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The Role of Biotechnology in Sustainable Agriculture: Views and Perceptions among Key Actors in the Swedish Food Supply Chain

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Abstract: Researchers have put forward agricultural biotechnology as one possible tool for increasing food production and making agriculture more sustainable. In this paper, it is investigated how key actors in the Swedish food supply chain perceive the concept of agricultural sustainability and the role of biotechnology in creating more sustainable agricultural production systems. Based on policy documents and semi-structured interviews with representatives of five organizations active in producing, processing and retailing food in Sweden, an attempt is made to answer the following three questions: How do key actors in the Swedish food supply chain define and operationalize the concept of agricultural sustainability? Who/what influences these organizations' sustainability policies and their respective positions on agricultural biotechnology? What are the organizations' views and perceptions of biotechnology and its possible role in creating agricultural sustainability? Based on collected data, it is concluded that, although there is a shared view of the core constituents of agricultural sustainability among the organizations, there is less explicit

consensus on how the concept should be put into practice or what role biotechnology can play in furthering agricultural sustainability.

Keywords: agricultural sustainability; biotechnology; sustainability policy; food production systems; environment; Sweden

1. Introduction

Researchers have put forward agricultural biotechnology, that is “any technique that uses living organisms or substances from these organisms to make or modify a product” [1] (p. 8), as a tool for increasing food production, while, at the same time, making agriculture more sustainable from an environmental point of view [2]. Research suggests that genetic engineering can be used to develop crop varieties that cope better with drought and salinity [3,4]; are more disease resistant [5,6]; and use nutrients more efficiently. These features are particularly desirable in a changing climate where the population grows and competition over arable land increases. However, agricultural biotechnology is a controversial topic, and not everyone is convinced that the net benefits of genetically-modified (GM) varieties will be positive overall. Critics point to the ecological and health risks involved and to the negative impacts of GM varieties on small-scale traditional farming, especially in the global South [7–9]. Thus, the current debate over agricultural biotechnology, especially GMOs (genetically-modified organisms), is framed in strongly dichotomous terms: biotechnology is considered either an important part of or a severe threat to the effort to create sustainable agricultural production systems.

To be able to assess the potential sustainability implications of biotechnology, a closer look into the sustainability concept and its definition and application is necessary. According to the received view, agricultural sustainability deals with the maintenance of agricultural production systems over time [10,11], but further detailing of the concept has been widely discussed [12–16]. No single agreed-on definition of agricultural sustainability exists today; instead, there is a variety of definitions in academic and policy discussions [17,18].

The diversity of meanings attached to the concept of agricultural sustainability has led some authors to argue that it is an essentially contested concept [19–22]. This means that it is a normative concept with two levels of meaning. The first level expresses a number of core ideas, which are substantive and non-redundant in the sense that even if actors have very different views on how the concept should be interpreted, they can still agree that in some situations, the conditions for agricultural sustainability are not present [23]. At the second level of meaning are a number of different conceptions, that is there are, “legitimate, yet incompatible and contested, interpretations of how the concept should be put into practice” [24] (p. 262), [25,26]. This means that, even if people agree about the core of the concept, there is considerable disagreement concerning how the concept ought to be implemented. One such point of disagreement concerns the role of biotechnology in creating sustainable agricultural production systems.

In this paper, it is investigated how key actors in the Swedish food supply chain understand and operationalize the concept of agricultural sustainability (sustainable agricultural food production systems) and what influence this may have on their views of agricultural biotechnology and its role in

creating sustainable agricultural production systems. Five actors participate in the study: The Federation of Swedish Farmers (Lantbrukarnas riksförbund, LRF), Lantmännen, ICA, Axfood and Coop. Based on policy documents and semi-structured interviews with representatives from the selected organizations, an attempt is made to answer the following questions:

- How does the organization perceive the concept of agricultural sustainability (sustainable agricultural production systems)?
- Who/what influences the organization's sustainability policies, including the organization's standpoint on agricultural biotechnology?
- What are the organization's views and perceptions of biotechnology and its possible role in creating agricultural sustainability?

Based on the empirical data, it is argued that, although there is no single agreed-on definition of agricultural sustainability, there is a shared understanding among key actors in the Swedish food supply chain of what the key constituents of agricultural sustainability are. At the same time, however, there is less explicit consensus on how the concept should be put into practice or what role biotechnology has in creating sustainable agricultural production systems. The open-ended character of the concept of agricultural sustainability provides an opportunity for various actors to make their favored sustainability discourse the dominant one in the general sustainability debate. The interview data suggest that the current Swedish agricultural sustainability discourse has been influenced by consumer opinion and the views of strong environmental organizations.

Section 2 describes the methods used. Section 3 briefly summarizes the results of the desk-based review of the selected organizations' sustainability policies. In Sections 4–6, the three aforementioned research questions are discussed based on the studied sustainability policies and the interviews with the representatives of the selected organizations. Sections 7 and 8 comprises some conclusions and suggestions for further research.

From here on, the terms “agricultural sustainability” and “sustainable agricultural production systems” will be used interchangeably. However, it should be noted that “agricultural sustainability” is the more commonly-used term, and even though it targets the sustainability of the production systems, it may also be used in a wider sense, including additional elements within the food production chain.

2. Methods

The study is a desk-based review of policy documents of key actors in the Swedish food supply chain, that is actors that play a role in the organization of producing, processing and retailing food and that consequently have a significant impact on the actual (un)availability of genetically-modified foodstuff on the Swedish market. At an initial stage of the research, two groups of actors were selected from a preliminary survey of the organizations active in the Swedish food supply chain: (i) organizations either owned by Swedish farmers or with the primary objective of representing Swedish farmers' interests; and (ii) food retailers. The inclusion of these two groups of actors enabled a review of policies related to food production in Sweden, as well as policies related to the import of food [27].

Three farming organizations were identified: The Federation of Swedish Farmers (LRF), Lantmännen and Ekologiska lantbrukarna (Association of Organic Farmers). Since Ekologiska lantbrukarna has

organic farming as their main objective, which rules out the use of biotechnology, they were not selected for this study. LRF is a politically independent interest and business organization with around 170,000 individual members representing some 90,000 enterprises [28], including the larger part of both organic and conventional farms (<http://www.lrf.se>). The organization's overall mission is to improve farming and forestry businesses and enable individual members to achieve their goals in terms of profitability, growth and quality of life. Lantmännen is an agricultural cooperative that is owned by 33,500 Swedish farmers (<http://www.lantmannen.se>). The organization's core mission is to increase the economic profitability of its members and maximize their capital returns. Lantmännen buys, refines and sells farmers' produce, but it is also a retailer of agricultural commodities and machinery. Lantmännen is also involved in research and development, such as plant breeding.

Three companies were selected from the identified grocery retailers: ICA, Axfood and Coop. Taken together, these three retailers represent approximately 87 percent of the Swedish food retail market [29]. The ICA Group is Sweden's biggest food retailer. It runs around 2400 retail stores in five geographic markets with a 50 percent market share in Sweden (<http://www.ica.se>). Axfood's retail business mainly consists of entirely owned chains, but it also has franchise agreements (<http://www.axfood.se>). It represents around 16 percent of the food retail market in Sweden. Coop is a consumer cooperative with 3.3 million members conducting its business via entirely owned chains (<http://www.coop.se>). It has a market share of around 21 percent.

Published policy documents from the five organizations were downloaded and thoroughly examined. A number of strategies were discussed in order to identify what would be the most informative method to identify the selected organizations' views on the role of biotechnology in furthering agricultural sustainability. Based on the available policy documents and the discussions, semi-structured interviews with those responsible for sustainability issues within the selected organizations (typically the organization's head of sustainability/environmental department) were identified as the most effective method of data collection. Five respondents, one from each organization, were approached and agreed to represent the organizations' views on the identified research questions. Thus, a total of five interviews were conducted.

The interviews were performed between June and November 2013 and followed an interview template structured around three themes: the concept of agricultural sustainability, the role of biotechnology in creating sustainable agricultural production systems and the role of external actors in shaping the organizations' sustainability (including biotechnology) policies (Appendix). The template was sent out to the responsible personnel of each organization beforehand. All interviews took between 45 and 75 min and were transcribed and analyzed through repeated readings of statements.

3. Sustainability Policies of the Selected Organizations

None of the selected organizations has a policy explicitly dealing with agricultural sustainability. Instead, sustainability aspects related to agriculture are dealt with in the organizations' general sustainability policies/programs, codes of conduct, corporate social responsibility (CSR) policies and/or policies dealing with specific environmental aspects. In general, LRF's and Lantmännen's policies are more explicitly oriented towards the sustainability impacts of food and fodder production than the policies of the grocery retailers. The latter predominantly focus on the sustainability impacts of activities

associated with the distribution of food (carbon emissions from transport, energy consumption in food distribution premises, climate impacts from refrigerants, *etc.*). None of the surveyed policy documents contains any explicit definition of the concept of agricultural sustainability. Only LRF and Lantmännen have adopted policies on agricultural biotechnology. In the next sections, the results of the desk-based review and the interviews are summarized and analyzed, for each of the respondents.

3.1. Organizations Owned by the Swedish Farmers

3.1.1. LRF

As noted above, none of the selected organizations explicitly defines “agricultural sustainability” or “sustainable agricultural production systems” in their sustainability policy documents. However, in a publication entitled *Sustainability in Swedish Agriculture 2012*, written by Statistics Sweden (Statistiska centralbyrån, SCB) with the contribution of LRF among others, it is stated that:

Sustainable agriculture integrates three different aspects: environmental health, economic profitability and social and economic equity. Sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs. A sustainable agriculture conserves our natural resources, is adapted to the environment and is environmentally ethical. An economically and socially sustainable development in the countryside requires for instance that agriculture produces high quality food at reasonable prices to the consumer and provides the producers a reasonable income [30] (p. 8).

These three sustainability aspects are also referred to in LRF’s pesticide policy, in which the organization describes how reduced pesticide use and economic competitiveness and growth can be reconciled [31].

LRF has adopted a policy on biotechnology that consists of six core principles concerning sustainability, precaution and ethics, competitiveness, freedom of choice, labelling and transparency and responsibility [32]. LRF has a positive attitude towards using GMOs in agriculture if they contribute to an environmentally- and economically-sustainable development and do not affect human quality of life negatively [32]. According to LRF, the risks and benefits of GMOs should be assessed on a case-by-case basis, taking into account the long-term benefits for society, humans and human health, non-human animals and the environment. As an example of positive environmental impacts of GMOs, the policy document mentions decreased use of substances that pollute water or impact negatively on biological diversity or human health.

3.1.2. Lantmännen

Lantmännen’s Code of Conduct [33] contains statements on environmental and social sustainability. The Code specifies that Lantmännen should aim to decrease its emissions to air, land and water and make resource use (including energy use) more efficient. The organization should work to develop transport logistics solutions that optimize resource use, decrease environmental impact and increase safety. The Code also mentions social aspects, such as creating safe and healthy work environments

(including decent pay and a ban on child labor) and human rights protection (including a ban on discrimination and harassment).

Lantmännen's Code of Conduct contains a separate section on genetic engineering. Lantmännen has a positive view of biotechnology and explicitly acknowledges technology's potential to contribute to more sustainable societies. At the same time, the organization recognizes that there might be risks associated with biotechnology and that every application has to be thoroughly assessed before it is put to use. The Code stresses that biotechnology assessments should be guided by the precautionary principle and that consideration must be paid to the demands and expectations of customers, as well as to market conditions. Regarding food products on the European market, the Code prescribes that they must not contain any raw materials from genetically-modified crops. In relation to fodder, Lantmännen ensures that it "can deliver GMO-free raw materials for feeds and feed products according to customer requirements" [33] (p. 2).

3.2. Retailers

3.2.1. ICA

ICA's different CSR policies, for example the Business Ethics Policy, Quality, Environmental and Social Compliance Policy and Health Policy, cover environmental and social sustainability issues. ICA's most important environmental goals include reducing its greenhouse gas emissions, energy use and waste and safeguarding biological diversity [34]. ICA participates in the UN Global Compact initiative and is thus committed to supporting social sustainability goals, such as the protection of human rights, the freedom of association and the elimination of discrimination in employment.

ICA does not have a cohesive policy on biotechnology. However, the organization has a positive attitude towards new technology that can contribute to better products from a consumer perspective. For ethical and environmental reasons, ICA questions the production and cultivation of genetically-modified food and crops that are not produced in a closed environment. GMOs and ingredients should, in ICA's view, be stored separately and be traceable [34]. At present, there are no such products available in ICA's stores. In order for ICA to market such a product in the future, the product must have consumer benefits and be safe for humans and the environment. In line with the UN Global Compact initiative, ICA strives to "encourage the development and diffusion of *environmentally friendly technologies*" [35] (p. 6). The ICA Group management team makes decisions about which GM products, if any, should be included in ICA's assortment.

3.2.2. Axfood

Axfood has adopted a sustainability program that describes goals and strategies for the group's sustainability work [36]. The program outlines goals related to products, transport, energy and use of premises, suppliers, employees and animal welfare. Like ICA, Axfood has no cohesive policy on biotechnology, but from its webpage, one can read, "Genetic modification is a relatively new tool, and Axfood realizes that this technology may be helpful in certain contexts" (<http://www.axfood.se/en/Sustainability/How-we-work/Standpoints/>). At present, Axfood has no GM products in its stores. If

introduced, such products should be labelled in order for customers to be able to make informed choices about whether or not to purchase them.

3.2.3. Coop

Coop has adopted a policy on sustainable development that addresses the financial, environmental and social consequences of their business [37]. The policy is generic, but it is clear from Coop's most recent annual sustainability report [38] that organic and Fairtrade labelling play an important role in the implementation of the policy. Other parts of the sustainable development policy concern Coop's own energy consumption, transportation, use of premises, recycling and food wastes. Coop is also engaged in a continuous dialogue on sustainability issues with several NGOs, such as the World Wide Fund for Nature (WWF), Fairtrade, the Swedish Society for Nature Conservation (SSNC) and the Swedish organic labelling organization KRAV. Coop also participates in the UN Global Compact initiative.

Coop has no policy on biotechnology, but according to their website, the organization believes that GMOs might have negative environmental impacts in the long term, not least on biodiversity, and that cultivation of GM varieties could have negative socio-economic impacts on farmers at the mercy of the big multinational companies. Today, Coop does not sell any products with genetically-modified additives.

4. The Concept of Agricultural Sustainability

As noted above, with the possible exception of LRF, none of the selected organizations has adopted a clear definition of "agricultural sustainability" or "sustainable agricultural production systems" to guide their policy work. However, the empirical data obtained through readings of the policy documents and the interviews show that some themes are recurring in the organizations' sustainability discussions and, thus, could legitimately be said to be part of the core of the concept of agricultural sustainability as understood by key actors in the Swedish food supply chain. Three such themes, or core aspects, can be identified: a clear commitment to environmental protection, in particular emission reductions and increased resource efficiency; a commitment to securing intra- and inter-generational equity, that is meeting at least the basic needs of everyone today and in the future; and a realization that sustainability (or sustainable development) involves several dimensions, or areas of concern, that need to be integrated in all planning and decision-making concerning food production, processing and retailing (*cf.* [23,24]).

4.1. Environmental Protection

Reductions of emissions and increased resource efficiency are at the core of the selected organizations' sustainability policies. Several of the organizations have adopted targets concerning carbon emissions and energy consumption. One of ICA's key environmental goals is to reduce the group's direct greenhouse gas emissions by 30 percent by 2020 compared to 2006 [34]. Axfood [36] has adopted the goal to reduce its carbon footprint by 75 percent by 2020, and Coop [37] has adopted the target to minimize its direct and indirect climate impacts and to become "climate neutral" in the long run. In addition to emissions reductions goals and goals relating to increased resource efficiency,

some of the organizations have adopted goals concerning other aspects of the natural environment, such as biological diversity and animal welfare.

From the policy documents and the interviews, it is clear that the organizations focus on environmental aspects and goals that relate to their own core areas of activity. All of the grocery retailers have adopted goals concerning waste reduction and the reduction of energy consumption in their premises. For example, Axfood has adopted the goal to halve its climate impact from refrigerants by 2015 using 2009 as the base year, and Coop has adopted the goal to minimize its waste and to recycle as much as possible. In contrast, the farming organization LRF has adopted sustainability policies specifically targeting food production activities. Two examples of these policies are LRF's chemical pesticide policy [31] and LRF's policy on the discharge of sewage sludge [39].

4.2. Equity

When asked about whose interests the organizations are safeguarding or prioritizing in their sustainability work, several of the informants mention spatially- and/or temporally-distant people. Using resources efficiently is considered vital in satisfying the needs or interests of the present generation, but also in order to "be able to deliver raw materials to a growing (future) population" (Lantmännen), so that in the end, "everyone gets their share" (LRF). Two of the interviewed retailers specifically emphasize their efforts to support socially-sustainable production in supplier countries. Both ICA and Coop participate in the UN Global Compact initiative, and Coop is actively working to increase its sale of Fairtrade products [38].

The interview data suggests that sustainability (sustainable development) is primarily understood in anthropocentric terms. That is, the main rationale for protecting the natural environment is to safeguard equal opportunities for welfare among humans living in different spatial and temporal locations. The needs and interests of non-human animals are referred to in some of the organizations' policies; however, they are not at the heart of the organizations' sustainability policies.

4.3. Sustainability Dimensions and Prioritizations

All of the interviewed representatives acknowledge that the concept of agricultural sustainability has several dimensions that need to be integrated in the organizations' sustainability work. This is in line with academic discussions on the concept of agricultural sustainability that emphasize that agricultural production should not only be economically profitable and environmentally benign, but should also meet human needs for food and contribute to quality of life [14,17]. From the organizations' sustainability policy documents, it is clear that most of the goals that have been included in the policies concern either environmental or social aspects of sustainable development. However, as explained by the representative of Lantmännen, this is not surprising, since economic goals are a 'natural' part of the organizations' reason for being and, therefore, do not have to be included in their sustainability policies.

Although the informants agree that the concept of agricultural sustainability consists of different aspects (ecological, economic and social) that are all central to the idea of creating sustainable agricultural production systems, they give slightly different answers when asked to exemplify what falls under the (three) sustainability dimensions. For example, when asked about the social dimension

of agricultural sustainability, all informants agree that work environment issues, such as safety, pay and human rights issues, are central. These aspects are also included in the organizations' sustainability policies, but again, refer partly to different parts of the food supply chain. LRF states that making farming a viable means of sustenance is an important social goal, whereas Lantmännen and the retailers also include their own staff and suppliers not directly involved in agricultural production.

A central idea in the sustainability literature is that sustainability is situated at "the intersection of environmental protection, economic growth, and social justice" [40] (p. 72). Thus, it is assumed that the three sustainability dimensions are reconcilable, at least in principle. However, in actual planning and decision-making, compromises and trade-offs often have to be made between goals belonging to different sustainability dimensions. When asked about whether they could think of any conflicts between the various sustainability aspects, all informants answered affirmatively. An example of a goal conflict mentioned by ICA was climate change mitigation *versus* local production. For example, life-cycle assessments could show that from an emissions reductions perspective, it is better to buy a certain product from another country. However, buying from abroad would conflict with ICA's policy of purchasing products locally.

Even goals belonging to the same sustainability dimension could conflict with each other. The representative from Lantmännen mentions how in the treatment of sewage sludge, recycling of nutrients could conflict with the national environmental objective of a non-toxic environment. The representative from Axfood explains how different environmental goals concerning energy and water use in vegetable production could be in conflict depending on the climatic conditions in the production area.

When asked about whether the organizations prioritize any sustainability aspects or interests, the informants again gave somewhat different answers. ICA performs annual "heat-map" analyses, which structure sustainability questions and issues into four fields according to their perceived importance. Which issues are prioritized can differ from one year to the next. Among the issues ICA currently prioritizes are product safety, climate change and social responsibility (workplace safety, salary, *etc.*). They also emphasize this in their annual sustainability report [34]. Lantmännen considers all dimensions important, but acknowledges that because of the organization's historical focus on economic profitability at the farm level, the challenge today is to strengthen the environmental and social aspects of agricultural sustainability. LRF considers all aspects equally important in the short run, but emphasizes that over a longer-term perspective, the ecological aspects are the most important ones. The stated reason for this is that if we "saw off the branch we are sitting on, it does not really matter what we do with the money" (representative from LRF).

5. Factors Influencing the Organizations' Sustainability Policies

According to the interviewed representatives, both internal and external actors influence the organizations' sustainability policies and their present standpoints on biotechnology. Internally, the organizations' members, owners and officers (sustainability departments or departments responsible for CSR issues, *etc.*) have the opportunity to raise issues and initiate policy reforms, which the organizations' decision-making bodies then discuss. Among the external actors that have an influence on the studied organizations' sustainability policies are regulatory authorities at national and EU levels, consumers and consumer organizations, various NGOs (in particular environmental organizations) and

the general public. The exact extent to which these external actors are allowed to influence the policy process could not be measured in this study, but it is clear from the informants' answers that consumers and NGOs have particular influence on the organizations' policies, not least their policies or standpoints on biotechnology. This finding is in line with previous studies on the influence of environmental/consumer groups on EU GMO regulation and, in particular, how NGOs have been able to influence the market behavior of downstream producers in the EU [41].

The interview data show that internal actors, such as the organizations' sustainability departments, predominantly raise some sustainability issues. Axfood mentions the environmental impact of refrigerators as an example of a sustainability issue that the organization deals with internally, without initiation or involvement of any external actors. This is in comparison with, for example, the issue of palm oil production, which many Swedish consumers consider to be a controversial issue, since in many cases it involves indiscriminate forest clearing and gives rise to conflicts with local populations. In relation to palm oil, consumers have exerted significant pressure on the organizations to adopt certain standpoints.

Several of the interviewed representatives admit that their organizations are sensitive to campaigns from NGOs. This is particularly evident in the case of biotechnology. Coop, for example, states that the anti-GMO campaigns of the Swedish Society for Nature Conservation have been particularly successful. The interviewees also mention other NGOs, such as Greenpeace and various environmental labelling organizations. When asked about what concrete influence the NGOs have had on the organizations' sustainability and/or biotechnology policies/positions, the representative from Lantmännen emphasizes that:

In one way or another, NGOs do affect our policies. Obviously, we do not change any policies overnight as a consequence of different campaigns being directed at us, but the public debate and activities of this kind do affect our policies over time.

NGOs have also been actively involved in the development of some of the organizations' sustainability policies. For example, Coop asked for advice from NGOs when developing their certification policy for wild-caught and cultivated fish. As noted above, Coop is also engaged in a continuous sustainability dialogue with several NGOs, such as WWF, Fairtrade and the Swedish organic labelling organization, KRAV.

In addition to NGOs, all retailers emphasize the importance of the consumers' views in shaping their sustainability policies. ICA and Coop refer to customer polls conducted on a regular basis with the aim to get a better picture of consumer opinions. The results of these polls feed into the policy process in various ways. ICA, for example, uses the results from consumer polls when deciding what sustainability issues to prioritize as part of the organizations' annual "heat-map analysis". At present, biotechnology is not a prioritized policy area. Part of the reason for this is that the issue has received relatively little attention from ICA's customers, compared to other issues, such as palm oil production and consumption. This is in comparison with Coop, which considers biotechnology a topic of importance among both its members and customers, a stance that strongly affects its standpoint on GMOs.

When asked about what they believe are the biggest obstacles to including biotechnology as a part of the organizations' sustainability work, several informants point to public attitudes and consumer opinion in addition to the stringent regulatory framework in force. According to the representative

from ICA, “there is a built-in fear and skepticism toward biotechnology among many consumers”. In ICA’s view, skepticism among Swedish consumers is mainly grounded in environmental thinking and the activities of strong environmental organizations that oppose GMO. This can be contrasted with consumer opposition in the Baltic States (where ICA is also a major retailer), where GMOs are mainly opposed out of fear that large biotech companies and products will outcompete local production [42].

The interviewee from LRF also raised the issue of the public fear that large biotech companies will monopolize the market. He believes that the prevalent negative opinion of GMO is not so much about the technology itself, but rather has to do with the perception of how the big companies have acted and how patent rights have been granted in the past. One possible way of overcoming the present obstacles identified by the LRF representative is to initiate a more nuanced public discussion about the role of GM varieties in creating more sustainable agricultural production systems. This discussion should not be limited to discussions of the risks associated with GM varieties, but should also cover the potential environmental benefits involved.

6. The Role of Biotechnology

During the interviews, questions were asked about the organizations’ views on biotechnology in a broad sense, including non-transgenic techniques. However, the discussion often led into analyses of the pros and cons of GMOs specifically; this was especially the case with the retailers. There was a consensus among the interviewees that drawing up policies based on a distinction between GMOs and biotechnology broadly construed might be too complicated for the general public.

None of the representatives mentioned specific examples in which biotechnology could be a way of obtaining a more sustainable agricultural production system. However, LRF and Lantmännen are generally positive towards the possible use of biotechnology if the technology could contribute to more environmentally- and economically-sustainable agricultural systems. Crop traits should be considered on a case-by-case basis, taking risks and benefits into consideration. This is in line with the current debate on the need for increased, but sustainable, food production to meet the predicted future demands and the challenges imposed by climate change where a number of strategies have been suggested, among those the use of biotechnology [43,44]. Examples of important crop traits targeted with biotechnological methods in the coming decades include resistance to plant fungal and viral diseases, drought and heat tolerance, improved use of plant nutrients and healthier products from a dietary perspective [43].

Despite its potential, biotechnology is a highly controversial and politicized issue. It is either viewed as an important part of sustainable agricultural systems or a severe threat to such systems. Both LRF and Lantmännen explain that environmental organizations and other NGOs affect a company greatly via their publicity campaigns by communicating their concerns about biotechnology to the broader community, thus restricting some opportunities players in the food chain may take. At present, those organizations (environmental organizations and other NGOs) still view GMOs and related technologies negatively. ICA and Axfood acknowledge that biotechnology could be a useful tool in obtaining more sustainable food production. However, none of the companies have or plan to have GM products in their stores. The representative from Coop states that she does not predict a change in Coop’s view on biotechnology in the near future. This is due to NGOs’ influence and negative public

attitude toward GMOs. All retailers concur that they do not anticipate marketing GM products in the current situation, as the risk of a general non-acceptance from consumers remains too high.

7. Discussion

The interview data support the argument that the concept of agricultural sustainability is essentially contested. From the interviews, it is clear that, although “agricultural sustainability” lacks a formal definition, key actors in the Swedish food production chain have a shared understanding of the concept’s core constituents. Through the document review and the interviews, three such constituents could be identified: commitment to environmental protection, commitment to securing intra- and inter-generational equity and realization that agricultural sustainability involves several areas of concern that need to be integrated in decision-making concerning food production, processing and retailing.

Biotechnology can affect the sustainability of agricultural production systems depending on how the concept of agricultural sustainability is put into practice. According to some writers, biotechnology, including transgenic varieties, could make the world’s agricultural production systems less sustainable from an environmental point of view through, for example, gene spread or increased invasiveness. It could also make the world’s agricultural production systems socially less sustainable if the regulatory system that develops in parallel with the introduction of GM varieties prevents socioeconomic development among certain segments of the population [7]. However, biotechnology could also contribute to making our agricultural production systems more sustainable, for example by making nutrient use more efficient or by reducing the land area needed for agriculture [45]. These are very important aspects as competition over natural resources, including land, increases due to population growth and changes in climate. Arguably, there is nothing inherently or manifestly unsustainable about biotechnology; it all boils down to particular applications and the environmental, social and economic risks that those applications involve, as pointed out by some of the informants in this study. There is growing scientific evidence that, if put to use wisely, biotechnology can indeed yield significant environmental benefits [2].

The lack of precise action guidance provided by the concept of agricultural sustainability, for example in relation to the use of biotechnology, does not mean that the concept has no policy relevance at all [46]. However, it does make the concept vulnerable to ‘hi-jacking’ by actors who have an interest in instantiating the concept to correspond to their own political agendas, as discussed by Aerni [47] and Gunnarsson Östling *et al.* [48]. How the concept is put into practice and which sustainability discourse is prevalent at a particular point in time is largely the result of a struggle between different actors over the second-level meaning of the sustainability concept. The actors who are strong in the debate also have the opportunity to make their favored sustainability discourse the dominant one in planning, decision-making and the public debate.

The influence of external actors on the policy process and the resulting conceptualization of the sustainability concept are noticeable in our study. In Sweden, the dominant current discourse says that biotechnology is not part of sustainable agriculture, at least not when it comes to food for human consumption. This is clear from the policies of the organizations participating in this study. Although a majority of the interviewed organizations claim to have a positive attitude towards new technologies in general and admit that genetically-engineered crop traits ought to be assessed on a case-by-case basis,

they categorically reject food products containing GM-varieties in their present assortments. Thus, the perceived role of biotechnology in creating sustainable agricultural production systems is somewhat ambiguous.

The interview data suggest that the prevalent agricultural sustainability discourse has been largely shaped by consumer attitudes and pressure from strong environmental organizations. The sensitivity of anti-GM campaigns generally increases as one moves further down in the food supply chain from production to retailing. That is, among the organizations that participated in our study, LRF appeared to be the least sensitive and the food retailers the most sensitive to anti-GM campaigns. Lantmännen positioned themselves somewhere in between LRF and the food retailers. This may be because of how susceptible the organizations are to changes in consumer behavior (choice). Consumer behavior can change easily and rapidly, sometimes overnight, as a result of political campaigns and media coverage. Although they affect all actors in the food supply chain, these changes in consumer behavior have a much more direct impact on food retailers than on an organization like LRF.

Researchers tend to believe that consumer's attitudes concerning GMOs and the use of biotechnological methods in plant breeding are more negative in Europe than in the rest of the world. However, a recent meta-study of 214 studies [49] suggests that consumers' attitudes toward biotechnology in the EU (including Sweden) do not differ from other regions in the world. The common view that Europeans are more negative toward GMOs results from more negatively formulated questions and a greater focus on risks and ethics in the EU surveys. Whether real or perceived, consumer attitudes on biotechnology are important for the players within the Swedish food supply chain and largely determine whether the technologies will be allowed to play a major role in the development of more sustainable agricultural systems.

As acknowledged by some of the interviewed representatives, the current biotechnology discourse may lose ground if, for example, public opinion changes. As noted above, the current discourse is very much framed in terms of the risks involved in cultivating GM varieties. Other common themes in the Swedish public debate on biotechnology and GMOs are: the naturalness and moral permissibility of 'playing God'; health issues related to the consumption of GM foods; and the alleged greediness of large biotech companies. A more balanced debate on biotechnology and GMOs could possibly come about with the help of academia, as suggested by one informant:

Researchers and research institutions should be clear about the facts. Somebody like [interviewee refers to a well-known Swedish researcher] has publicly announced several times ... and the environmental movement listens to him, that biotechnology is needed if we are to meet the challenges ahead. He has written about it in his books, but this message has to be announced more clearly: 'look, these are the facts,' so that populist arguments will not gain the upper hand in the debate (Representative of Lantmännen).

8. Conclusions

The results from both the study of the policy documents and the in-depth interviews reveal some interesting insights on how actors in the Swedish food supply chain perceive the concept of agricultural sustainability and the role of biotechnology:

Although the concept of agricultural sustainability lacks a formal definition, key actors in the Swedish food production chain have a shared understanding of the concept's core constituents. Through the interviews and our document study, we were able to identify three such constituents: commitment to environmental protection, commitment to ensuring intra- and inter-generational equity and a realization that sustainability involves several dimensions that need to be integrated in planning and decision-making concerning food production, processing and retailing.

In the interviewed organizations' view, there is nothing 'inherently' or manifestly unsustainable about biotechnology (including GMOs) as such. Particular applications of the technology must be assessed individually, taking into account the environmental, social and economic risks involved. At the same time, however, they reject food products containing GM-varieties in their present assortments. The perceived role of biotechnology in creating sustainable agricultural production systems can therefore rightly be described as ambiguous.

The essentially contested nature of the concept of agricultural sustainability (*i.e.*, general agreement on the first-level meaning of agricultural sustainability, but less explicit consensus on how the concept should be put into practice, in particular what role biotechnology could play in creating sustainable agricultural production systems) renders the concept vulnerable to political 'hijacking'. In Sweden, the prevalent agricultural sustainability discourse, including the perceived role of biotechnology in creating sustainable agricultural production systems, has been shaped by consumer attitudes and pressure from strong environmental organizations to a significant extent. The sensitivity of anti-GM campaigns differs along the food production chain from production to retailing.

It is important to keep in mind that the aim of the present study was a modest one and that the collected empirical data are sparse. In the study, only a relatively small part of the food and retail market was covered. Among the actors that were not included in the study were large dairy and meat cooperatives/associations, such as Arla Foods and Swedish Meats. Moreover, the study focused exclusively on the Swedish market, which might differ from other European countries.

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Author Contributions

All authors participated in the design of the study, in analysis of the data, and in writing of the paper. Karin Edvardsson Björnberg and Håkan Marstorp conducted the interviews. An external person was hired to transcribe the interviews. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

Appendix: Interview Template

A1. Background

- a. What is your role/function within the organization?

A2. Design and implementation of sustainability policies

- a. Who initiates and designs the organization's policy documents concerning sustainability/sustainable development?
- b. What factors/actors affect the organization's sustainability policies?
- c. Does the organization prioritize any particular sustainability aspects/areas?
- d. How are the sustainability policy documents used in the organization's daily work? Please give some examples.

A3. The concept of agricultural sustainability/sustainable agricultural production systems

- a. How does the organization define the concept of agricultural sustainability/sustainable agricultural production systems?
- b. How (in the organization's view) do the sustainability dimensions (ecological, economic, or social) affect one another?
- c. Whose interests/needs should (in the organization's view) be given priority in creating agricultural sustainability/sustainable agricultural production systems?
- d. Are there any goal, interest, or value conflicts among the actors in the field? If yes, please give some examples.
- e. The global demand for agricultural products is expected to increase in the future due to population growth and changed consumption patterns. Is it possible to intensify agriculture while at the same time rendering agriculture more sustainable?

A4. The role of biotechnology

- a. Does the organization work with issues related to biotechnology?
- b. What is the organization's view on biotechnology (including but not limited to GMOs)?
- c. Could biotechnology be used to increase agricultural sustainability? If so, how?
- d. What are the potential risks and goal conflicts involved?
- e. Can those goal conflicts be overcome? If so, how?
- f. In the organization's view, is the attitude towards biotechnology and/or GMOs changing? If yes, in what direction?

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