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Catalan agriculture and genetically modified organisms (GMOs) — An application of DPSIR model

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ABSTRACT

Although there is a strong controversy regarding the introduction and commercialisation of genetically modified organisms (GMOs) in Europe, GM maize has been sown in Spain since 1998. Stakeholders' positions on the role that GMOs play in trends of the state of agriculture and environment in Catalonia are analysed. The application of the Driving forces –Pressures – State – Impact – Responses (DPSIR) framework in this case study highlights its potential for organising and structuring information. However, the model can be ambiguous when used as an analytical tool in value-laden complex situations. Thus, GM agriculture is sometimes seen as a pressure on the agro-environment and sometimes as a modernising response to an economic and environmental crisis. A redefinition of the DPSIR categories is proposed, aiming to reflect on these situations by better acknowledging different legitimate perspectives and narratives. This is done, on the one hand, by allowing alternative descriptions of causal chains and, on the other hand, by taking into consideration social and political aspects besides the relationship between economics and environmental spheres.

1. Introduction

Introduction and commercialisation of GMOs have generated huge controversy in Europe. On the one hand, proponents claim far-reaching societal benefits of GMOs and see in this technology the key for improving competitiveness and promoting economic growth (European Commission, 2002) or yielding agri-environmental benefits, specially for farmers (see e.g. Carpenter et al., 2002). On the other hand, opponents challenge the potential benefits and raise questions on the purposes and uncertainties related to the environmental and social impacts of this technology, as well as their social distribution (Altieri, 2005; Carr and Levidow, 2000; Schubert, 2002).

Despite this controversy in Europe, GM maize has been widely cultivated in Spain since 1998. But maize is the only GM crop with a commercial licence in the EU. It is grown in Spain (75.000 ha), particularly in Aragon and Catalonia, and in very small amounts in other European countries. In the Catalan province of Lleida GM maize represents more than 60% of the total maize surface. At the same time, the organic agriculture sector is also growing in importance (CCPAE, 2005), except for maize (Binimelis, 2008a,b).

Introduction of agricultural GMOs has not been accompanied by public deliberation in Spain. Just recently, the discussion on the coexistence between GM crops and organic and conventional agriculture has raised issues on the current and future state of the agricultural sector in Catalonia and on the technical measures to be applied for avoiding unwanted presence of GM material in the conventional and organic production. This debate has been characterised by difficulties between the different stakeholders (public administration, conventional and organic farmers, farmers growing GM crops, environmental groups, business representatives) to establish a dialogue on how issues can be framed and what the concerns to take into account are (Binimelis, 2008b). The lack of transparency and understanding of each others' positions contributes to the conflict.

The DPSIR model has been used by the European Environment Agency (EEA) and EUROSTAT as a communication tool to structure information about the interactions between society and the environment. In particular, it has been widely applied for organising systems of indicators and statistics in relation to a policy aim. It is grounded in the assumption of the existence of causal relationships between the different components of the system: the Driving Forces, i.e. the underlying social and economic developments, induce Pressures on the environment and, as a consequence, the State changes. These changes in the condition of the environment can have Impacts on humans or the environment, which may cause societal Responses. For its simplicity, it is widely emphasized as an interdisciplinary communication tool between researchers and also between researchers and policy makers and stakeholders (see e.g. Gabrielsen and Bosch, 2003).

This potential, however, has recently been questioned (e.g. Maxim, this issue; Svarstad et al., 2007), arguing that the DPSIR framework has

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deficits as a tool for good communication due to its incapability to deal with multiple perspectives and definitions. For instance, in Svarstad et al. (2007), attention is drawn to the "strong realist view on knowledge behind the DPSIR", implying that the understandings of the environmental issues are narrowly presented as scientific truths, omitting different understandings of controversial issues. Finally, it is argued for the need to critically apply the DPSIR framework in specific cases, establishing a methodology that helps to incorporate perspectives and definitions of the problem stated by different stakeholders.

The aim of this paper is to critically apply the DPSIR model to the assessment of the agri-environmental situation in Catalonia, with special emphasis on the role played by GMOs. This is done through the implementation of the DPSIR definition developed within the ALARM project (see Maxim et al., this issue[1]). The application of the DPSIR model in this case, on the one hand helps in organising the information and, on the other, makes visible the differences in positions among stakeholders. It allows discussing the application of DPSIR schemes under conditions of uncertainty, in which a variety of narratives are present.

1.1. GM and organic agriculture as indicators — a literature review

A literature review discloses different approaches when considering GMO-based agricultural systems and organic agriculture within the DPSIR scheme. They differ both in the definition of the DPSIR categories themselves and in the interpretation of its significance in relation to the objective of the study. For a complete review of the use of indicators for assessing the role played by GMOs in the environment and agriculture, see Brauner et al. (2002).

The European Environment Agency (EEA) was initially including, in its reporting on the state of environment, the area planted with GMOs as an indicator (AGRI12). Although it was not formally classified in the DPSIR system, this indicator was related to structural, technological and management changes in the agricultural sector, which are associated to driving forces (Petersen, 2003). Use of GMOs has been also included as a driving force indicator by other authors. Hansen et al. (2002) classify it as a driving force indicator in their analysis and assessment of food safety using the DPSIR scheme. Notice that Hansen et al. (2002) target food safety while the purpose of EEA indicator scheme is to assess the state of the European environment. The demarcation of the object of study implies, in this case, the limitation of driving forces to three types of processes: the use of determinate compounds such as GMOs or the application of N; the use of technology and the structural developments of agricultural production, processing and marketing.

Other reports conceive the introduction of GMOs as a pressure. For instance, the OECD included "the introduction of new genetic material and species" as an environmental pressure indicator related to the theme "biodiversity and landscape" in its first "Core Set of Indicators for Environmental Performance Reviews" (OECD (1993), quoted in Brauner et al. (2002)). Other cases are the national environmental indicators in Italy, South Africa or Australia. This is consistent with the strict biosafety schemes (which include GMOs and invasive species) implemented by these countries. For instance, in Italy the issue is introduced through counting the area devoted to experimenting with GMOs in agriculture, considered as a pressure indicator (Mammoliti Mochet et al., 2003). In the case of South Africa, the indicator — distribution and abundance of GMOs invading natural systems— relates GMOs to their invasive potential. However, it is included as a dormant indicator, as it is considered that there is lack of data or knowledge in order to calculate it accurately (Le Maitre et al., 2002). Pressures are defined in the report as processes exerted on resources and ecosystems as a result of human activities (i.e. driving forces), including consumption and waste generation patterns and trends. For Australia, different types of indicators are proposed in relation with GMOs. Distribution and abundance of GMOs is included as a pressure indicator while control of exotic, alien and GMOs is also incorporated as response indicator (Saunders et al., 1998). Pressure is defined in this work as the human activities that affect the environment (note that the category "driving forces" was not included in the Australian report) while responses are characterized as the number of objectives settled and actions taken by humans to address perceived environmental problems or potential problems. Similarly, the United Nations Commission on Sustainable Development, on its turn, elaborated a series of indicators for sustainable development in line with the Agenda 21 process. The environmental sound management of biotechnology included both R&D expenditure on biotechnology and the existence of national biosafety regulations as response indicators under the D–S–R scheme.

Organic agriculture is also a relevant subject in this discussion. The area used for organic farming is included in the core set of indicators of the EEA. This is classified as a response indicator following the DPSIR model (EEA, 2005a). In the working definition of organic agriculture the contraposition of the use of GMOs to the organic production system "which puts a strong emphasis on environmental protection and animal welfare by reducing or eliminating the use of GMOs and synthetic chemical inputs" is explicitly mentioned (EEA, 2005b). Meanwhile, in the analysis done by Zalidis et al. (2004) to assess EU agri-environmental measures effectiveness, area planted with organic agriculture is included as an indicator of the main driving force, which in this case is agriculture.

This article is organised as follows. The next section characterises the Catalan maize sector and the current state of GMOs crops and organic farming. Then, the methodology of this case study is explained. The fourth section presents and discusses main results of the paper by organising the information on the agro-environmental stakeholders' assessment following the DPSIR scheme. The final section summarizes the findings and examines their implications on the present case study for policy-making.

2. The Catalan maize sector

This paper analyses the agri-environmental state of Catalan agriculture focusing on the role exerted by GMOs. This case study takes place in one of the European areas with more percentage of GMOs sown at a commercial scale. Its relevance is rooted in the fact that this situation has generated, on the one hand, an opportunity to reflect on what agricultural system is desired and what are the implications for biodiversity while, on the other hand, this deliberation has also allowed rethinking the scientific model and its relation to policy-making (science–policy interfaces). The notion of the GMOs themselves as threats (e.g. by conceiving them as biological invasions (Ewel et al., 1999; McNeely, 2001; Williamson, 1993)) or as positive responses to biodiversity loss will be here placed in the core of the discussion.

In Spain the introduction of GM maize took place in 1998, when five varieties with the modification Bt-176 and eleven of Mon810 were placed in the Register for Commercial Varieties. Both modifications were developed for insect resistance (especially targeting the European and Mediterranean corn borers: *Ostrinia nubilalis* and *Sesamia nonagrioides*). Since then, the number of available varieties has increased up to 61 in 2007. Farmers' acceptance of GM maize has been mixed in Spain. The GM surface represents about 14.5% of the total area sown with maize in 2007 (MAPA, 2007). The highest concentration of GM maize is in the North-East of Spain (Aragon and Catalonia).

Maize production is an important agricultural activity in Catalonia, mostly related to the meat industry. It is especially concentrated in the province of Lleida, a leading European region involved in livestock

[1] For other examples of the implementation of these definitions to specific case studies, see Rodriguez-Labajos et al. (this issue), Kuldna et al. (this issue), and Omann et al. (this issue).

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raising. With more than 2.5 million pigs, it heads Spanish production on feed and fodder with 27,000 ha cultivated with maize —of which around 15,000 were GM maize in 2006 (DARP, 2006). The area concentrates most of the agrarian activity in Catalonia, representing 12.1% of the employed population, while this percentage is only 2.3% for the whole region. However, the number of agrarian farms is diminishing, favouring land concentration (IDESCAT, 2003). Moreover, Spain imports maize from the largest GM maize producers, Argentina, Brasil and USA (MAPA, 2008). These imports are presumed to have a high content of GMOs (European Commission, 2005). The biotech sector is also growing in importance in Catalonia. About one hundred biotechnological companies are located in Catalonia. Moreover, the project to develop a "Catalan Bioregion" intends to favour the creation of 60 biotechnology companies, with over 1500 direct employments by year 2010 (ASEBIO, 2005). It should be noted that most of them are engaged in biomedicine. Still, it must be acknowledged that their presence could perhaps contribute to create an economic and political climate in favour of biotechnology in general.

Regarding the area sown with organic maize in Spain, there are limited data available. The Spanish Ministry of Agriculture has only published the figure for the total amount of cereals and legumes: 100,860 ha in 2003 (MAPA, 2004). However, Brookes and Barfoot (2003) estimated the area of organic maize in Spain to be about 1000 ha. Finally, the use of non-hybrid maize varieties supposes around 1% of the total maize seeds in Spain (no data for Catalonia) (MAPA, 2008).

3. Methodology of the case study

Research included a review of the official information available (including European Commission's press releases and communications, legislative documents and technical reports) as well as documents produced by other stakeholders. The second part of the study is based on field research in the province of Lleida, which started in 2002. Its aim is to consider stakeholders' viewpoints at the local level. To collect this information, qualitative techniques including workshops, group and individual in-depth interviews, as well as participant observation are used. Up to the end of 2006, 21 farmers, 6 managers of agricultural cooperatives and 3 agricultural engineers working in the local government's extension service were interviewed in the field.

In a third phase, other stakeholders, relevant at the policy level in relation to GMOs, agriculture and biodiversity conservation in Catalonia were targeted. It consisted of 18 semi-structured interviews and a quantitative questionnaire. The questionnaire included 35 statements that the respondents had to rank from 1 (totally disagree) to 4 (totally agree) designed to reinforce that stakeholders position themselves on issues related to the conception of GMOs, the potential risks and benefits associated with them and the coexistence between GM and non-GM, with emphasis in the biodiversity aspects[2]. Semi-structured interviews were divided in three thematic sections. The first one dealt with stakeholders' perception on the state of agricultural environment, while the second was on the information and communication linked to the GMOs issue in Catalonia. The third one included questions on the coexistence normative proposal.

The results of this paper show mainly the findings on the first section of the questionnaire, in which questions targeting the different elements (driving forces, pressures, state, impacts and responses) of DPSIR model were included. Discourse analysis was performed to elicit stakeholders' narratives. Discourse analysis is understood here as a way to understand a shared system of knowledge or belief and the social practices in which it is produced, "through which meaning is given to physical and social realities" (Hajer, 1995, p. 44).

[2] Some statements were based on a previous research conducted by Kvakkestad et al. (2007); others were specific for this case study.

Stakeholders for the third part were selected among politicians and public administrators, representatives from agricultural unions, experts from the genetic engineering and organic agriculture fields, as well as environmental and consumers' organisations. All of them were interviewed as representatives of their institutions. During the interview, participants were asked to list relevant stakeholders that should participate in the debate according to their point of view. In doing so, internal consistency in the selection of stakeholders was checked so as to ensure representation of the relevant perspectives. The different participants were asked, at the end of the interview, to position the institution they represent on the use of GMOs in agriculture.

Qualitative research usually takes into account that expressions of the interviewees should be interpreted according to the context, because it is possible that one interviewee wants to make public a speech or attitude in a context, but change them when it is in another context. While this is true, in the present article the interviews have been used to classify discourses on the main trends on the state of the agro-environment and also to build up a rich typology of driving forces, and it does not matter whether one particular interviewee would change his/her statements in a different context. Thus, a civil servant might admit in private that norms regulating distances between GM and non-GM fields are impossible to apply while in public he would be reluctant to do so. What matters is that both opinions are found in society.

4. The DPSIR framework applied to the agroenvironmental state of the Catalan agriculture — special emphasis on GMOs

In this section, stakeholders and their positions are characterised. Second, information from the case study is organised according to the DPSIR model.

4.1. Stakeholders

The list of the 18 participant stakeholders is in Table 1. They are characterised and grouped following their own description of their work and their relation to the agro-environmental state of Catalonia, with a special focus on GMOs and biodiversity. A third column shows the position that stakeholders declare themselves to have towards the use of GMOs in agriculture.

From the analysis of stakeholders' opinions regarding the use of GMOs in agriculture, several positions can be identified. Positive reactions can be observed in stakeholders directly involved in GMOs development and commercialisation while negative responses are linked with those stakeholders involved in social movements (NGOs, consumer associations), one of the farmers union and organic agriculture. Researchers related to biotechnology research position themselves as neutral. Finally, others decided not to position themselves clearly, appealing to the strong conflicts on this issue.

In spite of the different positions on agricultural GMOs as a broad scientific and social issue, when analysing their perceptions of the role that GMOs play in the Catalan agriculture, only two groups are evidenced. The first group includes stakeholders related to organic agriculture, the farmers unions, the consumers' organisation, environmental and development NGOs and the Green Party representative. The second is integrated by the genetic engineers, the spokesperson of an agribusiness company and the Catalan agriculture department.

4.2. Catalonia's agriculture crisis under the light of DPSIR

In this section, data collected from in-depth interviews and questionnaires is organised following the DPSIR model. The assessment of the state of agriculture in Catalonia — and the role played by GMOs — is done for the present time, although stakeholders were also asked to make projections for short and medium time.

Table 1
Participant stakeholders

Stakeholder[a]	Description	Position
Agrarian Cooperatives Federation	Two agricultural engineers working as technicians. The Federation groups more than 60% of the agrarian cooperatives in Catalonia, representing around 85% of the Catalan production	It is an available technology. Risks should be assessed as in any technology
Agribusiness company representative	Genetic and agricultural engineer, spokesperson of a major company selling GM seeds in Spain	Positive for GMOs
Agricultural engineer (1)	Organic agriculture engineer developing and conserving local varieties	Against GMOs
Agricultural engineer (2)	University professor and researcher, specialist in extensive crops	No position
Catalan agriculture department technicians	Two agricultural engineers working as technicians in the rural innovation unit, in charge of technology transfer	Observer
Consumers' organisation technician	Environmental scientist, technician of the environmental department of a consumers' organisation	Against GMOs due to precautionary principle
Development NGOs technician	Technician working in the Catalan Development NGOs Federation, campaigner of the food sovereignty programme.	Against GMOs
Environmental organisation spokesperson	Biologist, representative of an international environmental NGO in Catalonia	Negative for GMOs, very critical
Farmers union representative (1)	Maize farmer, member of the executive board of the union (representing 75% of Catalan farmers). Spokesperson on food security and quality	Against GMOs
Farmers union technician (2)	Technician agricultural engineer, working for the second most representative union in Catalonia	There is not enough experience and information concerning this technology
Green Party representative	Biologist, member of the Catalan Parliament representing the left-wing green party, which is in the Catalan government	GMOs refusal
International NGO member	Agronomist, working in an international NGO promoting sustainable management and use of agricultural biodiversity based on people's control and local knowledge	Against GMOs
Molecular biologist	Biologist and geneticist researching in an institution depending on the Spanish government	Neutral
Organic agriculture certification body representative	Director and technician of the organic agriculture certification body. It is a public body depending on the Catalan government	For the no existence of GMOs due to the difficulties in coexisting with organic agriculture in Catalonia
Public research institution on agricultural technology	Biotechnologist working in the development of new GM varieties and research related to pollen flow (coexistence) in a research institution depending on the Catalan government	We should not disregard the advantages that can be provided by this technology

[a] In light of the conflict that surrounds GMOs, the use of proper and institution names is avoided to ensure privacy of participant stakeholders.

4.2.1. State of crisis

The starting point of this research was the description made by stakeholders on the state of the agroenvironment in Catalonia, focusing on the role played by GMOs. The state is defined here, following Maxim et al. (this issue), as the quantity of biological (such as biodiversity erosion), physical (i.e. landscape fragmentation, decreasing number of farms) and chemical phenomena (i.e. pollution) chosen by stakeholders to describe the risks of not desirable agri-environmental changes in Catalonia.

The generalised characterisation of the Catalan agriculture was as in a state of crisis. All interviewed stakeholders coincided in this statement, with only small differences depending on the agricultural sector but concurring in the general assessment. The results among policy level relevant stakeholders fully coincide with previous research among farmers.

All stakeholders agreed in labelling conventional agriculture as highly polluting due to the high use of synthetic inputs or the agricultural oil dependency. The characterisation of agriculture as a source of pollution is strongly linked with slurry from pigs, which is considered a main agro-environmental issue in Catalonia. Following this narrative, conventional agriculture is unanimously described as being currently unsustainable. Other sides of this description are the overall characterisation of the farmers' situation, described as “desperate”, “discouraged”, “without an easy solution” due to low economic profitability. These circumstances lead to a diminishing number of farms and agricultural land in actual use, which is also considered as a threat for agricultural biodiversity and landscape conservation. It is interesting that nobody feels responsible for this situation, partly because most of the driving forces are considered by most stakeholders as external or even given.

Regarding maize production, all stakeholders coincide in recognising the growing importance of GM seeds. This situation, as it will be discussed, is assessed differently by the diverse stakeholders. Areas planted with GMOs have been continuously increasing since its introduction in 1998. In that sense, stakeholders have also referred to the dependency of Catalan agro-industry on imported animal feed and fodder which, in the case of maize and soy, are mostly GM. Another shared view regarding GMOs highlights power concentration in agribusiness companies, including access to patenting. The role of organic agriculture is characterised as still minor, but growing in importance. This general trend is not being followed by the Catalan organic maize production, which has diminished by 95% from 2002 (when the first analyses to detect GMOs presence were done) to 2008 (Binimelis, 2008a). It is seen with high concern by some stakeholders, especially those linked with organic sector (Binimelis, 2008b).

In spite of the overall coincidences, the group of stakeholders which is prone to the use of GMOs includes in the description of the state the consequences of the lack of implementation of the potential for modernisation — and specially biotechnology — which is seen as a promising technology for mitigating the environmental impacts of high input agricultural systems. A second difference in the description of the state is the inclusion by GMOs opponents of genetic contamination in the characterisation of pollution. This concept is used for referring to the unwanted process that transgenes from GM crops to other organisms and become established in natural or agricultural ecosystems (McAfee, 2003; Walters, 2004; Verhoog, 2007; Binimelis, 2004). It opens the possibility to cause direct effects to biodiversity by affecting non-target species or relatives through unintentionally transferring their traits of the GMOs. This contested statement and its implications will be discussed below.

4.2.2. Driving forces

Driving forces are changes in the social, economic and institutional systems, which are triggering directly and indirectly pressures on the environmental state of agriculture (Maxim et al., this issue). Focus is placed in the discussion on the role played by GMOs. Four non-hierarchical but interacting levels of driving forces can be distinguished (Rodríguez-Labajos et al., this issue), influencing the structure and relation between the social, economic, political and environmental systems. Socio-economic activities directly linked with the pressures are “primary driving forces”. They correspond to the level of management. Primary driving forces are considered to be more flexible in the

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short term than the "secondary driving forces", the policy level. In the long term and with a broader spatial sphere of influence there is the level of "tertiary driving forces", ideology and lifestyle. Finally, the "base driving forces" include fundamental trends, such as demographic or cultural, that are only influenced by social decisions in the long term. A characterisation of the main driving forces influencing the current agro-environmental state and linked with GMO introduction is presented in Table 2, after stakeholders' perceptions.

Changes in the cultural system, linked to demographic and socio-economic factors, are considered important basic driving forces by the interviewed stakeholders. Internal migratory movements from the countryside to urban areas have lead to the depopulation of permanent inhabitants in rural areas. This trend is reverted only temporarily, associated with the holiday periods or when temporary workers arrive to the rural areas. Moreover, out migration of rural young population translates in the ageing of rural population. The process has led to a "de-linkage" between most of the population and the rural areas and therefore, the agricultural practices. Following it, most stakeholders argue that agriculture has lost social importance and has been relegated to a secondary sphere in public policies.

Regarding tertiary driving forces, there was an agreement pointing out to globalisation of economies and trade as major driving forces. Consumption patterns are internationalised as the demand for imported products is increasing (e.g. maize and soybeans as commodities). Changes in consumption patterns are also mentioned at a local scale, as there is an increasing demand for the so-called "environmentally-friendly", "traditional" and "healthier" food. Also changes in knowledge, information and technological progress are referred to. The production-oriented model of agriculture and the changes in the social and cultural system have driven agriculture to specialisation (e.g. integration model in animal farms) and technification. This process, which started in Spain during the 1960s[3], occurs along the food chain: from hybrid seed varieties and imported animal races to processing at the final stages. GMO proponents include also among the tertiary driving forces the so-called "risk adversity" behaviour of agrobiotechnology opponents.

Table 2
Driving forces of the present agro-environmental state in Catalonia

Level	Description/indicators
Basic driving forces	Demographic factors
	Socio-political factors
	Economic factors
	Scientific and technological factors
	Cultural factors
Tertiary driving forces: ideology and lifestyle	Global trends
	Globalisation of economies and trade
	Globalisation of consumption patterns: increasing demand for imported products
	Consumption patterns
	Intensification of the demand for more environmental-friendly and traditional foods
	Changes in the cultural system
	De-linkage between rural and urban populations and lifestyles
	Loss of agriculture's social importance
	Knowledge information and technological progress
	Change of the demand for new technological developments in agriculture
Secondary driving forces: policy level	Common Agricultural Policy
	Subsidies linked to production
	International treaties, laws and regulations
	Free trade agreements
	Land use policy
	Changes in land use policies in favour of urbanisation and tourism
	Hydrological policy: shifts from dry to irrigated land
	Environmental policy
	Regulations on food security and quality
	Changes in chemical policy
	Research policy
	Promotion of research in biotechnology
Primary driving forces: management level	Changes in agricultural practices
	Increasing importance of input and technological-intensive agriculture
	Abandonment of arable land
	Land use practices
	Increasing land concentration
	Intensification of urbanisation
	Changes in landscape planning
	Trade
	Increasing number of import products
	Tourism
	Increasing flow of tourists into rural areas
	Technological transfer practices
	Low level of public technological transfer in agriculture

Secondary driving forces are linked to policy developments. Common Agricultural Policy (CAP) is pointed out as the major driving force, linked to subsidies geared to increase production. Besides CAP subsidies, increase of area sown with maize is related to hydrological policy and the conversion of dry to irrigated land, resulting in land concentration. Finally, maize internal production is also related to international treaties, laws and regulations, especially connected with maize quota agreements. Other cited land use policies are the changes in favour of urbanisation, related to second residences and tourist activities, competing with agricultural uses.

In regard to environmental policies, interviewed stakeholders not linked with the organic sector refer to the environmental and safety regulations as an obstacle for competing in the global market. For instance, obligations within the REACH policy (European registration, evaluation and authorization of chemicals system) to substitute actual commonly used broad spectrum herbicides linked to maize production were mentioned. Driving forces related to the research policy have also been pointed out. Most stakeholders identify Catalan research policy related to agronomy as oriented towards the implementation of biotechnology in agriculture, although some disagreements exist regarding this issue.

Primary driving forces are those at the management level. Management is defined here as policy enforcement but also to refer to those processes derived from shared practices. They are mostly linked with the implementation of agricultural policies. Stakeholders refer to intensification of agriculture linked to the production-oriented policy. The process of modernisation comes along with the promotion of technology and an input intensive agricultural model. Changes in land use practices are also important. Abandonment of arable land due to demographic and socio-economic grounds is stated. This abandonment, together with new land irrigation policies, has driven to a decreasing number of farms. In fact, only those farms with more than 100 ha have grown in Catalonia (IDESCAT, 2003). This is also connected with urbanisation patterns and changes in landscape planning, as the promotion of rural areas as tourism destinations. Finally, lack of public technological extension is also brought up by some of the interviewed persons.

4.2.3. Pressures on the state of the agro-environment

Adjusting the definitions used in Maxim et al. (this issue) to this case study, pressures are defined here as the consequences of the implementation of an agricultural model which are perceived by stakeholders as having the potential to produce changes in the state of the agro-environment leading or contributing to impacts. Although stakeholders share their views concerning the description of most of the driving forces, differences can be found regarding their perceptions on what are the pressures related to GMOs on the agro-environmental state.

[3] In the period of 1960s and 1970s the farming modernisation in Spain starts. The agrarian surface in Spain was reoriented to feed and fodder crops, such as maize. Moreover, during the 60s the importation policy began — through a Decree authorising importations — for this type of commodities (Domínguez-Martín, 2001).

The first group argues that GMOs represent a negative pressure for the agro-environmental state, as they worsen the environmental and social impacts of the present production model. This technology is discussed as representing a uniquely rapid increase in intensification (e.g. Watkinson et al., 2000). Moreover, it is argued that this process damages integrity of organic and conventional agriculture and the seed system. This point is connected with the reflection on uncertainty and irreversibility of the process. In that sense, GMOs are ranked, in the quantitative questionnaire, as contributing to a decrease of agrobiodiversity. Factors influencing this, according to stakeholders, encompass administration support to biotechnology research and introduction of GMOs, lack of social debate, pressures by agribusiness companies and deficiencies in communication mechanisms.

The second group assesses the introduction of GM maize, as it will be discussed below, as a positive response to the crisis, while characterising GMOs refusal as being a negative pressure. These stakeholders argue that there exists a technical compatibility between GM crops and organic and conventional farming as not substantial differences can be found between them. Concerning the potential of GM crops to pose risks to biodiversity, no consensus is found within the group. However, a general statement is that the introduction of new GM varieties results, to a greater or lesser extent, in an increment of the agricultural biodiversity, enhancing also the contribution of biotechnology for sustainability. From that point of view, the concept of contamination should be neglected as it implies a pejorative quality of GMOs.

4.2.4. Impacts

Impacts are changes in the environmental functions, affecting the social, economic and environmental dimensions, and which are caused by changes in the state of the agrobiodiversity, as examined by Maxim et al. (this issue). As we have already discussed, pressure characterisation varies among stakeholders. These differences in perceptions are subsequently linked to the definitions on impacts. Therefore, the two groups distinguished above maintain their differences when discussing the impacts.

The first group of stakeholders agrees in considering the so-called genetic contamination as a major impact on biodiversity exerted by the introduction of GM maize. Stakeholders within this group have argued that this could have implications from environmental, agronomics, economics and socials points of view, raising questions on food safety, integrity of organic agriculture and the seed system or concerning consumer's rights. The concept of genetic contamination is linked to both conventional and organic farming. However, as price for conventional and GM maize is not differentiated, and labelling regulations[4] leave a threshold for adventitious presence of GM traces, only few cases concerning conventional agriculture have been reported by farmers. On the contrary, most organic farmers and consumers reject the presence of GM material in organic products, which was prohibited in organic products by the European organic agriculture and farming legislation (Regulation 2092/91/EEC)[5] and discarded by the International Federation of Organic Agriculture Movements (IFOAM) and the Codex Alimentarius[6].

The second group of stakeholders starts from the basis that GM varieties presently sown in the area have been approved and thus, risk assessment has been conducted, among others, by the European Food Safety Agency. From this point of view, GM varieties are considered as safe as conventional ones or even safer as they have gone through more exhaustive risk assessments. Another important agreement within this group is to conceive genetic engineering as a continuation of conventional plant breeding, which can increase control and predictability of the expressed traits. Therefore, the concept of contamination is rejected and the cases in which unwanted presence of GM material have been found become only a matter of economic dispute, since organic production suffers diminishing economic profit. Finally, stakeholders classified in the second group bring up the opportunity costs of not using agro-biotechnology as an impact derived from the rejection of GMOs. In that sense, it is difficult to compete in the global market with basic products such as conventional maize.

4.2.5. Responses

Responses are defined as policy actions which are directly or indirectly triggered by the perception of impacts and which attempts to prevent, eliminate, compensate or reduce their consequences. All stakeholders have concurred in targeting the so-called “quality agriculture”. In that sense, the highly fragmented Catalan agricultural landscape is seen at present as a factor for the loss of competitiveness in the global market but it is also considered to have a future potential. This fragmented landscape, together with a highly variable topography and climatic conditions, are the basis for differentiated quality agriculture. However, the definition of quality is a matter of disagreement. On the one hand, the first group argues that quality would represent an organic agriculture-based model — which would exclude GMOs —, with a much higher share in the use of local seed varieties and direct selling mechanisms. On the other hand, the second group agrees in assessing the introduction of GM maize as a positive response towards achieving quality, obtaining a more competitive and environmentally-friendly agriculture, e.g. using less pesticides. In that sense, it is argued that an abolishment of restrictive legislation for GMO commercialisation, which burdens the producers, would contribute to enhance also competitiveness in global markets.

5. Discussion

As it has been developed, the role played by GMOs in the agro-environmental state of Catalonia can be described using alternative narratives or frames. Our results show that, on the one hand, different descriptions of the problem are possible, as different frames of the policy-objective exist. These empirical results coincide with previous studies on contending European agri-environment discourses, which categorized them as “eco-efficient” in the case of GMO proponents and “apocalyptic” for the case of opponents. A third discourse, “managerialist” has not been clearly identified in the case study (Levidow and Carr, 2007). It is important here to note that discourses are a shared way to reflect on a phenomena and their description always entails a reduction of the multiple views which are representing. In fact, the debate on GMOs has been characterised by confrontation at the societal level, but also by low consensus on the scientific issues and the analytical methods to be applied (Busch et al., 2004). The existence of different narratives depends on complex and value-laden considerations, shaped by interests embedded in different cultural, ethical and socio-economic context. Educational background seems to have also an influence in these contested perceptions among experts (Kvakkestad et al., 2007).

In spite of this, current definitions of the DPSIR framework (i.e. the ones used by the EEA (2005c)) establish the need for a scientific causal proof of the relationship between pressures and the impacts perceived in the socio-economic system, relying on a strong realistic view of knowledge. The establishment of the causal link between the different DPSIR categories is not only depending on the world-view, as it has been discussed, but it is also a function of the state of knowledge, the consideration on uncertainty for policy-making, the agreement on the

[4] Labelling thresholds were established in 0.9% for authorised modifications of each ingredient contained by the product (Regulation (EC) No 1830/2003).

[5] A new regulation, (CE) 834/2007, has been recently approved, which has to be implemented after the 1st of January 2009. It is explicitly allowing a 0.9% presence of GMOs in organic production.

[6] The Codex Alimentarius was created in 1963 by the Food and Agriculture Organisation and the World Health Organisation. It is a mechanism under international law on agreements which allows the parties — practically all of the countries involved in international trade of agricultural products — to document their mutual understanding of requirements for foodstuffs.

demarcation of the specific system of interest which is under analysis and the scale to be considered (Maxim et al., this issue). In that sense, the framing and objective of the analysis, the assessment of the significance of the impacts, the selection of indicators or aspects such as the weighting factors cannot only be decided from a scientific perspective, but are politically-motivated "as each indicator system is generally based either explicitly or implicitly on a defined objective specifying the direction in which reality is to change" (Brauner et al., 2002).

6. Conclusion

In this article the DPSIR model was used to organise information on the state of agro-environment in Catalonia, focusing on stakeholders' perceptions on the role that GMOs play in the agro-environmental system. Results show that the application of this framework allows displaying the available information, as well as to make explicit the different stakeholders' positions.

EEA DPSIR definition is based in causal relationships between the different components of the system in a mechanistic way. This could result in a communication deficit (Svarstad et al., 2007) when applied to complex situations, which are characterised by non-linearity, in which not all the relevant information is available or indeterminacy in framing the issue that exists. Definitions proposed by ALARM (see Maxim et al., this issue) try to overcome some of these shortcomings, allowing to incorporate contested discourses. Differences in conceptualising the same issue — the introduction of GMOs in agriculture — can lead to diverse policy actions. Broadening the scope of DPSIR definitions combining the 4 spheres of the sustainability frame could allow for the incorporation of multiple causalities and more complete descriptions of the system as well as to incorporate socio-political aspects to the analysis (Maxim et al., this issue). In this way, different discourses can be produced on the basis of an examination of the stakeholders' narratives, contributing to a more transparent and inclusive use of the DPSIR framework. However, transparency does not lead necessarily to conflict resolution.

Thus, defining the introduction of GMOs as a pressure or as a response could bring together an entirely different agricultural model orientation, originating also differences regarding regulatory actions, research expenditure, changes in management strategies or actions by public opinions. Making this information more transparent could help to improve the debate but also to sharpen it, by bringing into the open the underlying coincidences and differences. Also, recognising and making explicit complexity and uncertainty would help to improve the decision-making process by incorporating all legitimate perspectives into the analysis.

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