of factors, including air and water quality, as well as job security, human well-being and agricultural production. Impacts are a direct result of changes in state for both the economy (e.g., employment, income, prices) and the environment (e.g., environmental damage, emissions, land improvement).

Responses are intended to modify outcomes by changing human actions and mitigating undesirable results. Responses could be anything from reforming agricultural policies to designating protected areas to restricting emissions.

DPSIR's main tenet is that human societies and nature are interdependent. Since agriculture involves externalities associated with production and consumption, it's important for policy-makers to adopt a systemic approach.

DPSIR doesn't directly consider ethics and equity. Some agricultural externalities are not constrained by borders and others affect future generations, so these factors must also be taken into account. Reliable, shared metrics must be carefully chosen and publicly available data are necessary to evaluate program outcomes.

INTRODUCTION

AGRICULTURAL ECONOMY

Agriculture is usually regarded as a secondary economic player in the 21st century, regardless of the country. Based on data from the last decade gathered by the Organisation for Economic Co-operation and Development (OECD), agricultural gross domestic product (GDP) contributes to a small fraction of national GDP (Figure 1). For example, in Canada, agriculture accounts for 1.7 per cent of GDP, with limited variation over the last few years.

Forecasts from the OECD and the Food and Agriculture Organization (FAO) of the United Nations predict that the relative importance of food, feed and biofuel use will not change significantly on a global basis over the coming decade (FAO 2020). A burgeoning global population remains the major influencing factor and no major structural shifts in demand for agricultural commodities are expected. However, these global factsheets hide tremendous variation among countries, with the OECD/FAO forecasting a shift towards increased consumption of poultry, fish and vegetables in high-income countries, as health and environmental concerns drive consumption patterns. In contrast, in middle-income countries, consumers are expected to transform their diets from staples to animal products. The Outlook report assumes an intensification of livestock production and aquaculture, combined with improvements in feed efficiency. Consequently, feed consumption will continue to increase due to ongoing expansion of food animal production in low- and middle-income countries.

AGRICULTURAL EXTERNALITIES

As any other economic sector producing outputs, agriculture uses natural resources, some renewable, e.g., fisheries and forests, and others that are non-renewable, e.g., groundwater or fossil energy sources. Consequently, the primary function of agriculture, producing food, requires using and transforming raw materials up to an optimal point where the marginal costs of inputs equalize the marginal benefits of outputs. Yet, production processes are not independent of externalities, which are indirect consequences, for which the burden is borne by the society as a whole or by individuals, but not implied in the private production or the consumption of the good. Greenhouse gases (GHG) are the most obvious example of externality. The same Outlook states that OECD projects that direct GHG emissions will grow by six per cent compared to the current level. Here again, there are regional disparities, with emerging and low-income regions having higher output growth in livestock production systems that are inherently more emission intensive. In 2017, Canada accounted for approximately 1.5 per cent of global GHG emissions, of which agriculture contributed approximately eight per cent, as it has over the last decade (Environment and Climate Change Canada 2021).

AGRICULTURE AND SUSTAINABLE DEVELOPMENT

In 2015, the United Nations unanimously adopted sustainable development goals (SDG), as part of the 2030 Agenda for Sustainable Development. The 2020 SDG report documents progress made since 2015 and concludes a moderate and heterogeneous success (United Nations 2021). Some gains in education, in access to water and decreased incidence of some communicable diseases contrast with increasing food insecurity, steady environmental deterioration and a critical level of food waste.

It is noteworthy that at least seven of the 17 SDGs emphasized by the UN (1, 2, 6, 8, 12, 13 and 15) are closely related to agriculture (crops and terrestrial animals), to eradicate poverty and hunger, address climate change and enable economic recovery, particularly after the COVID-19 pandemic. There is an urgent need to design and implement rapidly actionable agricultural policies that: (i) allow us to meet the SDG; and (ii) account for local parameters, spanning from culture or history, to availabilities of natural and human resources. A preliminary step is analyzing which kind of responses policies are intended to trigger. To do so, we propose to adapt the so-called driver-pressure-state-impact-response (DPSIR) framework to agriculture.

APPLYING THE DPSIR TO DESIGN AGRICULTURAL POLICIES

The DPSIR framework is a holistic approach to policy developed by the European Environment Agency (EEA 1999). It has been widely applied in ecosystem assessments due to its usefulness for describing relationships between causes and effects of environmental problems (Balzan et al. 2019; Bell 2012; EEA 1999; Maxim et al. 2009; Spangenberg et al. 2015)environmental indicators have become indispensable to policy-makers. However, it is becoming more and more difficult for policy-makers to grab the relevance and meaning of the existing environmental indicators, given the number and diversity of indicators presently in use. And new sets of environmental indicators are still to be expected. Therefore, some means of structuring and analysing indicators and related environment/society inter-connections is needed. The purpose of this paper is to introduce the EEA Typology of indicators and the DPSIR framework (Driving forces, Pressure, State, Impact, Response. This framework, which facilitates identification and description of processes and interactions in human-environmental systems, is a practical tool promoting comprehension and communication among scholars, stakeholders and policy-makers.

A key concept is the multi-functionality of agriculture. It is critical to recognize that environmental, cultural and social services all affect human well-being (Vanbergen et al. 2020)thereby undermining the natural foundations on which agriculture is itself built. Averting the worst effects of global environmental change and assuring ecosystem benefits, requires a transformation of agriculture. Alternative agricultural systems to conventional intensification exist, ranging from adjustments to efficiency (e.g. sustainable intensification. Agricultural areas not only produce food, but they also provide other ecosystem services, including pest control, pollination, soil conservation, biodiversity and carbon sequestration. Furthermore, sustainable agricultural development is not only closely related to economic development, but it is also an issue of human survival. The COVID-19 pandemic yielded new insights regarding the importance of food in high-income countries. Supply chain disruptions and retail food shortages challenged consumer confidence and comfort. Agriculture is relatively more dependent than other industries on natural resources; consequently, climate and environmental factors contribute to the quantity and quality of agricultural outputs.

Although the concept of ecosystem services was at first purely ecology-oriented and designed for valuation of natural and semi-natural ecosystems, the 2003 Millennium Ecosystem Assessment widened the concept toward socioeconomic aspects by integrating cultivated and urban areas. However, its bias toward the environmental dimension may hinder its use for valuating land use changes in the context of sustainable development, as it addresses social and economic issues only indirectly as a consequence of environmental changes. While detailing the DPSIR framework, we seek to define drivers of agricultural activities, their consequences (negative and positive) on ecosystems and societies' well-being and how policies will affect the agricultural social-ecological system.

DRIVERS

Drivers are the processes and anthropogenic activities that fulfil basic human needs, leading to pressures on the environment. Population growth increases demands for food, competition for land and other natural resources. The more people have access to affordable food, the more they shift towards high-protein, low-fibre diets. In addition, other human activities, including recreation, tourism, international trade and regulations are also drivers of agricultural activities, as is climate change (Zhou et al. 2013).

PRESSURES

Pressures are directly linked to human activities from drivers, triggering changes in state. State needs to be understood here as a physical state. Pressures associated with agricultural activities arise from various origins. Some are directly linked to land use change, e.g., intensity of grazing, cropping, rural desertification and landscape homogenization, whereas others are related to policies, particularly when they are not co-ordinated. Additional sources of pressure arise, e.g., presence of diseases affecting crops or animals, or climate variations, the latter being both a driver and a pressure of agricultural activities. Furthermore, other pressures will influence the state of agricultural systems, which cannot be directed or managed within the agricultural sector. For example, global warming, human use of arable lands or water consumption all consist of unmanaged pressures at the boundaries of the agricultural system, as they result from an aggregate of human activities, most not directly related to agriculture (Oesterwind et al. 2016)their causes, and environmental assessments emerged in recent years. Often authors use non-uniform and inconsistent definitions of key terms like driver, threats, pressures etc. Although all of these studies clearly define causal dependencies between the interacting socio-economic and environmental systems in an understandable way, still an overall imprecise wording could induce misunderstanding at higher policy levels when it comes to integrated ecosystems assessments. Therefore we recommend using unified definitions for a better communication between science and management within national, regional and international environmental policies, for example the European Marine Strategy Framework Directive (MSFD.

STATES

States can be defined through societal, economic and environmental functions measured with indicators. To assess the state of the environmental portion of the system, relevant processes should be considered, with consideration given to retaining the following indicators: biodiversity index, land use index, air and water quality index, eco-environmental quality index, plant coverage index and fertilizer productivity. Socioeconomic indicators, developed on individual or regional scales, include job security, job location, human well-being, level of infrastructure and of course provision of agriculture for production activities.

IMPACTS

Impacts are a direct translation of changes in the state. Impact indicators may consist of rural economy, employment level, incomes, consumption levels and commodity prices. On the environmental side, this could be an improvement or a degradation of land, water quality, biodiversity and GHG emissions. It is noteworthy that the previous indicators are all related to the multi-functionality of agricultural activities and the ecosystem-based services they provide (Gregory et al. 2013).

RESPONSES

Responses are intended to modify various outcomes of the model by implanting human actions set by individuals or organizations. Responses may seek to modify drivers, e.g., reform of an agricultural policy or regulation of prices, tariffs or quotas. Responses designed to relieve pressures may include promoting virtuous environmental agricultural practices, incentivizing a type of production or adopting a new technology. Actions may be taken to protect or enhance the state by setting environmental targets and allowing economic agents to trade within the market. Policy-makers may designate protected areas or provide targeted income support. Last, responses can mitigate undesirable impacts. Examples of policies consist of insurance programs, incentives for emissions control or provision of alternative revenue sources for affected people.

POLICY IMPLICATIONS AND CHALLENGES IN POLICY DESIGN

The use of the DPSIR model integrating ecosystemic services facilitates anticipating the effects of policies and their impacts on the social-ecological system. In this regard, the notion that human societies and nature are interdependent is fundamental. Anthropic activities affect ecosystem dynamics, which in turn affect humans' well-being (Oteros-Rozas et al. 2019)previous work has mostly focused on one or the other. Here, we apply such a holistic approach to depicting the global food panorama through a quantitative multivariate assessment of 43 indicators of food sovereignty and 28 indicators of sociodemographics, social being, and environmental sustainability in 150 countries. The results identify 5 world regions and indicate the existence of an agrifood debt (i.e., disequilibria between regions in the natural resources consumed, the environmental impacts produced, and the social wellbeing attained by populations that play different roles within the globalized agrifood system. It is important for policy-makers to adopt a systemic approach, especially with policies aimed at externalities associated with production or consumption processes, which are frequently the case with agricultural policies. Any policy will involve trade-offs; consequently, a potential gain on one side of the system can generate distortions on another side.

Two important policy implications, not directly considered in the model, are ethics and equity. Use of resources and pollution emissions raises concern around environmental justice, property rights' allocations and liabilities. These concerns need to be considered in a spatial dimension, as many externalities do not have borders, and in a temporal dimension, which in the human scale means transgenerational. Although beyond the scope of this article, policy-makers need to take them into account (Gupta et al. 2020)in doing so, social justice or equity issues tend to come as an afterthought, while there is evidence that environmental challenges and policy responses are not equity (including gender-.

Last, although this model is a very useful tool to describe the complex and sometimes unintended effects of policies, it needs to be accompanied by ex ante or ex post quantitative analyses, measuring their effects. To that end, two major challenges arise. The first is the choice of the metrics (Bockstaller et al. 2015). An important issue in assessing sustainability of practices is a reliable, shared metric, which will be consistently used over time. Because the states of the social-ecological system generally evolve relatively slowly, this is a critical point to monitor any policy effect. A closely related and crucial issue is data availability. Publicly available data, collected by government bodies or private organizations, are necessary to accurately evaluate program outcomes. Policy design and implementation need to be accompanied by policy evaluation, and indicators for evaluation of outcomes need to be determined in advance, thereby ensuring transparency, both for persons affected by the policy and also decision-makers.

Figure 1: Ratio of agricultural GDP over total GDP in per cent (2015), in function of the GDP per capita. Source OECD.

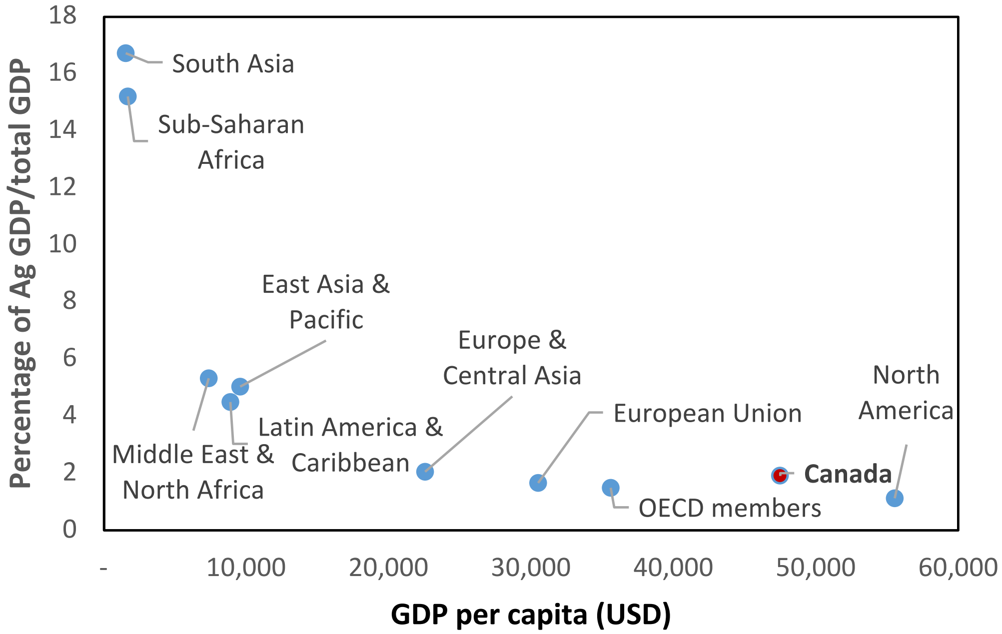

Figure 2: Driver-Pressure-State-Impact-Response (DPSIR) Framework Adapted to Agriculture

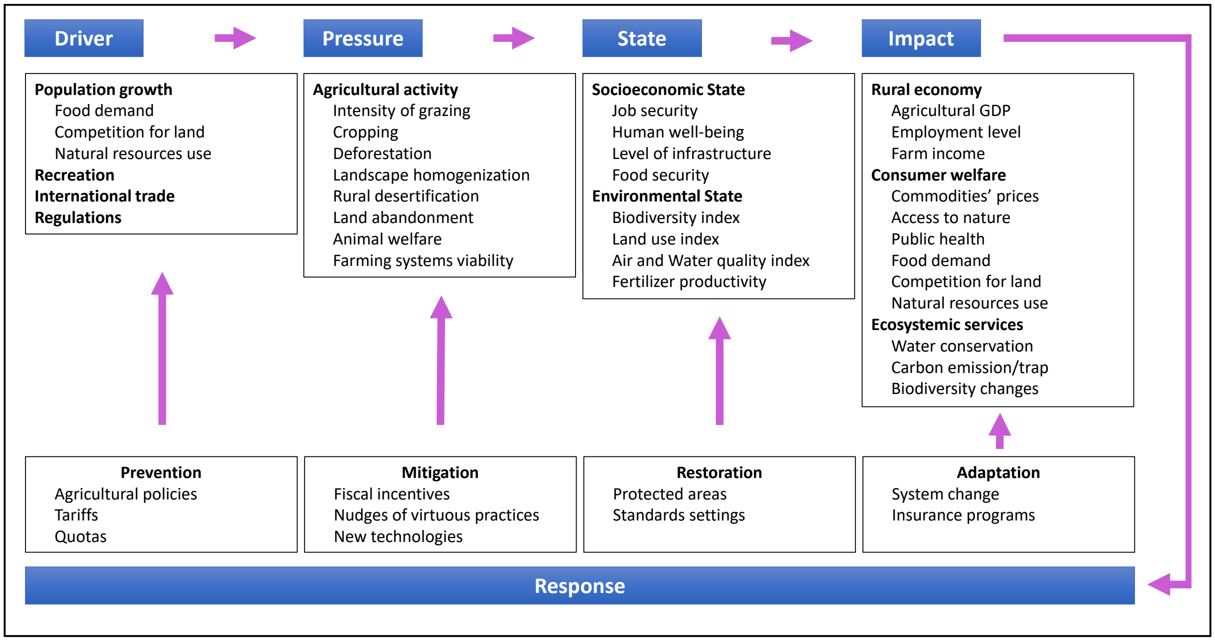

Table: List of the UN's 17 Sustainable Development Goals; those in bold are directly related to agriculture.

The 17 UN Sustainable Development Goals
GOAL 1: No Poverty
GOAL 2: Zero Hunger
GOAL 3: Good Health and Well-being
GOAL 4: Quality Education
GOAL 5: Gender Equality
GOAL 6: Clean Water and Sanitation
GOAL 7: Affordable and Clean Energy
GOAL 8: Decent Work and Economic Growth
GOAL 9: Industry, Innovation and Infrastructure
GOAL 10: Reduced Inequality
GOAL 11: Sustainable Cities and Communities
GOAL 12: Responsible Consumption and Production
GOAL 13: Climate Action
GOAL 14: Life Below Water
GOAL 15: Life on Land
GOAL 16: Peace and Justice Strong Institutions
GOAL 17: Partnerships to Achieve the Goal

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Guillaume Lhermie joined the University of Calgary from the University of Toulouse, where he was Associate Professor in Animal Health and Veterinary Public Health Economics. He also held an Adjunct Assistant Professor position at Cornell University. A veterinarian by training, he also holds an MSc in Economics and a PhD in Pharmaco-epidemiology and Innovation.

Dr. Lhermie's research interests include Planetary Health and Infectious Diseases challenges, the economics of antimicrobial use and resistance at the farm, supply chains, and global levels, and sustainability challenges. He serves as an expert in animal health economics for international organizations, national agencies and NGOs. Dr. Lhermie strives to inform policymakers, helping them to design sound, resilient policies.

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