International Journal of Agricultural Sustainability

ISSN: 1473-5903 (Print) 1747-762X (Online) Journal homepage: http://www.tandfonline.com/loi/tags20

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Yanniek Schoonhoven & Hens Runhaar

To cite this article: Yanniek Schoonhoven & Hens Runhaar (2018) Conditions for the adoption of agro-ecological farming practices: a holistic framework illustrated with the case of almond farming in Andalusia, International Journal of Agricultural Sustainability, 16:6, 442-454, DOI: 10.1080/14735903.2018.1537664

To link to this article: https://doi.org/10.1080/14735903.2018.1537664

INTERNATIONAL JOURNAL OF AGRICULTURAL SUSTAINABILITY
2018, VOL. 16, NO. 6, 442–454
https://doi.org/10.1080/14735903.2018.1537664

Conditions for the adoption of agro-ecological farming practices: a holistic framework illustrated with the case of almond farming in Andalusia

Yanniek Schoonhoven[a] and Hens Runhaar [b,c]

[a]AlVeLaL, Association of Farmers, Ranchers and Businesses, Granada, Spain; [b]Forest and Nature Conservation Policy Group, Wageningen University and Research, Wageningen, Netherlands; [c]Copernicus Institute of Sustainable Development, Utrecht University, Utrecht, Netherlands

ABSTRACT

Agricultural landscapes offer unique habitats for many species. Because agriculture is a major land use worldwide, changes in farming practices can have major repercussions for biodiversity. Particularly in Western Europe, ongoing intensification and scale enlargement but also land abandonment and poor agricultural practices leading to land degradation form a major threat to agrobiodiversity. Agro-ecological farming practices are suggested as an alternative way of farming in order to conserve and enhance biodiversity. Yet knowledge about what factors explain farmers' adoption of agro-ecological farming practices is fragmented and incomplete. In this paper, we offer a holistic framework that specifies these factors and how they are interconnected. The framework is illustrated and refined by means of a case study analysis of almond farming in Andalusia. The chosen case represents a specific localized farming practice that currently negatively impacts biodiversity but for which agro-ecology forms an attractive alternative regarding biodiversity. The case study demonstrates that our framework offers a useful tool to systematically identify the different factors that affect agro-ecological farming adoption, interlinkages between factors and particularly the more structural barriers to agro-ecology.

KEYWORDS

Agro-ecology; adoption; sustainable agriculture; onion model; agrobiodiversity; governance

1. Introduction

Agricultural landscapes offer many opportunities for biodiversity. Although there are exceptions, in general, low-intensity farmlands offer the most favourable habitats for biodiversity (Osawa, Kohyama, & Mitsuhashi, 2013; Sanderson, Kucharz, Jobda, & Donald, 2013; Tscharntke, Klein, Kruess, Steffan-Dewenter, & Thies, 2005). In practice however many agricultural landscapes move away from this ecologically ideal situation, because of both intensification and land abandonment but also land degradation due to over-exploitation (Foley, Ramankutty, Brauman, Tilman, & Zaks, 2011; Rey Benayas & Bullock, 2012; Sanderson et al., 2013). Species richness and abundance in agricultural landscapes is particularly threatened because of the removal of hedges and hedgerows, the artificial lowering of water tables, nitrogen and sulphur deposition, and pesticide use associated with agricultural intensification. Illustrative is the continuous decline in farmland birds, pollinators and other insects in Europe (EEA, 2015a, 2005b; Hallmann, Sorg, Jongejans, Goulson, & De Kroon, 2017; Ollerton, Erenler, Edwards, & Crockett, 2014).

Agro-ecological farming is often promoted as a promising alternative for modern farming as it is associated with substantially lower environmental impacts

CONTACT Hens Runhaar hens.runhaar@wur.nl
Supplemental data for this article can be accessed at https://doi.org/10.1080/14735903.2018.1537664

(DeLonge, Miles, & Carlisle, 2016). The academic literature defines agro-ecological farming as a way of farming that is holistic in its nature and that is based on 'various ecological processes and ecosystem services such as nutrient cycling, biological nitrogen fixation, natural regulation of pests, soil and water conservation, biodiversity conservation, and carbon sequestration' (Wezel et al., 2014, p. 3) with the goal of improving the sustainability of ecosystems and bringing economic as well as environmental benefits to farmers and communities. Characteristic of agro-ecology are soil cover, biodiversity (both below and above ground), crop diversification, limited to no tillage, swales, etc. (Kennedy & Smith, 1995; Sherwood & Uphoff, 2000; Toensmeier & Herren, 2016).

Yet similar to other forms of more sustainable agriculture, implementation of agro-ecological farming is slow (Duru, Therond, & Fares, 2015; Erisman et al., 2016; Pretty & Bharucha, 2014; Runhaar, 2017). Scientific research on factors that explain farmers' willingness or barriers to adopt agro-ecological farming practices (ranging from participating in agri-environment schemes (AES) to more radical transformation of farming) is diverse. Some studies have focused on farmers' motivations to adopt agro-ecological practices and this can be influenced by e.g. information about the benefits of agro-ecology (e.g. De Snoo et al., 2013; Van Dijk, Lokhorst, Berendse, & de Snoo, 2016). Other studies focused on the influences of the social context of farmers on their willingness to adjust their practices (Pretty, 2008) or the larger system that governs agri-food chains (Duru et al., 2015). And there are studies that analysed the effectiveness of governance arrangements such as AES in terms of contributing to more ecologically friendly farming practices (e.g. Smits, Driessen, & Glasbergen, 2008). Yet what is missing is a holistic framework that integrates personal and contextual factors that explain transitions towards agro-ecological farming and how these factors are related.

This paper aims to fill this knowledge gap. We build on a recently published, multidisciplinary framework that aims to identify favourable conditions for farmers to engage in nature conservation practices in the Netherlands (Runhaar et al., 2017). Although nature conservation is only one aspect of agro-ecology the framework draws from a broader literature on factors stimulating behavioural change by farmers and thus offers an interesting starting point.

The remainder of this paper unfolds as follows. In Section 2, we define our key concepts and develop our analytical framework. In Section 3, we illustrate and refine our framework by applying it to a specific case, namely almond farming in Andalusia, Spain. In this case, land degradation forms a major threat to biodiversity. In this particular case adoption of agro-ecology is slow, making it an interesting case to apply our framework. In Section 5, we wrap up with our main conclusions and end with some reflections.

2. Analytical Framework

2.1. Agro-ecology for conserving, enhancing and utilizing biodiversity

Agro-ecology refers to farming practices that rely on ecosystem services rather than on external inputs (Isgren, 2016; see also Wezel et al., 2014). Bretagnolle et al. (2018) state 'Agro-ecology considers biodiversity and ecological processes to be at the heart of the agro-ecosystem functioning, through the provision of ecosystem services, and has great potential for developing innovative and sustainable agricultural production methods' (p. 823).

Agro-ecological farming aims to reduce the environmental impacts of agriculture while meeting the growing demand for food, contributing to landscape quality and biodiversity, and enhancing resilience (Therond, Duru, Roger-Estrade, & Richard, 2017). Agro-ecology is both used as an overall farming concept (e.g. Díaz, Fargione, Chapin, & Tilman, 2006; Sherwood & Uphoff, 2000) and as a strategy to battle specific problems associated with farming, such as land degradation (e.g. Pearson, 2007).

It has been recognized that at least in the short term, yields from agro-ecology are lower than that of conventional farming, although there are also studies that show that equal yields are possible (Erisman et al., 2016). It has been claimed that agro-ecology can generate more stable farmer income, also because of more resilient soils and farming systems (e.g. Erisman et al., 2016), but as other studies conclude differently (see, e.g. Thorn, Friedman, Benz, Willis, & Petrokofsky, 2016) more research is needed on the impact of agro-ecology on farmers' livelihoods.

In the operationalization of agro-ecology into specific measures and farming practices the concept bears resemblance, and also partly overlaps, with concepts such as sustainable intensification, ecological agriculture, resilient agriculture, conservation agriculture, sustainable agriculture and carbon farming (e.g.

Erisman et al., 2016; Govaerts et al., 2009; Pretty, 2008; Smith & Olesen, 2010; Therond et al., 2017). Some shared measures and themes include elements are zero tillage, crop rotation, efficient irrigation and natural pest control.[1] The operationalization of agro-ecological principles to farming practices depends on the type of agricultural activity involved (e.g. crop farming or dairy farming), soil characteristics, climate conditions, intensity of farming, socio-economic contexts etc. (Therond et al., 2017).

2.2. Conditions for farmers to adopt agro-ecological practices

As Pannell already mentioned in 1999, it is very difficult to get farmers to radically change their way of farming. Such changes often only happen when they coincide with an extreme opportunity or problem (Pannell, 1999). But the literature mentions other conditions for change as well (see Introduction).

In this paper, we build on, and extent, the framework developed by Runhaar et al. (2017) which identifies four conditions that contribute to changes in farming practices that contribute to, and potentially benefit from, biodiversity (see Figure 1). We assume these conditions are also necessary prerequisites for transitioning to agro-ecological farming.

A first condition is that farmers should be motivated to adopt agro-ecological practices. That should not be voluntary only however; therefore, a second condition is that there should be a particular demand for farmers to adopt such practices. A third condition is that farmers should be able or enabled to implement agro-ecological farming practices. They should have the resources and skills required. A fourth and final condition is that agro-ecological farming should be legitimized, i.e. not inhibited or restricted by governmental regulations or social norms.

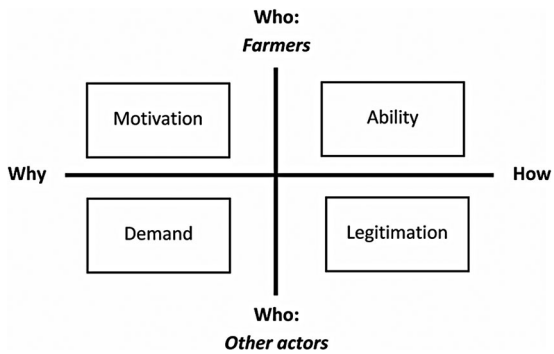

Figure 1. Conditions for farmer adoption and implementation of farming practices that contribute to biodiversity. Source: Runhaar et al. (2017, p. 267).

The authors assessed the presence of the four conditions by analysing the influence of farmers' characteristics (e.g. intrinsic motivations), the influence of governance arrangements such as AES (e.g. how demanding are they?) as well as contextual factors (e.g. prevailing social norms). Factors were derived from different disciplines, including policy sciences, planning, organizational studies, educational studies, management and social psychology (Runhaar et al., 2017).

Application of the framework to the case of nature conservation practices by Dutch farmers showed that 'demand' and 'ability' in terms of farmers being able to recover the costs of nature conservation form very important (but largely lacking) conditions. Another conclusion was that there may be interactions between conditions (e.g. the absence of business models that support the implementation of conservation measures ('ability') negatively impacts on 'motivation') (Runhaar et al., 2017).

We extend the framework by tailoring it to the case of the adoption of agro-ecology (which results in new and partly different factors contributing to the four conditions) and, moreover, by trying to show how the various factors are related (something which is largely missing in the original framework). For the latter we organize the factors according to the 'Onion Model', a model that is employed to identify different levels of influence on a certain subject (e.g. Bothma, Lloyd, & Khapova, 2015; Unkelos Shpigel, 2016). These levels form a sort of layers round that subject, hence the onion metaphor. Similar to the original framework we distinguish between farmers and their context but differentiate between 'direct' and 'distant' contexts. The direct context consists of what farmers experience in their daily work, e.g. opportunities and constraints found within farming styles or interactions with farmers' families, friends, direct peers and neighbours (often associated with 'social capital'; e.g. Pretty, 2008). The distant context includes actors and factors that are often beyond the sphere of influence of farmers, e.g. agricultural policy, conditions set by suppliers and processors etc. (Runhaar, 2017).

Factors and connections between the factors are identified by starting with barriers and enablers as experienced by farmers and then 'zooming out', i.e. by looking for underlying motives and factors. Taking the onion as a metaphor this means pealing

of an onion but from the inside out. For instance, difficulties in finding funding for conservation measures can be related to a lack of consumer demand for nature friendly produced food (Runhaar et al., 2017) and the dominant 'productivist' rationale of many agrifood chains promoting increased production in increasingly efficient ways (Duru et al., 2015). In this way, we enable the identification of more structural barriers and enablers of the adoption of agro-ecology.

In addition, we cluster factors in categories, in order to enable a systematic identification of factors. We employed the following categories: social, economic, policy and informational factors. These categories are derived from the literature that discusses factors necessary for governing a transition towards agro-ecology. Sherwood and Uphoff (2000) and Isgren (2016) discuss the role and importance of public policy. Hart, McMichael, Milder, and Scherr (2016) distinguish between economic factors (e.g. creating new markets) and social factors (e.g. partnerships, networks and support from NGOs). Carlisle (2016) and Isgren (2016) mention the importance of cognitive factors such as information, background knowledge and education.

Figure 2 visualizes the analytical framework, by illustrating factors that may influence the four conditions for the adoption of agro-ecological practices and how different types of factors may interact.

Table 1 summarizes factors distilled from the literature, organized following the four conditions and the above categories. We consulted both literature on agro-ecological farming and more generic literature on factors that contribute to more environmentally friendly behaviour. The factors therefore are *potential* or *theoretical* factors and mainly enable the systematic exploration of relevant factors in specific contexts. One factor appears to have an influence on two conditions, namely peer pressure (influencing motivation as well as legitimacy).

3. Illustration of the framework: almond farming in Andalusia

3.1. Justification of the case study chosen

We applied our framework to the case of almond farming in Andalusia, Spain, in order to illustrate and, if necessary, refine the framework. The case chosen represents a specific localized farming practice that currently negatively impacts biodiversity (mainly through land degradation) but for which agro-ecology forms an attractive alternative regarding biodiversity (García-Ruiz, 2010). As we show later, agro-ecological farming is already practised by some farmers and actively promoted among other farmers. This makes almond farming in Andalusia an interesting, illustrative case for identifying factors affecting the adoption of agro-ecology.

3.2. Brief introduction into the case study

The south of Spain in which the province of Andalusia is located has a typical Mediterranean climate. It knows two rain periods, high summer temperatures and low (zero degrees) winter temperatures. This in combination with an evapotranspiration that is five times higher than the annual rainfall results in an ever-drying region. A whole year of rain often falls within a few days causing major flash floods and washing away the top soil. Deforestation, grazing and burning of land have expanded desert-like areas. While it seems to be that the climate has changed much in the South of Spain, research suggests that the climate has been relatively stable for the past 6,000 years and that water has always been a scarce resource. Traditionally this was solved in the following ways: 'every source of irrigation is used, dry farming, dams, terraces and drought resistant crops' (Gilman, Thornes, & Wise, 2015).

Migration out of rural areas has increased pressure on the land and gave way for monocultural practices of which almond planting is the most common in Andalusia. Agriculture in the second half of the twentieth century was characterized by more powerful machinery, high investments in chemical inputs, switch to high-yield seeds, and expansion of irrigation. While these changes contributed to the livelihoods of some, it destroyed many low-productivity farms. Profitability of machinery depended, and still depends, on the size of the farm, as do labour costs and other investments. Young people eventually went to the city instead of following their parents (Collantes & Pinilla Navarro, 2011).

According to the Spanish National Statistics Institute (INE.SE), in Andalusia <10 hectare farms only make up 12% of all farmland, but represent 68% of the farm businesses. Farms with a size in between 10 and 30 hectares cover 13% of all farmland and are run by 15% of all farm businesses. Farms larger than 30 hectares farms cover 74% of the farmland

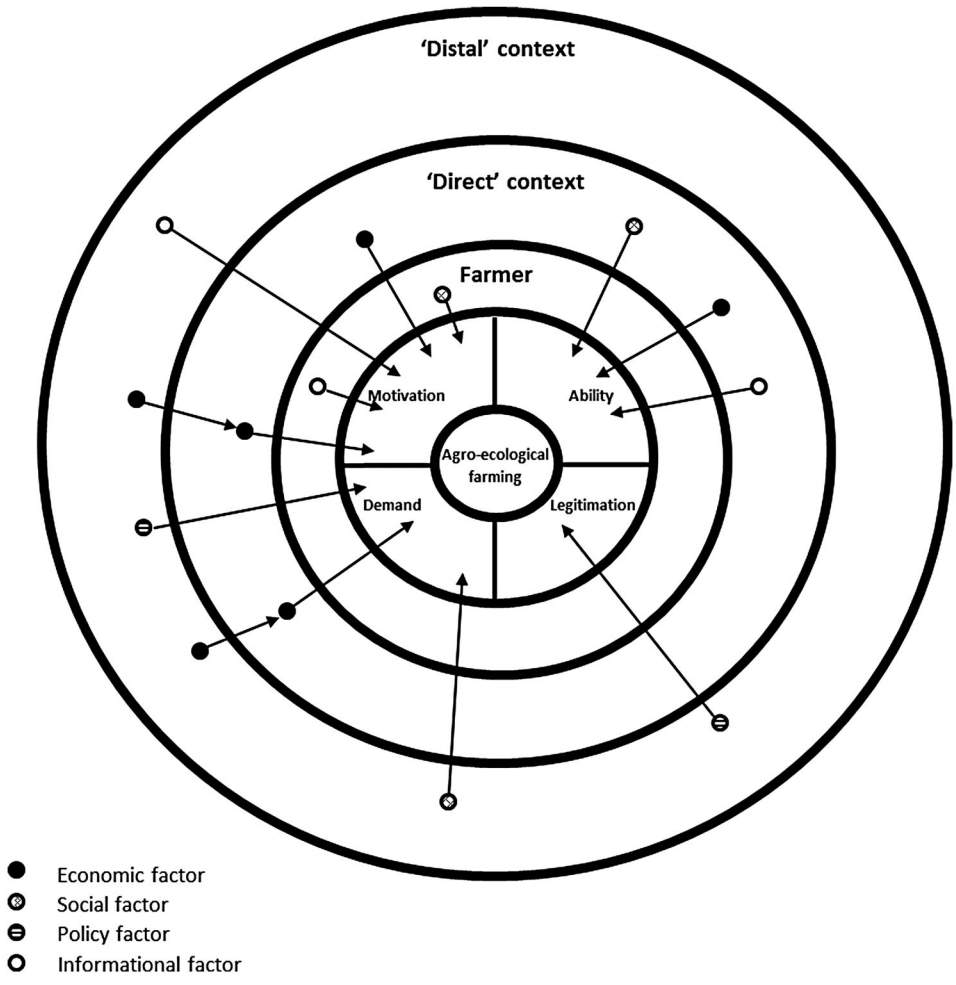

Figure 2. Visualization of the 'onion model' linking conditions for agro-ecological farming, influencing economic, social, policy and informational factors and possible interlinkages.

and encompass only 10% of all farm businesses. Most farmers (85%) reside in the group of 40 years and older (65+).

3.3. Agro-ecology in Andalusia

The operationalization of agro-ecology is context-dependent (see Section 2). Agro-ecological practices that are considered essential in degraded agricultural lands, also in order to restore soils, include diversification (Kremen, Iles, Bacon, & Bacon, 2012; Kremen & Miles, 2012; Pala, Ryan, Zhang, Singh, & Harris, 2007; Sánchez et al., 2014), tree management (Pearson, 2007; Rigueiro Rodríguez, McAdam, & Mosquera-Losada, 2009; Sánchez et al., 2014; Sayer et al., 2013), soil management (Abawi, Thurston, & Thurston, 1994; Holland, 2004; Kennedy & Smith, 1995; Sherwood & Uphoff, 2000; Soane et al., 2012) and water infrastructure (Kremen et al., 2012; Lopes et al., 2011; Toensmeier & Herren, 2016). These practices should help decreasing erosion, increasing fertility, increasing infiltration of water and increasing biodiversity.

The above practices have been translated into 12 specific measures by the Dutch NGO Commonland (see Figure 3), eight of which are applicable for the almond region in the South of Spain. Sustainable irrigation for example is not included because the almonds growing in Andalusia are all dryland almonds (secano-not irrigated). Integrated pest management is a practice that has not been studied in the almond sector and is therefore not included in the analysis.

Table 1. Potential factors contributing to farmers' motivation and ability to adopt agro-ecological practices.

Conditions	Categories of factors	Specific factors	References
Motivation: **the extent to which farmers are willing and motivated to participate in agro-ecological practices**	Economic	Impact of measures on primary processes	Pannell (1999); Stonehouse (1996)
		Cost-benefit ratio	Uri (1998), Kassam et al. (2012), Sánchez, Álvaro-Fuentes, Cunningham, and Iglesias (2014)
		Subsidies	Runhaar et al. (2017)
		Investment possibilities	Stonehouse (1996), Ferwerda (2015), Uri (1998)
	Social	Recognition	Runhaar et al. (2017), Uri (1998)
		Rewards	Driessen, Dieperink, van Laerhoven, Runhaar, and Vermeulen (2012)
		Degree of autonomy in choosing and implementing results	Runhaar et al. (2017), Baker and Eckerberg (2013)
		Values	Uri (1998), Ahnström et al. (2009)
		Peer pressure	Runhaar et al. (2017), Borgström, Zachrisson, and Eckerberg (2016), Hart et al. (2016)
	Informational	Education	Uri (1998)
		Training	Meyer (2009)
		Understanding of the farm ecosystem	Uri (1998), Sánchez et al. (2014)
	Political	Bureaucracy	Meyer (2009), Ferwerda (2015)
		Corruption in government	Ahnström et al. (2009)
Ability: **the extent to which farmers are capable to farm according to agro-ecological principles**	Economic	Availability of new business models	Ferwerda (2015), Knowler and Bradshaw (2007)
		Available finances	Uri (1998), Stonehouse (1996)
		Market conditions	Hart et al. (2016), Driessen et al. (2012)
	Social	Peer pressure	Runhaar et al. (2017), Borgström et al. (2016)
		Values	Uri (1998), Ahnström et al. (2009)
		Community support/trust	Borgström et al. (2016), Runhaar et al. (2017)
	Informational	Skills	Uri (1998), Meyer (2009), Borgström et al. (2016)
		Farming style	Westerink, Melman, and Schrijver (2015)
		Communities of practice	Borgström et al. (2016), Runhaar et al. (2017)
		Research	Uri (1998)
		Learning	Uri (1998), Meyer (2009)
		Information about benefits	Engel and Pagiola (2008)
	Political	Involvement of NGO's	Hart et al. (2016)
		Support from government (incl. subsidies)	Runhaar et al. (2017)
Demand: **the extent to which farmers are requested or obliged to farm according to agro-ecological principles**			
	Economic	Environmental/market regulations	Ahnström et al. (2009)
		Demand for sustainable products	Hart et al. (2016)
		Conditions in contracts with customers	Driessen et al. (2012)
	Social	Public opinion about agriculture	Giomi, Runhaar, and Runhaar (2018)
		Religious values	Runhaar et al. (2017)
		Peer pressure	Runhaar et al. (2017), Hart et al. (2016)
	Informational	Understanding of request to do regenerative practices	Meyer (2009), Uri (1998)
	Political	Pressure from NGO's	Uri (1998)

(*Continued*)

Table 1. Continued.

Conditions	Categories of factors	Specific factors	References
		EU CAP subsidies	Baker and Eckerberg (2013)
		Pressure from government	Baker and Eckerberg (2013), Hart et al. (2016)
Legitimacy: **the extent to which farmers are allowed to farm according to agro-ecological principles**	Economic	Degree of freedom with contracts/legislation	Ahnström et al. (2009)
	Social	Norms	Uri (1998)
		Social control	Runhaar et al. (2017)
		Peer pressure	Runhaar et al. (2017), Borgström et al. (2016)
		Cultural setting	Knowler and Bradshaw (2007), Borgström et al. (2016)
	Informational	Innovativeness	Ferwerda (2015), Meyer (2009)
		Community of farmers	(Runhaar et al., 2017; Borgström et al., 2016; Hart et al., 2016)
	Political	strictness of legislation and standards	Ahnström et al. (2009)
		Indirect effect of adjacent policies	Baker and Eckerberg (2013)
		Framing of agriculture in policy and communication	Baker and Eckerberg (2013)

3.4. Measuring conditions and identifying factors: data collection

In-depth interviews were conducted in order to explore to what extent agro-ecological practices were or were not applied and how farmers' decision-making about agro-ecology was influenced by the theoretical conditions and factors discussed in Section 2. The interviews were conducted on-farm, which allowed to make observations in order to verify the presence of agro-ecological practices.

A total of 30 interviews were conducted by the first author, with an average length of 2 hours. In this case study, the focus was on farmers with more than ten hectares of arable land because these are farmers who farm as part of their livelihoods. The farmers were contacted through a local NGO (AlVelAl), actively involved in engaging almond farmers in agro-ecological farming. On the one hand, the farmers identified and interviewed were not necessarily representative of other farmers in the province because they were more knowledgeable of agro-ecology. On the other hand, this allowed them to reflect on their motives for (not) adopting certain agro-ecological practices. In view of the illustrative nature of the case study, the latter argument was considered more important than the former.

The interviews started with open questions about the obstacles and motivations for (not) adopting agro-ecological measures. The answers were coded in terms of the factors from Table 1 and in terms of positive or negative influences on decision. In the second part of the interview, respondents were asked to reflect on the importance of factors that were not mentioned initially.

The presence or absence of the four conditions for the adoption of agro-ecological practices was made in an indirect way, namely by means of the scores on all factors associated with the conditions (again, see Table 1). A '1' was given to factor that was considered to have a positive influence on adoption and a '–1' in the case of a negative influence. By aggregating all factor scores from all 30 interviews, an overall picture emerged about the presence of conditions for all 8 measures and all 4 practices, as well as for adoption of agro-ecology in general.

See the Supplementary material document for more information about the respondents and the questionnaire.

4. Results

Figure 4 shows the adoption of agro-ecological measures by the 30 farmers who were interviewed. On average measures are implemented by about one-third of the respondents. Adoption rates differ per measure, but not extremely. No figures are available regarding adoption among all almond farmers in Andalusia. For some measures, data are available for all farmers in that province (which includes many other agricultural activities). In view

	practice	effects	economic impacts	ecological impact		
				soil	water	biodiv.
Water infrastructure	Earth works (swales; dams)	Increase water availability; reduce run-off and erosion	+	+-	++	+
	Wind breaks; hedges		-	+	+-	+
	Sustainable irrigation		++	+	+	+
Soil management	Vegetation cover	Increase fertility through nutrients, microorganisms and soil organic content, reduce erosion, increase infiltration, reduce evaporation	+-	++	++	++
	Compost, mulching & manure		++	++	+	+
	Nitrogen-fixing crops		+-	++	+-	+-
	Reduced / no tilling		+	++	+	++
Tree mgmt	Integrated pest management	Reduce need for synthetic pesticides	+	+	+-	++
	Sustainable phytosanitary management		-	+	+-	++
Diversifi-cation	Crop diversity: Aromatics, Cereals	Income and biodiversity gains from diversified operations and establishing of eco-corridors	++	+	+	+
	Livestock integration		+	++	-	+-
	Mosaic landscape planning		+-	+	-	++

Figure 3. Agro-ecological practices for degraded agricultural lands. Source: Ferwerda (2015).

of these data, our sample of farmers seems to implement more often sediment trapping, (winter) ground cover and compost (but we do not know whether that is specific for almond farming). As indicated, representativeness was not our main aim; illustrating our analytical framework was.

Table 2 provides an overview of the motivations and obstacles farmers perceived in their decisions or considerations to adopt agro-ecological practices. Only factors that were referred to more than four times during the 30 interviews are shown. Factors that were mentioned five to 10 times are presented with a + or – (indicating a positive or a negative influence). Factors that were mentioned between 10 and 15 times are presented with a ++ or – – and factors mentioned 15 times or more are presented with a 3 +++ or – – –. Some factors appear both in a positive way (i.e. motivations) and in a negative way (barriers). Apparently, these factors work out differently at farm level.

Table 2 suggests that the factors that contribute to the four conditions for the adoption of agro-ecological practices are context-specific. Whereas we found several factors that are in line with what other researchers have found (see Table 1), we also found some additional ones. Another observation is that

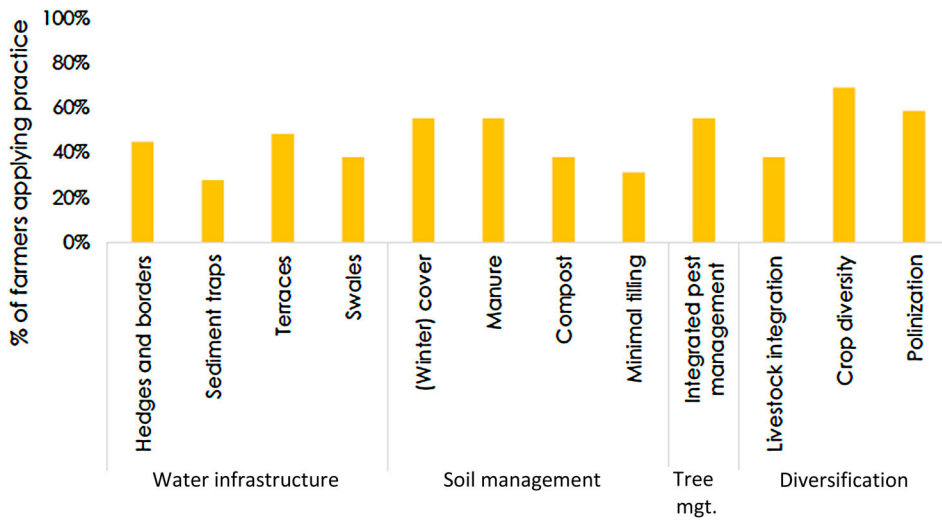

Figure 4. Adoption of agro-ecological measures by the interviewed almond farmers in Andalusia.

Table 2. Most important factors affecting the adoption of agro-ecological practices, mentioned by the interviewees.

Conditions	Factors	Positive (+) or negative (−) influence
Motivation	Understanding of the ecosystem	+++ or −
	Cost-benefit ratio	++ or – (no visible proof)
	No/limited market demand for agro-ecological products (*)	–
	Subsidies	++
	Lack of community support and trust (*)	−−
	A felt responsibility for future generations	++
	Peer pressure (*)	–
	Norms and values	−−−
Ability	Cost-benefit ratio	++ or – (no visible proof)
	Skills	+
	Community of practitioners (*)	++
	Lack of finance and investment possibilities	−−−
	No market demand for agro-ecological products (*)	–
	Subsidies	++
	Lack of community support and trust (*)	−−
	Lack of innovativeness	–
	Understanding of the ecosystem	+++ and −
Demand	Political context (rules that facilitate conventional farming rather than agro-ecological farming and mistrust in politicians by farmers)	–
Legitimacy	Community of practitioners (*)	++
	Lack of community support and trust (*)	−−
	Norms and values	−−−
	Peer pressure (*)	–

Note: (*): factor applied to multiple conditions.

there are various factors that influence multiple conditions.

In Figure 5 we organize the factors from Table 2 according to the onion model, as visualized in Figure 2. This helps interpreting the factors in two ways: one, it shows how they are interrelated and two, it indicates the origins of the factors. For the sake of readability, we did not show the nature of the factors (economic, social etc.). Figure shows how several factors from the distal context play out at farmer's decision-making about agro-ecological farming. For instance, norms and values, referring to the dominant views of what makes a 'good farmer' (cf. Riley, Sangster, Smith, Chiverrell, & Boyle, 2018) directly influence some farmers' motivation to engage in agro-ecological farming and indirectly influence other farmers through a lack of community support and trust and even peer pressure (to not adopt agro-ecological farming, because it is considered as inferior).

5. Discussion and conclusions

In this paper, we developed and illustrated a holistic framework that integrates various types of factors that explain the adoption of agro-ecological farming, including their interrelations. The main components of the framework are (a) conditions that promote the adoption of agro-ecological practices and (b) the specific factors that in turn contribute to the presence or absence of these factors. The factors were categorized into four clusters (economic, social, informational and policy) in order to enable a systematic exploration of factors. A literature review resulted in a list of theoretical factors. An 'onion model' was used in order to further categorize factors in terms of characteristic of farmers; their direct context; and the distal context in which they operate and to connect these factors to more fundamental, systemic factors.

The case study of almond farming in Andalusia showed that the classification into conditions and factors is mainly a heuristic that helps identifying the specific factors in specific contexts, rather than a comprehensive and unambiguous list. The factors that we identified based on the 30 interviews also suggest that farmers mainly reason from their own perspective and their direct context and that they have less eye for the distal context. More fundamental factors, such as a limited demand for agro-ecological products and, perhaps even more fundamentally, the common orientation of many agri-food systems towards productivity and efficiency rather than towards sustainability (e.g. Duru et al., 2015) are hardly or not mentioned during the interviews. This may be because this context is either considered as a given, or is not so visible for farmers (e.g. because they supply to intermediaries).

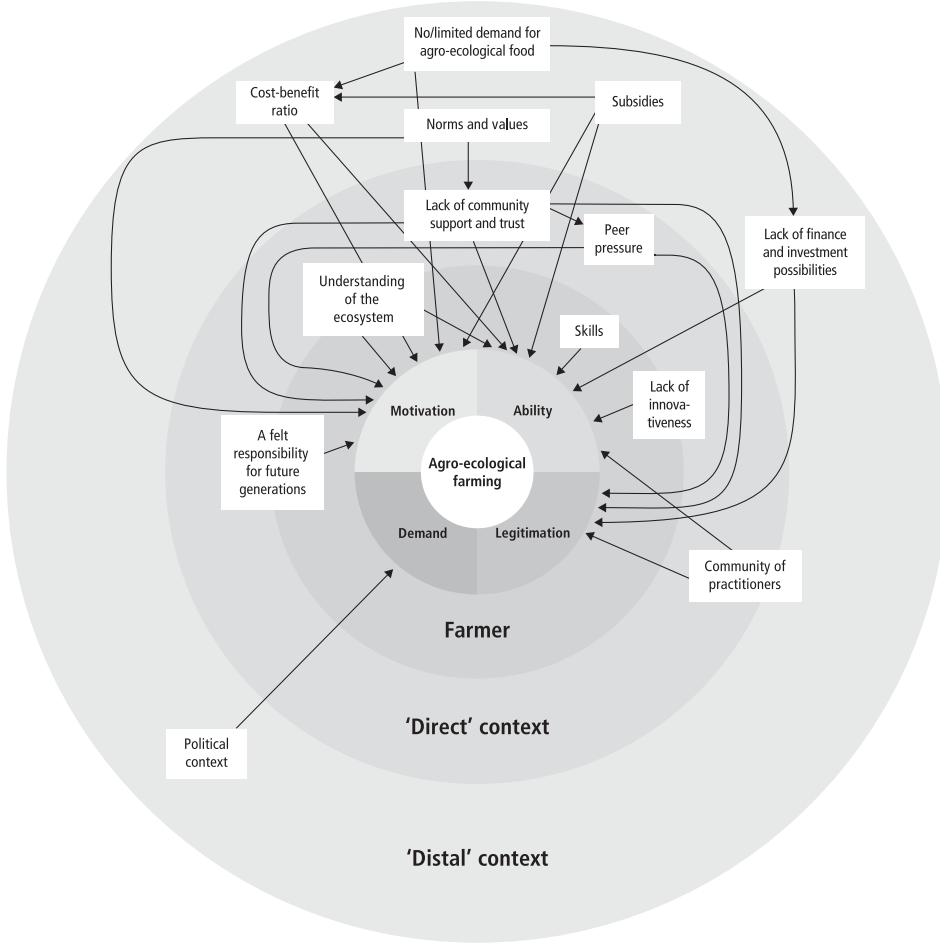

Figure 5. The most important factors affecting the adoption of agro-ecological practices in almond farming in Andalusia, organized according to the 'onion model'.

This suggests additional data collection is needed for identifying additional factors in the 'distal context'. The perceived factors however offer valuable points of application for such an analysis.

We conclude that the analytical framework is a step forward in the attempt to get a better understanding of what drives and impedes a transition to agro-ecological farming, moving beyond thinking in terms of 'lists' of barriers and enablers (cf. Biesbroek et al., 2015) and trying to connect farmers' perceptions and experiences and the 'system' they are in. One of the next steps is the exploration of promising interventions that can help overcoming barriers and that can provide the conditions that promote the adoption of agro-ecological farming practices. Again, the barriers that farmers perceive can form a starting point to identify the more structural factors in the direct and distal context, which in turn are the starting points for designing interventions such as creating awareness and a consumer demand for agro-ecological products, integrate agro-ecology in agricultural education, show-casing agro-ecological farming at the regional level etc. In this way, our analytical framework not only enables a better understanding of what drives or enables agro-ecology, but also offers a more or less practical tool to (re)design agricultural policies and interventions by NGOs and agri-food companies.

Note

1. Perhaps also clarifying in this context is what agro-ecology is *not*, i.e. features associated with 'industrial agriculture' that agro-ecology does not share: nitrogen, phosphorous and pesticide use and impacts; irrigation and

water scarcity; tillage, bare soil and soil degradation; use of fossil energy and climate impacts; farming system specialisation, landscape simplification and biodiversity degradation (Therond et al., 2017).

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Hens Runhaar http://orcid.org/0000-0001-7790-097X

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