Regulation of Agroecosystems: A Social Systems Analysis of Agroecology and Law

E.B. Noe and H.F. Alrøe

Abstract There are two main challenges for law and policy to foster a sustainable development of agri-food systems through regulation. The first challenge is that the regulation of a certain aspect often does not lead to the intended outcomes. Regulative measures can only perturb, disturb or irritate agroecosystems because they are self-organising and autopoietic systems. All regulation of autopoietic systems depends on self-regulation because it is the ability of the agroecosystem to observe the disturbance and its internal schema of logic that will define the reaction. The second challenge is that regulation of one aspect often leads to unforeseen and unwanted side effects regarding other aspects. These unintended effects call for more regulations to deal with them, leading to a paradoxical situation of an increasingly growing web of regulation and effects, a situation that is concretely reflected in the exponential growth rate of the amount of positive law on agriculture and environment. These challenges are amplified by the increasing complexity created by specialisations in science, law and farming practice, a complexity that cannot be dealt with by further specialisation. In this chapter, we argue, based on social systems theory, that there is a need for a second-order platform of agroecological regulation where different scientific and law perspectives can meet and communicate about sustainable development and regulation of agroecosystems. But it requires that each perspective acknowledges its own blind spots and acknowledges that the agroecosystem can be seen from many other perspectives.

Keywords Agri-food systems • Perspectivism • Polyocular framework • Second-order science • Sustainability

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1 Introduction

In the last 30 years, there has been an increasing focus on agri-environmental policy and regulation to support a sustainable development of agri-food production systems, and the growth rate of positive law on agriculture and environmental regulation has been exponential.[1] The sustainability focus not only is on safe and healthy food production but also includes a range of other concerns like protection of environment and nature, biodiversity, landscape, rural livelihood and food sovereignty. Different approaches have been followed to deal with these issues, like multifunctionality, cross-compliance, voluntary measures, organic agriculture, etc. Despite these attempts, law and policy are increasingly being challenged in fostering sustainable development of agri-food production, and there is a need for a more holistic and integrative approach to deal with policy and regulation of the area of agro food systems and thereby a need for better interaction and transdisciplinarity between law and agroecology.[2] Agroecology is globally seen as a concept that can host such a holistic effort,[3] especially among the Latin American scholars.[4] In this chapter, we will address the challenges and potentials of using the notion of agroecology as a platform for holistic agri-environmental policy and regulation from a social science perspective, or more specifically a social systems theoretical perspective.

2 The Problems of Regulation of Agroecosystems

As we see it, there are two main challenges in sustainable regulation of agri-food systems. The first challenge is that the intended regulation of a certain aspect often does not lead to the expected outcomes, e.g. pesticides tax does not have the expected effect on the use of pesticides, or the regulation of the use of manure does not have the intended effect on reduction of nutrient losses to the environment. There may be several possible explanations of this lack of effects. It could be due to the fact that the technical/biological understanding underlying the regulation is not good enough, e.g. that the effect of a certain action is over- or underestimated. Another explanation could be that the real systems do not resemble the models and understanding that underlies the calculation of the expected outcome (e.g., due to different cropping systems, different technologies or different farming practices). A further explanation could be that the farmers or the management of the agrosystems do not behave as expected by the technical and economic calculation, e.g. pesticide taxation does not lead to the estimated reduction in use of pesticides

[1] Monteduro (2013), pp. 2–11.

[2] Monteduro (2013).

[3] Dalgaard et al. (2003), pp. 39–51; Pretty (2008), pp. 447–65.

[4] Altieri (1995); Wezel et al. (2009), pp. 503–515.

because the farmers use other logics of calculation. This could be in the case of very large farms that use the rationale that when they are driving with the sprayer with fungicides anyway, they might just as well add an insecticide against aphids, to avoid the risk of being forced to drive again for an extra treatment. In this calculus, the concern for organising manpower and the capacity of equipment is much more important than the particular cost of a pesticide. Or this could be because the farmers hold other values than the partial optimisation of profit underlying the pesticide taxation, e.g. in the case of farming systems where clean fields and high-yielding crops have a value in itself, strongly linked to the professional identity of the farmer. Such values also change the calculus behind the decision-making completely. Prescriptive regulation, like the growth of green catch crops, is another example of possible discrepancy between expected and actual outcome because the effect of green catch crops is dependent not only on the establishment of catch crop (that the action is taken) but to a large extent on how the crop is established (how the action is taken).

These examples illustrate that it is not only a matter of understanding the technical and economic aspects of the farming systems but also an issue of conflicting values. For instance, in the case of a very dedicated arable farmer, he will by all means try to obtain high yields and clean and professionally looking fields. And the more legal measures of regulation that are put forward to reduce the intensity of arable production to protect the environment and nature quality, the more this farmer will move into opposition the legislation and search for ways of avoidance. This can be described as a dilemmatic situation of regulation.[5]

The second challenge is that regulation of one aspect often leads to unforeseen and unwanted side effects regarding other aspects. For example, the regulation of animal welfare in terms of outdoor pigs can result in increased loss of nutrients to the environment,[6] and support to biogas production can lead to reduction of organic farming due to the competition for land between growing corn for biogas and roughage for organic dairy farming.[7] Another example is that legal regulation of food safety in chicken production contributes to the closure of small poultry slaughter houses,[8] which amplifies industrialisation of chicken production, decrease in animal welfare and rural depopulation in terms of small holders. These unintended effects call for more regulations to deal with them and lead to the increasingly paradoxical situation[9] that the more regulation that is put forward to deal with the unintended side effects, the more likely they will produce new unintended side effects in an increasingly growing web of correlated effects and side effects. This mechanism is concretely reflected in the exponential growth rate of the amount of positive law on agriculture and environment.[10]

[5] Alrøe and Noe (2011), pp. 152–67.

[6] Eriksen et al. (2006), pp. 256–266.

[7] Schwarz et al. (2012), pp. 235–62.

[8] Antle (1996), pp. 1242–47.

[9] Alrøe and Noe (2011).

[10] Monteduro (2013).

In addition, this paradox of regulation is exacerbated by the fact that within the fields of science, law and policy there is an ongoing process of specialisation and differentiation into sub-branches focusing on different aspects, to deal with this increasing complexity.[11] And due to this increasing complexity and specialisation, there is literally no communication between the different bodies of policymaking and regulation.

The point is that how farming systems react on a certain legal regulation cannot be predicted or understood from an isolated economic, biologic, agronomic or social perspective but must be understood from an insight into the farming systems themselves. We thereby share the realisation that there is a need for new and integrative way to deal with the challenge of regulation of sustainable agri-food systems. We so also share the idea that the notion of agroecology can serve as a platform to establish and build such integrative approaches.[12] However, we do not see any possibility to turn the wheels back and establish a unitarian perspective on agroecology, and agroecological regulation, basically because the increase of complexity is irreversible and therefore also the need for specialisation and differentiation.[13] Instead, our argument is that we should see agroecology as a polyocular platform of second-order observations.

The aim of this chapter is to present our theoretical understanding of agroecology as a polyocular platform for second-order observation of the sustainability of agroecosystems based on a perspectivist theoretical framework[14] and our theoretical understanding of agroecosystems as autopoietic self-organising systems based on a social systems theoretical approach[15] and, furthermore, to discuss how these two insights can be used to develop an integrative platform for sustainable agroecological regulation. First, we will go into a deeper discussion of how to understand agroecology as a case of second-order observation.

3 Agroecology as a Platform for Second-Order Observation of Sustainable Agriculture

The notion of agroecology is widely used in the literature in the meaning of a study of interactions between soil, plants, animals and humans[16] or a study of technical, natural, social and human aspects.[17] It is strongly linked to the normative perspec-

[11] Noe and Alrøe (2015).

[12] Monteduro (2013).

[13] Luhmann (1984); Noe and Alrøe (2015).

[14] Alrøe and Noe (2014).

[15] Noe and Alrøe (2006), pp. 34–48.

[16] Dalgaard et al. (2003).

[17] Pretty (2008).

tives of sustainable farming based on ideals of how the interactions between these systems or aspects should be managed in a holistic and sustainable way, taking into account the environmental, agronomical, social and societal dimensions. Especially in the South American tradition, agroecology is seen also as a movement against large industrial farming systems, favouring small-scale family farming,[18] parallel to the partly organic farming discourse in the global north.[19]

Our way of understanding and using the notion of agroecology in this context is as an epistemological approach to observe agroecosystems based on the wider perspective of sustainability and sustainable development. We see agroecosystems as heterogeneous systems,[20] hybrids between technical, economical, biological and social systems, with the potential of many different kinds of observations from many different and relevant perspectives with regard to different values.

We share the common understanding that agroecology needs a multidisciplinary systems approach. But from our point of view, this also means that none of the perspectives involved in themselves can observe "agroecosystems" as such. In science, "agroecosystem" will always be defined by the "scientific eyes" observing. For example, a biological perspective observing an agroecosystem will focus on the biological processes and interactions going on, an economic perspective will define the system as a flow of money and transformations of assets, a sociological perspective will focus on human interactions and how the involved humans interact with nature, technology and economy. Our point is that, on the one hand, these different perspectives are needed to observe the system from an agroecological perspective, but, on the other hand, the perspectives are not simply puzzle bricks that add up to an agroecological understanding of the agroecosystem (see Fig. 1).

None of the individual perspectives can observe the agroecosystem as such; agroecology as a research perspective relies on these first-order perspectives and does not have its own first-order perspective to observe an agroecosystem as such. None of the disciplinary first-order perspectives involved offers a point of observation that can include the other observations, which means that no position has a privilege point of observing an agroecosystem.

To illustrate this, we can use the examples of "nature quality" and "rural livelihood". The research perspective of nature quality will focus on biodiversity and how different aspects and actions of the agroecosystem affect or will affect biodiversity. The description of the agroecosystem will mainly be a description of the prevalence of species in small biotopes and the degree of disturbance of these biotopes. The perspective of rural livelihood will focus on the living conditions of the people involved in the agroecosystem as well as living conditions in the communities surrounding the agroecosystem. Are there work opportunities, good working conditions, good conditions for family life, etc.? A description from this perspective will typically include the number of employees, salaries, work hours,

[18] Altieri (1987).

[19] Alrøe and Noe (2008), pp. 5–22.

[20] Noe and Alrøe (2006).

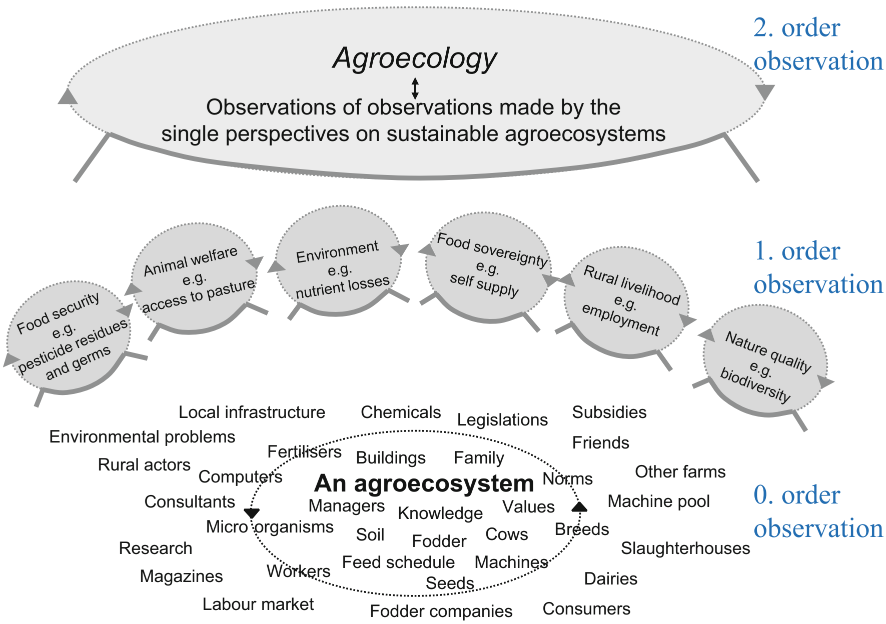

Fig. 1 Agroecology as a second-order science based on observation of first-order observations, with the agroecosystem as the shared object (0. order observation) (modified after Noe et al. 2008, pp. 1–15)

degree of self-supply and infrastructure. None of these descriptions can be integrated in the other perspectives. Biodiversity is only relevant for the rural livelihood perspective if it, e.g., increases the value of living there, increases the possibilities for rural tourism or increases the possibilities to collect food. And the employees are only relevant to the description of biodiversity if they disturb or contribute to maintaining biodiversity, e.g. by keeping sheep or cattle for nature conservation purposes. The two perspectives are so to speak blind to each other's perspectives. And none of them are able to see the potential synergy effects between the two aspects. The potential synergies can only be explored as a process of another logic than that belonging to the first-order observations. But this requires the involvement of both perspectives, the same way that binocular sight depends on the observations from two eyes to see depth. Depth is a mental construction that does not belong to either of the two eyes but cannot be made without synchronised observations of both eyes.[21]

Our claim is therefore that we need to understand agroecology as a second-order observation of the first-order observations of the single perspectives involved in what we call a multi-perspectival and polyocular approach.[22] We see it as a

[21] Alrøe and Noe (2014); Bateson (1979).

[22] Alrøe and Noe (2014).

multidisciplinary way to study agriculture and food production that focus on the sustainability of the agroecosystems studied, implicitly based on the values underlying the discourses of sustainability.

However, if no first-order perspectives have access to understanding and observing the agroecosystem as such (0.-order), how can we then operate with the ontological idea of an agroecosystem and thereby coordinate and synchronise so that the different perspectives observe the same object? To address this issue, we draw on the systems theoretical idea of autopoiesis, the idea that agroecosystems are self-organising systems. This is what makes it possible to observe the agroecosystem as an object from different angles, and which also makes agroecosystems able to observe themselves as organisation systems but not necessarily or likely as agroecosystems.

4 The Autopoietic Understanding of an Agroecosystem

Maturana and Varela define all living organisms as autopoietic systems, which means that they are self-creating and self-organising systems. Living organisms are operationally closed but open to material flows. Niklas Luhmann has adapted this understanding to encompass social systems, which he claims operate in communication.[23] We have further developed this theory to comprehend hybrids like agroecosystems.[24]

In Fig. 1, we illustrated an agroecosystem as potentially involving a lot of different heterogeneous elements like tractors, cows, knowledge, etc. And it is easy to comprehend that there is a potential surplus of elements that can be included in an agroecosystem, in terms of different plant and animal breeds, different technologies, etc. But each included element also offers a surplus of possibilities, e.g. a computer can be used to collect and process enormous amount of production data, or it can be used as a means of searching technical information on the internet or as a means of communication. The elements offer the possibilities, but they do define which possibilities are actualised; this must be defined by the agroecosystem (contingency). Like each word offers a surplus of meaning, but it is the sentence, the text or maybe the wider discursive context that defines what the meaning is or how it is meant to be actualised. In Fig. 1, the circle with two arrows illustrates this dynamic self-organising process of selection of elements and possibilities.

The basis of this approach to see a farm as a self-organising system is that the system can be observed as a continuous process of decision-making forming a more or less coherent strategy. From a systems theoretical point of view, there are two important dimensions of a decision. One is the systems closure dimension, in terms

23 Luhmann (1984).

24 Noe and Alrøe (2006).

of what options belong to the system and what potential options are excluded from the system. The other is the time dimension, that every decision needs to mark its present with a past and future.

To deepen the first dimension, systems closure, decisions should here be understood in relation to a semiotic understanding of contingency. In a Peircean terminology, every (dynamic) object has a surplus of meaning, not only in terms of actualised meaning but also in unknown potential meaning in relation to some interpretant.[25] To give an example, if we look at "cow" as a dynamic object and the farming system as the interpretant, there is a surplus of possibilities of how a cow can be interpreted in the farming system. It can be interpreted as a dairy cow yielding milk, a beef cow yielding beef, a grazing cow performing nature conservation, etc. The point is that not all these possibilities can be actualised at the same time and that the (dynamic) object in itself does not define what is realised and what is not; in a semiotic understanding, this belongs to the immediate object and the interpretation as parts of a triadic sign relation.[26] From this viewpoint, the way an organisation system creates itself, by closure, is through a continuous process of negotiation and decisions on what possibilities (interpretations) belong to the system and what possibilities are excluded.[27] These selections or interpretations are faced with contingency, in the sense that, on the one hand, the organisation system is forced to decide and, on the other hand, it could have made other choices of interpretation.

To deepen the time dimension of decision-making, every decision marks a before and after. For example, an agreement or contract is not valid without a date, which marks that now the decision has been made and will frame the future differently than the past. Introducing time supports two important insights. The first is that an organisation system needs to be seen as a flow of decisions continually marking both an inside and outside of the system and a before and after. The other insight is that an organisation system is forced to take a development pathway, not determined by the surroundings of the systems but determined by the decisions made by the system in reaction to its surrounding world.[28]

From this autopoietic understanding of a farm as an autopoietic self-organising system follows some other features. The continuous flow of decisions (interpretations) must be systems internal operations. It is only the system itself that can define what interpretations or immediate objects belong to the system. A way to understand this is that the organisation system has to produce and reproduce its own schema or logic, which connects the flow of decisions. Such different production logics can easily be observed empirically, and detailed studies have shown that there are several different viable development strategies.[29] Underlying these

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[25] Alrøe and Noe (2014).

[26] Peirce (1994).

[27] Noe and Alrøe (2006), p. 45.

[28] Alrøe and Noe (2012), pp. 39–52.

[29] See, e.g., van der Ploeg and Long (1994).

systems logics is meaning, in the sense of Viktor Frankl's notion of meaning understood as meaningfulness.[30] Instead of understanding farming systems as primarily goal-orientated systems, we see autopoiesis as meaning driven. The meaning is inherent to the system and is not an option for negotiation. Farming systems may therefore also be understood as logo-poietic systems, self-organising and autopoietic systems that are driven by the will to meaning.

This autopoietic understanding also means that it is the organisation system itself that has to observe and react to changes in the surrounding world. For instance, if the price of milk is decreasing, it is up to the dairy farming system to recognise this as a difference it has to react to. And how to react to these changes is linked to the system's logic, e.g. either to increase milk yield or to expand herd size. No organisation systems are able to be sensitive to all changes in their surroundings, so often it can be observed that the systems are sensitive only to the changes that seem most important to their strategies, and thereby they reduce the complexity of their "Umwelt" or phenomenological world.[31]

This means that how an agroecosystem is organised and how it reacts on changes in the surrounding environment and perturbations of the system cannot be understood from a universal logic of the social, technical, economic or biologic systems but needs to be understood from the internal logic of the agroecosystem as an autopoietic self-organising system.

5 Implications for Understanding the Regulation of Agroecosystems

The systems theoretical understanding of an agroecosystem as a self-organising system and the understanding of agroecology as a platform for multidisciplinary second-order observations from a sustainability perspective have a range of implications for how we can understand and develop an integrative platform for sustainable agroecological regulation and thereby for how to bridge between agroecology and law. We will start with the implications of the autopoietic understanding of agroecosystems as object for regulation and how agroecology as second-order multidisciplinary platform can serve also as a platform for the integration of law and regulation from the perspective of agroecology.

[30] Frankl (1962).

[31] Alrøe and Noe (2012) and Noe and Alrøe (2015).

5.1 The Challenges of Legal Regulation of Agroecosystems

The autopoietic understanding of agroecosystems has strong implications for our understanding of the conditions for regulation. Firstly, the operational closure means that there isn't any direct access to the autopoiesis. Regulative measures can only perturb, disturb or irritate the autopoiesis of the agroecosystems, no matter whether it is prescriptive, economic or normative measures that are applied. All regulation of autopoietic systems depends on self-regulation. Secondly, there is no one-to-one causal relationship between the intended logic behind the measures and the reactions in the agroecosystems. It is the ability of the agroecosystem to observe the disturbance and its internal schema of logic that will define the reaction. To illustrate this, we again use pesticide tax as an example. How an agroecosystem reacts on a certain tax cannot be calculated solely as a cause–effect relation. If the tax is high, it of course has an effect in irritating or disturbing the agroecosystem, but from a social systems theoretical understanding the effect is not defined by the tax but by the agroecosystem. An agroecosystem continually needs to react on changes in the encompassing world, and any form of regulation can be seen as changes in the environmental setting of the agroecosystem. But the reactions depend on the system's logic and related values and thereby on how the agroecosystem has reduced the complexity of its environment. If it is a very market-orientated agroecosystem, it will likely react on even very small price fluctuations, e.g. by changing crop rotation or changing input factors. If it is a very production-orientated agroecosystem, it may adopt new breeds or technologies even with an expectation of small increases in yield.

In Table 1, we have used the understanding of agroecosystems as autopoietic systems as a framework to analyse the system reactions and pros and cons for three different forms of regulation. None of these forms of regulation target the agroecosystem as a whole. They work through technical, biological or behavioural regulation (perturbation) of the systems based on an underlying understanding of how the systems are functioning. Different types of regulative measures have different pros and cons, and as indicated in the table the reaction of the systems and the effects of the measures in the individual agroecosystems will depend on the system's logic and values.

In the case of prescriptive regulation, it is possible to ensure and control that the intended actions are taken, e.g. that 60 % of the fields are covered with catch crops. But the effects of this regulation are highly dependent on the agroecosystem due to, for instance, different soil types, crop rotations and management practices; for example, are the catch crops established properly and in time to be able to retain nutrients?

Looking at economical incitements, even small changes in taxes on, e.g., pesticides may have an effect on market-orientated agroecosystems, while even very high taxes will have no effect on the internal organisation of agroecosystems orientated towards high productivity, although they may affect the economy of the systems notably. Normative measures like voluntary schemes, support to extension,

Table 1 Advantages and disadvantages of different forms of regulation analysed from an agroecosystems perspective

Forms of regulation	Examples of measures	System reactions		Pros	Cons
		System logic	System values		
Legal: injunction/ prohibition	Green catch crops	The effect of the catch crops is very dependent on how the system is organised. If the rationale is not shared, the reaction can be contrary.	System values play only an indirect role.	It is possible to control.	The real effect is unknown, and the side effect to the system is unpredictable.
Incitements: taxes/ subsidies	Pesticides tax	The sensitivity to taxes is dependent on both the values and logic of the system.		It regulates directly on the target; there is less disturbance of the autopoiesis of the agroecosystem.	High taxes are imposed to make all agroecosystems react; it leads to permanent dependence on taxes.
Normative: campaigns/ information	Voluntary agreement on pesticide reduction	It will only be a part of the system's logic if it becomes incorporated in the system's values.	Sensitivity is very dependent on values; some react very strongly in the intended direction, while others react against.	There is cheap and little control. It is co-constructive with the autopoiesis of the systems.	The agroecosystems that do not share the intention behind the campaign may react contrary.

and recommendations for good farming practices may have an effect on agroecosystems that already hold a strong focus on sustainability but can have the opposite effect on agroecosystems based on other values, reflected in statements like "As long it is legal to spray, I will do so and need to do so to be competitive with other farmers". And the more and stronger normative measures used, the more frustrated the farmers already dedicated become, and the less the other farmers care.

As demonstrated, the autopoietic understanding of an agroecosystem exposes the challenges to sustainable regulation because it cannot be foreseen how the system will react to exposure of different regulation measures based on one perspective only. Here we argue that law and regulation are facing the same challenge to obtain a platform for agroecological regulation that agroecological research is facing to study the sustainability of agroecosystems.

5.2 The Polyocular Understanding of Agroecological Regulation

Agroecological regulation does not have its own first-order perspective from where it can observe an agroecosystem as such (see Fig. 2). Law systems in general must necessarily be based on second-order observations. In any kind of regulation, the law perspective has to build on other perspectives observing the agroecosystem, either as an economical system through the lens of economy, a biological system through the lens of biology, an agronomical system through the lens of agronomy, etc. If the agroecosystem is understood as a technical system, law and regulation will be targeting technical matters such as the handling of liquid manure or the requested space for the animals. If it is seen as an economical system, law and regulation will be targeting taxes and subsidies. The choice of scientific perspective has consequences not only for the measures that are applied by the law systems but also for how the effects are measured and, more importantly, for what effects are not measured.

To deal with the increased complexity created by the differentiation of scientific perspectives and the institutional differentiation in policy and administration, the law systems have also undergone a differentiation. In our understanding, the differentiated branches of law systems are facing the same challenge in producing a coherent and sustainable regulation of agroecosystems as the different research perspectives do in establishing a coherent agroecological research perspective. Our contention is that there is not only a need for cooperation between law and science in agroecology but that the both lawmakers and researchers need to meet on the second-order platform of agroecology to obtain a polyocular view on the potentials for sustainable regulation and support of the development of agroecosystems.

But how to organise such platform in practice is not an easy case. It needs to be institutionalised in some way avoiding to be just another differentiation of science and law perspectives. Here we have a few principles to follow:

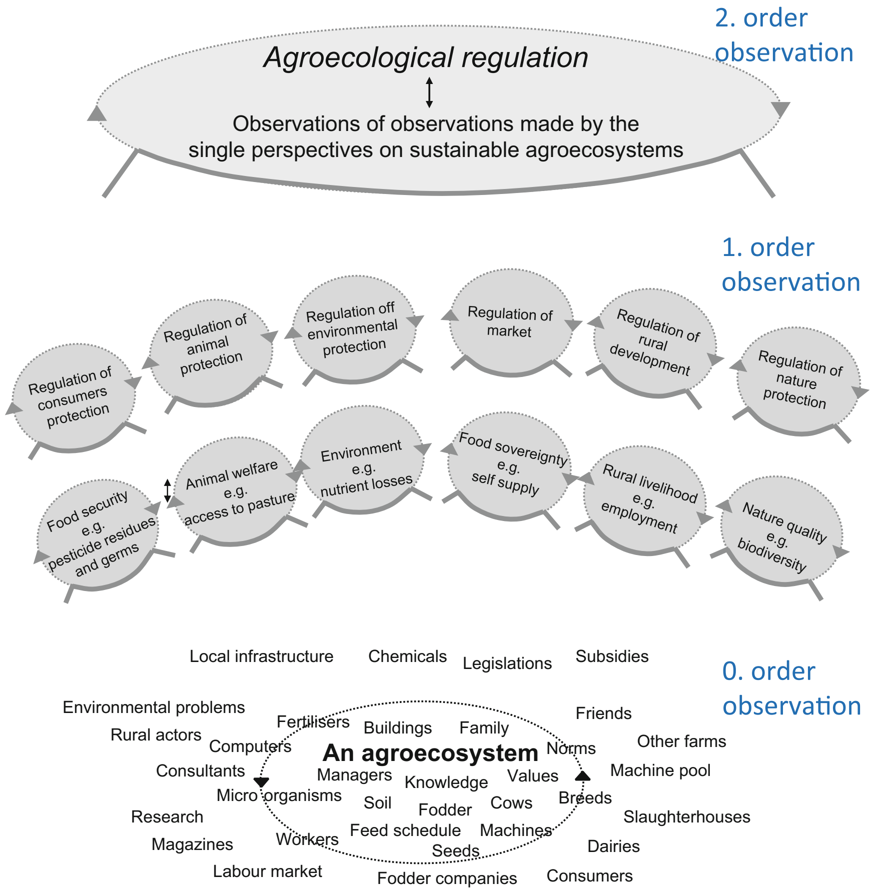

Fig. 2 Illustration of the second-order polyocular platform of agroecological regulation

- There must be time, room and resources for meeting and participating in this polyocular communication.
- Polyocular communication can only be organised around a specific problematic.
- The need for polyocular communication to be acknowledged by the different science and law perspectives involved.

6 Concluding Remarks

We have argued that the platform of agroecological regulation is fundamental for scientific perspectives and law perspectives to meet and communicate about sustainable development and regulation of agroecology. The increased complexity created by specialisation in science, law and farming practice[32] cannot be dealt with by further specialisation. And the exponential growth rate of positive law illustrates this paradoxical situation very well. We have argued that the way forward is not to try to turn the wheel back and construct a unitarian perspective on sustainability; this is not possible, and attempts to do so will only contribute to further differentiation and increase in complexity. The way forward is to form a new ground where different perspectives can meet and join in a second-order polyocular communication. But it requires that each perspective acknowledges its own blind spots and acknowledges that the agroecosystem can be seen from many other perspectives. We have argued that the autopoietic understanding of agroecosystems helps to establish an useful shared ontology (working ontology) that changes focus from the systems formed by the observing perspectives to how each agroecosystems observe and organise themselves. It also serves as a pivotal insight for discussing and observing the intended and unintended effects of different regulative measures.

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