https://doi.org/10.1016/j.foodpol.2016.12.009

Seufert, V., Ramankutty, N., & Mayerhofer, T. (2017). What is this thing called organic?–How organic farming is codified in regulations. Food Policy, 68, 10-20.

What is this thing called organic?

- How organic farming is codified in regulations

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Abstract

Organic farming is one of the fastest growing sectors of world agriculture. Although it represents only 1% of world agricultural area, organic is one of the most recognized food labels and most people in developed countries consume some amount of organic food today. There is a wide range of interpretations of what organic means by different actors in the sector. Here we examine eight different organic regulations from across the world to understand how they have codified the large diversity of ideas inherent in organic agriculture. Our analysis shows that organic practices and regulations do not differ substantially between countries – across the board organic regulations define organic mainly in terms of

'natural' vs. 'artificial' substances that are allowed (or not) as inputs. This interpretation of organic as “chemical-free” farming, largely void of broader environmental principles, does not fully incorporate the original ideas of organic theoreticians who conceived it as a holistic farming system aimed primarily at improving soil health, thereby leading to improved animal, human, and societal health. This narrow focus of organic regulations can be explained by the interest of organic consumers who predominantly buy organic because they believe it is healthier and more nutritious due to the absence of harmful substances. Organic regulations need to place more emphasis on environmental best practices in order to ensure that organic agriculture can contribute to sustainability objectives.

Highlights:

- The meaning of organic agriculture is highly debated
- Regulations define organic mostly in terms of ‘natural’ vs. ‘synthetic’ inputs
- Environmental best practices are not well represented in regulations

Keywords: organic agriculture, organic policy, sustainability, content analysis

Acknowledgements

This work was supported by a grant from the Grantham Foundation, as well as a Discovery Grant from the Natural Science and Engineering Research Council of Canada to N. Ramankutty. T. Mayerhofer was supported by a RISE Worldwide scholarship from the German Academic Exchange Service (DAAD). We thank Sarah Turner for input to the development of ideas and analysis. We use the sequence-determines-credit approach (Tscharntke *et al*. 2007, doi:10.1371/journal.pbio.0050018) to determine authorship sequence.

1. Introduction

Organic agriculture is often proposed as a solution for producing food with reduced environmental impact (Tilman 1998; Scialabba & Hattam 2002). Even though it constitutes less than 1% of global agricultural land and less than 5% of retail sales in most high-income countries (Willer & Lernoud 2015), it represents one of the fastest growing food sectors. In high-income countries most people consume organic at least occasionally[1]. Organic today is the most recognized food label, whose basic meaning is understood by most consumers. And organic is the only farming system whose management practices are codified by law in most countries (Rigby & Cáceres 2001). Organic food thus represents one of the few means through which consumers can have some control and knowledge about how their food is produced (Allen & Kovach 2000).

But what does organic agriculture actually mean? The meaning of organic is shaped by the different actors involved – consumers, producers, theoreticians, and regulations (see Fig. 1). Accordingly, there have been many debates about the definition of organic agriculture (Rigby & Cáceres 2001), as well as the different forms in which it manifests itself today (Guthman 2004). Many of the commonly cited definitions are ambiguous (e.g. IFOAM 2006), and different people associate different things with it and buy organic for different reasons (Hughner *et al.* 2007). This wealth of meanings and associations is also rooted in the history of organic agriculture and in the manifold ideas expressed by the original organic movement (Conford 2001; Heckman 2006). But the lack of a clear vocabulary and conceptualization of organic agriculture makes a discussion about its problems and benefits challenging. Indeed, debates about whether organic farming could contribute to more sustainable agriculture are often highly polarized (Trewavas 2001; Goklany 2002; Mäder *et al.* 2002).

What distinguishes organic from 'sustainable' or 'agroecological' management is that organic practices are well defined and in many countries regulated by laws. Regulation and certification is central to the current concept of organic agriculture in most countries. Regulations are therefore a useful place to start understanding how the views of the

[1] 73% of Americans, for example, consume organic food at least occasionally (Hartman Group 2006), while 58% of Canadians say they consume organic food every week (COTA 2013).

different organic actors have been codified and what organic agriculture means today (Rigby & Cáceres 2001).

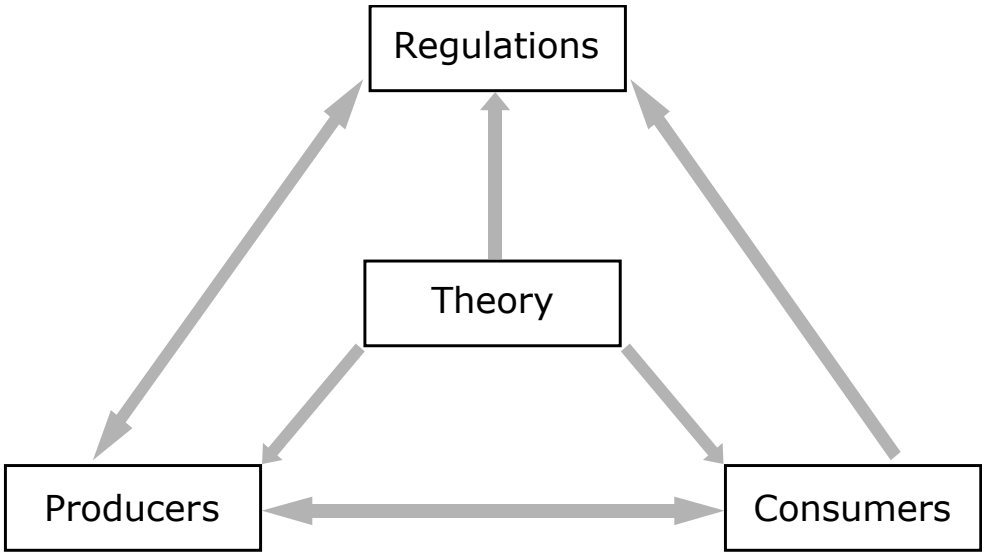

Figure 1. The different poles of influence defining organic agriculture today. Consumer demand is considered one of the main drivers of organic agriculture (Fromartz 2007). Producers shape how organic agriculture manifests itself in practice. Organic theoreticians influence the ideas about organic farming, and have an important role in the history of organic agriculture. Finally, regulations legally define organic practices and rules.

In this study we examine how organic agriculture is defined and codified in organic regulations today, and how organic practices and principles differ between regulations across the world. To this end we (1) perform an international comparison of organic practices between different regulations and standards, and (2) examine the organic principles used in the discussion and codification of organic agriculture in these regulatory texts. We then present some thoughts on the major influences on organic regulations, through (3) an analysis of environmental best practices represented in organic regulations, a (4) brief review of the ideas of organic pioneers, as well as (5) a review of the literature on motives of organic consumer. We conclude this paper with a call for an increased focus of organic regulations on environmental best practices to enhance the potential of organic agriculture to contribute to a sustainable food system.

2. The codification of organic in regulatory texts

2.1 A brief history of organic regulations

The original concept of organic agriculture developed as a critique of the emerging industrial food system in the 1920s to 1950s (Conford 2001; Fromartz 2007; Vogt 2007). But it was only in the 1980s, driven by an emerging environmentalism and health-concerns about exposure to pesticides, antibiotics and hormones, that organic agriculture, which promised a more 'natural' and healthier agriculture, experienced a surge in popularity (Fromartz 2007; Lockeretz 2007). As organic sales began to skyrocket, organic farming organizations and consumer groups started lobbying for a legal regulation of the organic label and of organic practices, resulting in the development of national organic standards beginning in the 1980s (Conford 2001; Schmid 2007; Scott *et al.* 2009).

In the United States (US), the first state-level organic regulations emerged in the 1970s, followed by the National Organic Program (NOP) nearly 30 years later (Vos 2000; Friedland 2005; Fromartz 2007; Mosier & Thilmany 2016). The first European wide organic regulation was established in 1991, replacing national regulations that had been established in most countries since the 1980s (Lampkin *et al.* 1999; Padel *et al.* 2009). Some countries, like Australia, do not yet have a legally binding national organic regulation but still use widely accepted national voluntary standards defined by government bodies (AUS 2009) or the organic industry (ACO 2010). In recent years more and more low and middle-income countries have started implementing organic regulations in order to ease trade with high-income country markets. Uganda, for example, adopted a national organic standard in 2004, which was followed by a regional East African organic standard in 2007 (UNCSD 2012). Similarly, after considerable growth of the organic sector, Mexico introduced a national organic program in 2006 (Nelson *et al.* 2010), and a national organic standard with production guidelines in 2013. Today, nearly 100 countries worldwide have implemented or are developing organic standards (OTA 2016).

At the international level, several organizations are attempting to harmonize organic standards globally. The International Federation of Organic Agriculture Movement

(IFOAM) (an umbrella organization founded in 1972) and the *Codex Alimentarius* (set up by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) in 2001) aim to establish a consensus definition of organic practices across different countries that facilitates free trade in nationally regulated organic food (Lampkin *et al.* 1999; Vos 2000). Both the IFOAM and *Codex Alimentarius* standards have been very influential in the definition of many national organic standards (Lampkin *et al.* 1999).

2.2 Data and methods

We analysed organic regulations from a set of representative countries across the world. To identify the most important countries, we used the most recent global organic data (Willer & Lernoud 2015) to identify the top three countries according to four different criteria (see Table 1). The following 11 countries were selected by this process: India, Uganda, Mexico, Australia, Argentina, USA, Falkland Islands, Austria, Sweden, Germany, France.

For European countries (Falkland Islands, Austria, Sweden, Germany, France) the new harmonized EU regulation was analysed. Australia does not have a legally binding organic regulation. Instead, we used the National Standard for Organic and Biodynamic Produce, a voluntary standard for the organic industry defined by the Australian government (AUS 2009). In Argentina, organic agriculture is regulated through a large number of separate laws and there is no single organic standard; we therefore excluded Argentina from the analysis. Overall, we examined 8 different organic regulations representing 33 different countries (28 countries part of the EU plus 5 other countries plus 2 international framework texts; Table 2).

Table 1. Countries included in the analysis. Values represent number of organic producers; total area certified organic and in conversion to organic agriculture (in ha); % of total agricultural area that is organic; organic sales (in Mio. €). Values are for the year 2013 if not otherwise indicated. Source: (Willer & Lernoud 2015).

	Country	**2013 value**
Countries with most organic producers	India	650,000
	Uganda	189,610 (2012)

	Mexico	169,703
Countries with highest total organic agricultural area	Australia	17,150,000 ha
	Argentina	3,191,255 ha
	USA	2,178,471 ha
Countries with highest share of organic agricultural land[2]	Falkland Islands	36.3%; 403,212 ha
	Austria	19.5%; 526,689 ha
	Sweden	16.3%; 500,996 ha
Countries with the largest domestic organic markets	USA	24,347 Mio. €
	Germany	7,550 Mio. €
	France	4,380 Mio. €

We used several different approaches to compare how organic agriculture is discussed in these selected regulations. First, we classified *management practices* or inputs discussed in different regulations according to whether they were required, recommended, authorized, discouraged, or prohibited by the regulations. The management practices considered included land management (conversion, parallel production), crop production (species choice, pest control, fertilization), livestock production (species choice, breeding, feed, veterinary treatments, housing, transport and slaughter) and processing (food additives, processing aids). This helped identify where regulations differed in the types of practices discussed, as well as in the extent to which these practices were regulated.

Table 2. Organic regulations included in the analysis.

Country	**Regulation name**	**References**
International	Joint FAO/WHO Food Standards Programme, Codex Alimentarius, Organically Produced Food (2001)	FAO and WHO (2001)
International	The IFOAM Norms for Organic Production and Processing, Version 2005	IFOAM (2006)
Australia	National Standard for Organic and Biodynamic Produce – Edition 3.4 (2009)	AUS (2009)

[2] Note that Liechtenstein (despite having the second highest share of organic agricultural land) was excluded due to its small size.

European Union	Council Regulation (EC) No 834/2007 on organic production and labelling of organic products &	EU (2007)
	Commission Regulation (EC) No 889/2008 laying down the rules for the implementation of EC No 834/2007	EU (2008)
India	National Programme for Organic Production (NPOP), sixth edition (2005)	NPOP (2005)
Mexico	Ley de Productos Organicos (LPO), Nueva Ley DOF 07-02-2006	LPO (2006)
	Lineamientos para la Operación Orgánica de las actividades agropecuarias, October 2013	LPO (2013)
Uganda	UgoCert (2005), Uganda Organic Standard (UOS) for organic production and processing	UOS (2005)
United States	National Organic Programme, e-CRF Data as of November 1, 2013	USDA (2013)

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Second, we conducted a content analysis to assess the importance of different organic *principles* in regulations using a qualitative weighting and scoring approach (see Hsieh & Shannon 2005; Krippendorff 2012)[3]. This allowed us to assess the extent to which differences in regulated management practices might reflect differences in the conceptualization of organic agriculture. To do this, we first identified management practices that are typically regulated in organic regulations (see Table 3). We focused our analysis on land-based crop and livestock systems, as well as on practices related to food production, thus excluding sections dealing with bee keeping, aquaculture, mushroom production, harvest of wild plants and animals, labelling, inspection & certification process, accreditation of certification bodies and packaging. We then derived a list of key organic principles, based on principles and objectives discussed in preambles of organic regulations. Instead of defining organic principles *a priori* based on theory and external sources (e.g. like Padel *et al.* 2009; Darnhofer *et al.* 2010), we inferred organic principles from the legal texts themselves. We identified seven key organic principles discussed in regulations: (1) natural, (2) local, (3) soil, (4) biodiversity, (5) water, (6) animal well-being, and (7) human health. We excluded the principle of 'social' from our analysis because social aspects are barely mentioned in most organic regulations, with a few exceptions[4].

[3] Content analysis encompasses a wide variety of methods used for "making replicable and valid inferences from texts (or other meaningful matter) to the context of their use" Krippendorff (2012, p. 24).

[4] The IFOAM standard dedicates two pages to social standards, recommending some basic rights, social security systems and labour protection for organic farm workers and asking operators to have a policy for social justice, prohibiting the use of child or forced labour and declaring that production that is based on the violation of basic human rights shall not be declared as organic. The Mexican regulation does mention social standards in one sentence, while the Ugandan UOS dedicates an entire page to social justice, prescribing and recommending similar things as the IFOAM regulation.

Table 3. Matrix of organic management practices vs. organic principles that could be used to discuss each practice.

	Organic principles						
Management practices	Natural	Local	Soil	Water	Biodiv	Animal	Human
Conservation areas			X	X	X		
Irrigation			X	X	X		X
Crop rotation			X	X	X		
Tillage			X		X		
Pest control	X				X		X
Fertilization	X	X	X	X			X
Species choice	X	X			X		
Livestock housing						X	
Livestock feed	X	X				X	
Veterinary treatments	X					X	X
Livestock breeding	X				X	X	
Livestock transport & slaughter						X	
Additives & processing aids	X						X

Next, we identified the organic principles that different management practices represent (see Table 3). For example, a regulation might discuss fertilizer use in the context of 'natural' by allowing only inputs from natural (i.e. plant, animal or mineral) origins and prohibiting synthetic substances; or in the context of 'local' by requiring nutrient sources to come from the farm or the region; or in the context of 'soil' by emphasizing concepts like soil fertility and addition of soil organic matter; or in the context of 'water' if minimizing fertilizer use to preserve water quality was discussed; or in the context of 'human' if safe fertilizer and manure handling practices to ensure food and worker safety were discussed.

We then assigned scores to each regulation based on how strongly the relevant principle was represented in the discussion of each management practice, assigning a full point if the regulation of a specific practice was strongly oriented at achieving the envisioned principle, half a point if the principle was a clear influence but with considerable concessions, and zero points if it appeared to have no influence. To increase the reliability of the content analysis and achieve a form of analytical triangulation, two

independent researchers who were involved in the research project (the first and last authors of this paper) separately carried out the coding of organic regulations[5]. We used the average score assigned by the two researchers as our final score, but we also examined inter-rater reliability by testing whether and how the identity of the coder influenced the results inferred from our analysis. Note that this content analysis did not distinguish between practices that are required versus recommended (e.g. differences in the language such as "producers must adhere to" versus "producers should consider that").

We then ranked the importance of organic principles within each country/regulation based on our scores weighted by the number of words used to discuss each management practice[6]. We decided to use this weighting approach, as the different management practices were not equally important in regulations (e.g., discussion of conservation areas was typically confined to a couple of sentences while fertilization practices were usually discussed at length). We used a squared weighting factor as this put stronger emphasis on the more objective word count, compared to the more subjective scoring.[7] We conducted a sensitivity analysis to examine (1) whether the identity of the researcher, (2) the scoring system[8], or (3) the weighting method influenced the results.

2.3 Organic practices in organic regulations

Broadly speaking, the organic regulations examined are quite similar in terms of management practices regulated. This is not surprising given the large amount of trade in

[5] For a discussion of the role of inter-rater reliability in qualitative research see, for example, Armstrong *et al.* (1997).

[6] Relative to the total length of the text discussing all the management practices we included in our analysis.

[7] An example of this scoring method: the principle of 'natural' received a score of 0.5 for the management practice 'pest control' in regulation X, and was then multiplied by the square of the relative word count (e.g. 0.12^2) used in this same regulation to discuss pest control (relative to all management practices discussed in the regulation). All weighted scores for 'natural' across different management practices in regulation X were then summed and ranked relative to the scores of the other organic principles.

[8] i.e. a three-point scoring system of 0, 0.5 or 1 points, or a two-point scoring system only assigning either 0 (principle not discussed) or 1 point (principle discussed).

organic products between countries (FiBL & IFOAM 2013), and that the aim of international organic standards is to achieve harmonization between countries in order to facilitate trade. IFOAM and *Codex Alimentarius* try to establish international reference standards that can act as minimum guidelines, but can be complemented by additional, stricter national or private standards. The influence of the IFOAM text on some of the national regulations, especially India and Uganda, is noticeable. Several countries have also developed bilateral agreements in order to establish equivalency in organic standards [9]. The EU has, for example, established equivalency agreements with Argentina, Australia, Canada, Costa Rica, India, Israel, Japan, New Zealand, Switzerland, Tunisia and United States.

Generally, organic regulations define prohibited activities or substances (e.g. the use of genetically engineered products, synthetic pest or weed control substances, or the use of ionising irradiation for the treatment of food), and required activities (e.g. outdoor access for livestock or crop rotations). Compliance is enforced by accredited government or private certifying agents. Some regulations (e.g. the Indian NPOP) also delegate the formulation of additional standards and management requirements (e.g. stocking rates or the minimum percentage of farm set aside as conservation area) to the certifying agents. The certifying agents are paid by producers, which, critics argue, can create a conflict of interest as certifiers do not want to lose their customers through overly strict controls (Friedland 2005). Many regulations require the producers to formulate a management plan that details the production system and management practices used, the inputs applied and sometimes a prediction of the quantities produced. The certifying agency typically has to be informed of any changes to the management plan. In addition, inspections of the farm are carried out, typically a minimum of once a year. Product testing is typically not required, except when there is reason to suspect non-compliance with organic standards or contamination of products.

[9] Equivalency of organic standards means that although there are minor differences between organic regulations of countries (and regulations are therefore not harmonized), the guiding principles for organic production are acknowledged to be similar and the products certified under the other countries regulation is therefore allowed to be marketed as organic without needing to undergo a second certification (Giovannucci 2006; OTA 2009).

Despite the large similarities between regulations, some differences in organic practices are still worth noting, some of which can be explained by considering country-specific context. For example, the EU standard has some unusual exceptions to the prohibition of genetically modified organisms (GMO) in organic agriculture compared to other regulations, allowing veterinary medicines produced from GMOs, as well as food and feed additives derived from GMOs if there are no alternative GMO-free substances on the market. But in the EU, GMO use in agriculture generally and its presence in food products is much more strictly regulated than, for example, in the US. Conventional food products in the EU are generally GMO-free or has to be labelled if it contains products derived from GMOs. Avoidance of GMOs is therefore not an important consideration for organic consumers in the EU (McEachern & Mcclean 2002).

Another notable difference is that the US regulation includes a negative list of natural substances that are not allowed, while it allows the use of all other natural substances not listed, while other standards include positive lists of substances that are allowed and prohibit any substances that are not listed. The US and Australian regulations are especially strict about antibiotics, in that slaughter stock that has been given antibiotics at any point cannot be sold as organic. In contrast, other regulations authorize the sale of organic animals treated with therapeutic use of antibiotics after certain withdrawal periods.

Even though the general principles according to which animal management is regulated are very similar in all regulations – e.g. animal housing that allows for natural behaviour and movement patterns, company with other individuals of the same species, natural light & ventilation – the degree to which these principles translate into specific requirements differs substantially between regulations. The EU and Australian regulations are, for example, the only ones that prescribe the minimum amount of indoor (and in the case of EU also outdoor) area required per head of livestock. Also, while all regulations require access to the outdoors for livestock, only the US regulation requires a minimum proportion of livestock feed for ruminants to come directly from grazing. All other regulations recommend access to pasture when conditions allow, but do not require it.

There are also some differences in how practices like crop rotations are regulated: In some cases (e.g. Mexico), they are strictly required; mostly, however, crop rotations are only recommended and typically discussed as part of a larger set of practices that can be chosen from.

Overall, there are more similarities than differences in how management practices are regulated in different organic regulations. Differences between regulations are often in the emphasis given to certain management practices rather than in concrete management requirements.

2.4 Organic principles in organic regulations

The comparison between principles yielded remarkably similar results independent of researcher, scoring or weighting method used (Table A3, Appendix A). Absence of synthetic inputs is the single most important principle in almost every one of the regulations examined (Table 4), ranked first by a wide margin in aggregate, receiving almost double the score as the second ranked principle. Animal welfare and human health receive similar scores, and their scores are again more than double that of the next principle (soil). The organic principles associated most with environmental sustainability, i.e. soil, water and biodiversity, are not very prominent in organic regulations. This picture does not differ much between different regulations (Table 4) or when different methods are used (Table A3, Appendix A).

Table 4. Ranking of importance of organic principles within each regulation. See Table 2 for an overview of the different regulatory texts examined, and see Table A1 in Appendix A for a colour version of this table.

	Natural	**Animal**	**Human**	**Soil**	**Local**	**Biodiv**	**Water**
Mexico	2	1	4	5	3	7	6
IFOAM	1	7	2	3	6	5	4
Australia	1	6	3	4	7	5	2
Uganda	1	2	5	4	3	6	7
India	1	6	2	4	5	3	7
EU	1	2	3	5	4	7	6
USA	1	2	3	4	7	6	5
FAO	2	1	3	4	7	6	5
Rank	1	2	3	4	5	6	7

Score	77	46	42	21	17	16	13

There are, however, some notable exceptions to this general picture. The Indian regulation stands apart in strongly emphasizing biodiversity, while the Australian regulation emphasizes water issues much more than other regulations (not surprising given the dry climate of Australia). Mexico and Uganda emphasize local issues more than other regulations. And the IFOAM, Indian and Australian regulations emphasize animal issues far less than other regulations. IFOAM, the most holistic but also least specific of the regulations, shows the highest rank for soil issues – a core idea of the original organic pioneers.

3. The definition of organic according to regulations

Our examination of organic regulations highlights that there are no major differences in the regulation of organic practices between different national and international organic regulatory texts. International trade in organic food has contributed greatly to a harmonization of organic regulations between different countries. Although there are some differences, discourse about organic as well as the specific practices prescribed in different organic regulations are very similar. As global trade in organic produce continues to increase, the need for equivalency or harmonization of organic regulations will become more important. This is reflected in the on-going negotiations of equivalency agreements[10] as well as in the on-going work of the International Task Force on Harmonization and Equivalency in Organic Agriculture convened by IFOAM, FAO and UNCTAD (Giovannucci 2006). Given the degree of consistency between different regulations analysed, we can arrive at some broad conclusions about how organic is defined by these regulations.

[10] The EU for example just signed an equivalency agreement with the US in 2012.

3.1 Organic regulations are about 'natural' versus 'synthetic' inputs

Despite the broader definitions used in preambles of organic regulatory texts (Padel *et al.* 2009), organic regulations are, in practice, defining organic agriculture as a chemical-free management system, based on avoiding synthetic inputs, and relying on natural substances instead. In all regulations the majority of the text is devoted to a discussion of allowed and prohibited inputs, typically discussed in the context of 'natural' versus 'synthetic' substances. 'Natural' substances are typically defined as those of animal or plant origin, as well as mined substances of low solubility, while 'synthetic' substances are "manufactured by chemical and industrial processes" and may "include products not found in nature, or simulation of products from natural sources" (IFOAM 2006, p. 13).

The organic principle of 'natural' does not, however, only relate to non-synthetic inputs. The idea of using natural *processes* to manage an organic system is also prominent in regulations; for example, the recommendation to use crop and animal species with high resistance to pests and diseases, or to use crop rotations and cover crops for crop nutrient management. Many regulations emphasize that the use of allowed substances should only be considered a last resort, when other measures have failed to achieve the intended management goal. The Australian standard, for example, states: "Inputs must not be used as a permanent measure to support a poorly designed or badly managed system. Non-essential use of inputs is counter to organic and bio-dynamic farming principles" (AUS 2009, p. 50).

In general, however, regulations tend to put a stronger emphasis on natural *substances* than natural *processes*. Typically regulations spend a couple of sentences stating that pest or soil fertility management or management of livestock health should be based on natural processes, after which they extensively discuss criteria and requirements for the use of allowed substances. In addition, the use of different natural processes is typically listed as recommended, and not required. For example, the European commission regulation (EU 2008) spends 40 words on the use of natural processes (e.g. high quality feed and exercise) for disease prevention in livestock, and then continues using more than 300 words to discuss requirements for the use of natural and synthetic veterinary

treatments. The US NOP spends 65 words discussing the need to manage soil fertility and crop nutrient requirements using "rotations, cover crops, and the application of plant and animal materials", and then discusses at length (using 450 words) requirements for what constitutes allowed inputs (USDA 2013).

3.2 Organic regulations are not setting good standards for environmental sustainability

Our analysis supports the frequent criticism that the codification of organic practices has led to a reductionist perspective of organic agriculture, focused on avoidance of synthetic inputs (Allen & Kovach 2000; Goodman 2000). The prohibition of synthetic inputs does not, by itself, constitute more environmental friendly management (Kirchmann & Bergström 2001; Bahlai *et al.* 2010), or represent a sufficient condition for sustainability, and may not even be a necessary one (paraphrasing Hodges 1993, as cited in Rigby & Caceres 2001, p. 26).

To investigate this further, we compiled a list of management practices identified as environmental best practices in farming (Altieri & Rosset 1996) and reviewed whether and how these practices are regulated in organic regulations. In this exercise we did distinguish between practices that are 'required' (e.g. "the producer must"), and those that are mentioned but 'not regulated' (e.g. "it is recommended the producer should"). We find that management practices that have been identified as important components of sustainable agriculture - like permanent soil cover through cover and catch crops (Altieri & Rosset 1996; Tonitto *et al.* 2006), or the use of crop associations, and a mixture of crop varieties (Altieri & Rosset 1996; Zhu *et al.* 2000) - are typically not clearly regulated in organic regulations (see Table 5). While some of these sustainable management practices might be crop- or climate-zone specific (e.g. agroforestry or cover crops) and thus cannot be required for all farmers, most of these practices could be implemented in the majority of farming systems.

Some other concerns of sustainable agriculture are also mostly, or entirely, absent from organic regulations. Few of the regulations, for example, discuss water conservation, and none require specific irrigation practices, even though agriculture is the largest user of

freshwater worldwide (Rosegrant *et al.* 2009), and increasing water use efficiency is a major concern for sustainable agriculture (Tilman *et al.* 2002). Only the Australian and Mexican regulations have detailed discussions of water management, for example requiring farmers to conserve water and to use local water resources without impacting flora and fauna (AUS 2009, p. 16; LPO 2013, Artículo 33). The Indian and Ugandan regulations follow the IFOAM standard that "operators shall not deplete nor excessively exploit water resources, and shall seek to preserve water quality" (IFOAM 2006, p. 15), but without further detail. All other regulations examined – i.e. EU, US and the *Codex Alimentarus* - do not even mention irrigation or water management. In the scoring of organic principles water therefore received the lowest score of all organic principles (Table 5).

Table 5. Comparison of how different sustainable management practices identified by Altieri & Rosset (1996) are regulated in organic regulations. / - indicates the management practice is not discussed; *NR* (Not Regulated) – indicates the practice is discussed but not regulated, or its use is suggested but not required; **Req.** – indicates use is required. See Table A2 in Appendix A for a colour version of this table, and Table A5 for more details about how these practices are regulated.

	IFOAM	**FAO**	**Aus.**	**EU**	**US**	**India**	**Mex.**	**Ugan.**
Living mulch*	/	/	/	/	/	/	/	/
Dead soil cover**	*NR*	*NR*	*NR*	/	*NR*	*NR*	*NR*	*NR*
Cover Crops	*NR*	/	/	/	**Req.**	*NR*	**Req.**	*NR*
Conservation tillage	*NR*	/	*NR*	*NR*	*NR*	/	*NR*	*NR*
Alley cropping	/	/	/	/	*NR*	/	**Req.**	/
Agroforestry	/	/	/	/	/	/	**Req.**	/
Living Barriers***	/	/	*NR*	/	/	/	NR	/
Rotations	**Req.**	*NR*	**Req.**	**Req.**	**Req.**	*NR*	**Req.**	**Req.**
Crop Associations	*NR*	/	*NR*	/	*NR*	*NR*	**Req.**	**Req.**
Cultivar Mixtures	*NR*	/	/	/	/	/	/	*NR*
Animal integration	/	*NR*	*NR*	*NR*	/	NR	**Req.**	/

*a cover crop interplanted or undersown with the main crop
** mulching with dead biological or synthetic material
***a windbreak usually involving trees and/or shrubs

Another sustainability concern that is essentially absent from organic regulations is nutrient use efficiency. This is discussed as an aim of organic agriculture, but not

translated into any concrete management requirements. Even though most organic regulations emphasize that the focus of nutrient management on organic farms *should* be on nutrient recycling rather than applying external inputs, the *amount* of inputs is not actually limited. The European and the Mexican regulations limit the amount of animal manure applied to fields (to 170 and 500 kg of nitrogen per ha respectively), but they do not limit total nutrient inputs. The use of organic instead of synthetic nutrient inputs does not, by itself, result in reduced loss of nitrogen or phosphorus from the system (Kirchmann & Bergström 2001). Nutrient efficiency in agriculture requires targeted management to reduce excess nutrient application by meeting crop demand as closely as possible (Berry *et al.* 2002).

This lack of concrete management requirements that relate to environmental sustainability appears rather paradoxical as regulations often state (for example in their preambles) that organic agriculture entails best environmental practices and is aimed at enhancing the environmental performance of agriculture (NOSB 2011, p. 30). Environmental principles are, however almost entirely absent from the regulations- for example, in the US regulation soil principles are ranked in the middle and biodiversity principles come almost last (Table 4).

It could be argued that some of the management methods associated with best environmental practices – like diversified crop rotations, integration of leguminous crops, or application of compost and crop residues – by default *have* to be part of an organic management system, as the prohibition of chemical nutrient inputs and pesticides *requires* reverting to such practices to achieve good crop and animal production. In practice, however, it is perfectly possible to manage a farming system without chemical inputs but also without using sustainable management practices. Many examples show that organic farms, especially large-scale organic production, can rely on 'natural' but external inputs like animal manure and allowed organic fertilizers and pesticides, without adopting other sustainable management practices (Buck *et al.* 1997; Guthman 2004).

3.3 Organic pioneers would be disappointed with today's regulations

Sir Albert Howard is arguably one of the most important figures of the original organic

movement. Joseph Heckman, in a review of the history of organic agriculture, writes that "Sir Albert Howard would likely be dissatisfied with the current status of the organic movement" (Heckman 2006, p. 148). The conceptualization of organic agriculture in today's regulations differs in substantial ways from some of the key principles of organic agriculture as advocated by organic pioneers.

Howard would have agreed with the prohibition of synthetic inputs in today's organic regulations, as "artificial manures lead inevitably to artificial nutrition, artificial food, artificial animals, and finally to artificial men and women" (Howard 1940, chapter 3, para. 16). Howard and other organic pioneers had, however, a more holistic understanding of health and of 'natural' than current organic regulations. For organic pioneers 'natural' meant an "obedience to the laws by which the world is governed" (a writer to Sir Albert Howard's journal 'Soil and Health', Conford 2001, p. 92). Avoiding 'artificial manures' would, by itself, not lead to healthy food, but human health was dependent on a fertile soil, which was a core concept of organic philosophy (Könemann 1939; Howard 1940; Balfour 1950). Howard starts his '*An Agricultural Testament*' with "The maintenance of the fertility of the soil is the first condition of any permanent system of agriculture" (Howard 1940, chapter 1, para. 1). Even many of the social and political ideas encapsulated in the organic movement were centred around soil - "wealth, welfare, prosperity and even the future freedom of this nation are based upon the soil" (Louis Bromfield, 1945, as cited in Conford 2001, p. 105). Howard's version of organic regulations would probably have dedicated most of their rules and standards to good soil management practices. But in today's regulations soil ranks low compared to other principles (Table 4), and key soil terminology used by organic pioneers like humus, composting, organic matter, and soil fertility is almost entirely absent.

Another core idea of Howard that is missing from today's regulations is the 'Law of Return'. Howard observed that in the ancient traditional farming systems of South Asia that he admired – most prominently the farming system of the Hunzas in Pakistan – "the very greatest care is taken to return to the soil all human, animal, and vegetable wastes after being first composted together" (Howard 1940, chapter 12, para. 10). He therefore proclaimed that a sound agriculture was not possible without returning to the soil what was removed from it through harvest. Howard is often referred to as the 'father of

modern composting', as the study of different composting methods was a central element of his work. Composting was not only the best way to increase soil fertility and foster soil biological activity, but also allowed the recycling of urban wastes for use in rural agriculture – one of "Howard's favourite projects" (Conford 2001, p. 86). Organic regulations today are, instead, rather ambiguous about the use of human excrements or sewage sludge due to food safety concerns (see Supplemental Table S4). Some regulations (e.g. US, EU, Uganda) do not allow any use of human wastes. Other regulations prohibit the use of sewage sludge but allow the use of human excrements on non-edible crops (e.g. Mexico), while some countries prohibit the use of human excrements but allow the use of treated sewage sludge (e.g. India, Australia).

Since the times of Albert Howard the food system has changed considerably, and it is only natural to expect organic agriculture to also have changed since then. But some of these original ideas of the organic movement are still highly relevant today. Many current debates about what constitutes sustainable agricultural management are consistent with Howard's idea that soil health is a core element (Parr *et al.* 1992; Doran 2002), and that closing nutrient cycles in agriculture - especially the phosphorus cycle, where availability is limited – is an important environmental goal (Tilman *et al.* 2002; Cordell *et al.* 2009). Bringing some of these organic concepts back into organic regulations could thus connect organic agriculture back to its roots, while also addressing food system sustainability challenges.

3.4 The definition of organic agriculture in regulations is driven by consumers

Organic agriculture is a strongly consumer-driven sector (Fromartz 2007). And we hypothesize that the reason why organic regulations focus on regulating 'natural' versus 'chemical' inputs can be traced to the primary motivations of consumers. Although the scientific evidence on the health benefit of organic food is unclear (Smith-Spangler *et al.* 2012; Barański *et al.* 2014), and although organic consumers identify a wide range of motives, the most common stated reason for buying organic food is health and pleasure (Zanoli & Naspetti 2002; Hughner *et al.* 2007). The healthiness of organic food is often

associated with the absence of chemical residues, as well as a higher nutritional value of organic food (Hughner *et al.* 2007). This focus on health as the most common motive appears to be consistent across different regions of the world (Davies *et al.* 1995; Chang & Zepeda 2005; Dahm *et al.* 2009; Sirieix *et al.* 2011).

Even though several qualitative reviews on the motives of organic consumers have been conducted (Yiridoe *et al.* 2005; Hughner *et al.* 2007; Schleenbecker & Hamm 2013), there has been no systematic review on the topic yet. To confirm the impression from a qualitative review of the literature that the predominant reason for consumers to buy organic is health, we summarized the results from studies on organic consumer motives included in the three qualitative reviews conducted on this topic so far (i.e. Yiridoe *et al.* 2005; Hughner *et al.* 2007; Schleenbecker & Hamm 2013), as well as some additional studies on the topic we found (see Appendix B for details on studies included). To compare studies, we ranked the purchasing motives of organic consumers, as well as the characteristics associated by consumers with organic products identified in each study. Appendix B provides further details and more background on the comparison. Table 6 summarizes the main results derived from 34 studies we included in this analysis.

Table 6. Importance of different aspects of organic food for consumers, i.e. (1) characteristics associated with organic products, and (2) motives for organic consumers to purchase organic food. See Appendix B for details, including a list of references of studies included in the analysis.

		Health	Natural	Environment	Animal	Social
Product characteristics (N=10)	Score	0.76	0.92	1.20	2.32	2.82
	Rank	1	2	3	4	5
Purchasing motives (N=25)	Score	0.61	1.23	1.33	1.71	2.55
	Rank	1	2	3	4	5

This analysis supports the notion that health aspects – including aspects of food safety and food quality - are the most important characteristic associated with organic food by consumers today. This belief that organic food is healthier, safer and tastier is grounded on the belief that organic food is free of chemical substances, like pesticides, antibiotics, and growth hormones, and that it is more nutritious. 'Natural' is thus the second most important characteristic associated by consumers with organic food (Table 6).

Environmental motives typically rank highest of the altruistic values associated with organic food, while animal welfare comes fourth, and social issues – supporting local smallholder farmers, or giving fair prices to farmers - ranks last (see Table 6).

The importance of consumer demand in the formulation of organic standards is sometimes very clearly stated in regulations. Several regulations (e.g. Mexico and Australia) state the production of food of high nutritional quality as the first principle of organic agriculture, while many of the regulations mention that processing aids and food additives should not impair the 'authenticity' of the organic product (e.g. FAO & WHO 2001, p. 11; Aus 2009, p. 39; IFOAM 2007, p. 58 & p. 64). The Australian standard, for example, explains that: "The use of additives and processing aids of non-agricultural origin included in the Annexes, takes into account the expectations of consumers that processed products from organic production systems should be composed essentially of ingredients as they occur in nature" (Aus 2009, p. 39).

The importance of consumers in defining organic regulations is also evident in the process of how these regulations come to be formulated. In many countries the formulation of organic standards has been the outcome of a long process during which different stakeholder groups were consulted, and public comments received (Vos 2000; Padel *et al.* 2009; Mosier & Thilmany 2016). A first draft of the US NOP, for example, received more public comments than any previous USDA regulation. Most of these comments concerned the list of allowed substances (Friedland 2005). The EU is currently revising organic standards. The first draft, released in early 2014, received strong criticism from farmer groups. The draft included more stringent rules on contamination of organic products (e.g. requiring residue-testing for baby food, and lowering the allowable levels of residues in organic products), as well as the elimination of exemptions allowed in the current version (e.g. the use of in-conversion feed or of non-organic seeds), as well as a strengthening of the control system. As justification for revising the standards, the European Commission stated the interest of consumers in pesticide-free food and the need to improve consumer confidence in organic products (EU 2014b).

4. Bringing the environment back into organic regulations

Ideally, regulations for sustainable agriculture would be outcome-based, setting environmental targets that need to be achieved, as is done, for example, to address air pollution. But the sustainability challenges associated with agriculture are manifold - ranging from biodiversity loss, land degradation, climate change mitigation and adaptation to water resource depletion - and monitoring these outcomes is more difficult. We do, however, believe that organic agriculture could be a powerful tool to move towards more sustainable food production for several reasons, including the continued growth of the organic sector, the strong consumer demand for organic products, and the widespread recognition of the organic label. Most importantly, however, organic currently represents in most countries the only legally-defined label that allows consumers to know about and influence through their consumer behaviour how their food is produced.

Rather than regulating environmental outcomes, organic regulations should continue to be process-based and explicitly include clear requirements for environmental best practices. Such requirements could include, for example, a minimum amount of leguminous crops in rotations (Crews & Peoples 2004), the use of cover crops (Tonitto *et al.* 2006), plant diversification schemes like inter-cropping and trap crops (Letourneau *et al.* 2011), the use of crop varieties with high genetic diversity (Zhu *et al.* 2000), use of conservation tillage (Hobbs *et al.* 2008) or enhanced integration of animal and cropping systems (Naylor *et al.* 2005), all of which have been identified as important environmental best management practices. Some best practices that are already required in some countries (e.g. the setting aside of a certain portion of the farmland as conservation area in Australia, the prohibition of clearing primary vegetation in Uganda and India, or the need for multi-storey cropping systems including native species in areas where the primary vegetation is rainforest in the Mexican regulation) should be adopted by other countries. In order to better represent the ideas of organic pioneers, organic standards should focus on requiring closed nutrient cycling by, for example, encouraging integrated crop-livestock systems, allowing the use of (appropriately treated) human

wastes and municipal composts, limiting the amount of off-farm inputs, or by monitoring soil fertility standards.

Stricter regulation of environmental best practices in organic regulations would most likely bring new challenges, including (1) potentially higher costs for producers leading to some producers exiting organic agriculture, (2) potentially higher prices for consumers, and (3) lower willingness to pay (WTP) for environmental attributes compared to health attributes of organic food. In the following we will discuss each of these challenges in turn.

A recent meta-analysis of studies across North America, Europe and India found that organic farming has typically higher labour but lower input costs, and that despite lower yields, organic is, on average, more profitable than conventional farming due to premium prices received (Crowder & Reganold 2015). Despite this generally higher profitability of organic agriculture, the organic sector is still often supply-limited, and increases in organic area have lagged behind increases in consumer demand (Oberholtzer *et al.* 2005; EC 2010). The barriers that prevent farmers from adopting organic agriculture despite its higher profitability are not well understood but probably include the cost and uncertainty of the transition period, insufficient technical support and access to information on organic practices, lack of marketing opportunities, operational aspects like higher labour requirements and the ease of pest and weed management, as well as farmer attitudes, social pressures and norms (Padel 2001; Schneeberger *et al.* 2002; Rodriguez *et al.* 2009). On the one hand, these current patterns suggest that stricter environmental best practices in organic regulations would most likely not reduce the profitability advantage of organic farming[11]. On the other hand, stricter regulations might create additional barriers for farmers to enter organic agriculture and thereby increase the gap between organic demand and organic supply. Future research and targeted policies need to address the factors preventing farmers from entering the organic market.

A related question is whether stricter organic regulations would lead to an increased concentration of the organic sector by forcing small-scale producers out of organic

[11] Especially given that in the studies included in the meta-analysis by Crowder & Reganold (2016) the breakeven premiums required to make organic as profitable as conventional was only 6%, and considerably lower than the actual 30% price premium received by farmers.

agriculture as they might not have the capital needed to change their operation in order to meet new standards. To understand this better, one potential case study is the recently proposed stricter animal welfare standards for poultry production in the US NOP. An analysis by the USDA amended to the proposed rule suggests that the costs of compliance to these stricter standards would most likely be higher for larger producers, as small producers are already often implementing higher standards (e.g. lower stocking densities and more access to outdoor space), while larger producers might not be able to acquire sufficient land area to comply to new standards without reducing flock sizes (USDA 2016). A similar pattern might apply if stricter environmental best practices were implemented in organic regulations, as small-scale organic producers are often already using sustainable practices like animal integration, higher crop diversity, or smaller field sizes (Belfrage *et al.* 2005), while large-scale organic producers are often using more intensive undiversified agricultural practices (Buck *et al.* 1997; Guthman 2004).

The next question is how more explicit inclusion of environmental best practices in organic regulations would potentially influence consumers. Increased costs of organic production might increase the organic premium and consumers might not be willing to pay such premiums for environmental standards. But firstly, analyses of recent trends in organic price premiums suggest that premiums are not decreasing despite the growth of the organic sector, as prices are not determined only by the costs of organic production but also by the high demand in the organic sector (Oberholtzer *et al.* 2005; Carlson & Jaenicke 2016). Secondly, even though 'health' is the most common motive for organic consumers, altruistic values of environment, animal welfare and societal well-being are still of importance to many organic consumers today (Zanoli & Naspetti 2002), Table 6); 30% of English respondents (Hutchins & Greenhalgh 1995), 50% in Germany (Oltersdorf 1983), and 85% in Ireland (Davies *et al.* 1995) stated, for example, that they bought organic food mainly or partly for environmental reasons. Thirdly, consumers have often been shown to have high WTP for clearly defined and communicated additional attributes of organic food (Lusk & Briggeman 2009; Zander & Hamm 2010). Currently one of the main barriers to organic consumption is confusion and lack of knowledge of the different organic labels used and their meaning (Hutchins & Greenhalgh 1995; Padel & Foster 2005; Janssen & Hamm 2012). But the more information is provided about an organic

product, the more people are willing to buy it and pay a higher price for it (Soler *et al.* 2002; Stolz *et al.* 2011). And consumers with strong environmental values have often a higher WTP for organic food (Gil *et al.* 2000; Lusk & Briggeman 2009; Costanigro *et al.* 2016), as they associate organic food with superior environmental performance (Costanigro *et al.* 2016). Clearer environmental standards in organic regulations would thus allow consumers to more clearly differentiate the environmental attributes of organic food and thus potentially increase their WTP for organic premiums.

Given these trends we therefore believe that clear environmental standards in organic regulations that can be communicated to the consumer might not necessarily reduce the demand for organic food but could, instead, allow for increased growth of the organic sector by meeting the demands of organic consumers with environmental values and by increasing consumer trust in the organic label.

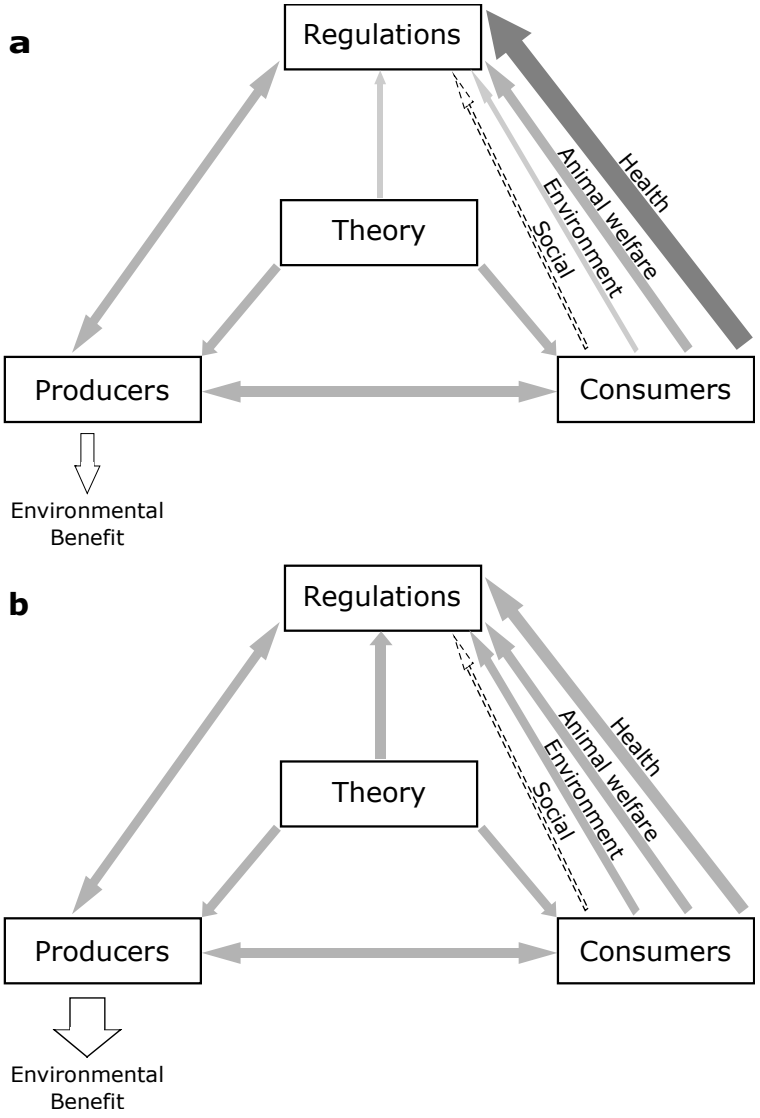

Fig. 2. The current main poles of influence of organic agriculture (**a**) and how these poles would look like if the environment was brought back into organic regulations (**b**). The thickness and shade of arrows indicates the importance of each influence; dotted arrows indicate influences that are basically non-existent.

5. Conclusion

Organic regulations appear to be caught between different and often opposing interests and therefore watered-down to be rather one-dimensional. As the organic market continues to grow, and as more farmers enter organic production, and a larger, and more diverse group of consumers demand affordable chemical-free food, there is a risk that organic agriculture will be reduced even more to the lowest common denominator

between the different interest groups, i.e. absence of synthetic substances. The original idea of organic being environmentally friendly farming is in danger of being lost.

Organic regulations are the place where organic agriculture is defined today. Organic regulations should therefore be very clear about what the goal of organic agriculture is. If organic agriculture is to primarily deliver chemical-free food to consumers, organic regulations should include more product standards (e.g. food safety, residue-free food) rather than prescribing process standards, as they do today. If organic agriculture is, instead, to stay truer to its original ideas and include a holistic understanding of ecosystem and human health and more sustainable (soil) management practices, organic regulations should include more environmental best practices in their process standards.

But such policy changes need to be supported by continued research in three key areas: Firstly, agricultural and environmental research needs to clearly identify the environmental best management practices that lead to beneficial environmental outcomes. Secondly, economic and psychological research needs to better understand the WTP of consumers for environmental attributes of organic food, and how these attributes should be communicated to increase consumers' WTP. Thirdly, social research needs to identify the reasons keeping farmers from entering organic agriculture. If we address these knowledge gaps and at the same time include clearer environmental standards in organic regulations, organic agriculture could play an important role in the creation of a more sustainable food system.

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Supplementary Material

Appendix A: Additional Tables

Table A1. Colour version of Table 4 in main text. Comparison of importance of organic principles within each regulation.

	Natural	Animal	Human	Soil	Local	Biodiv	Water
Mexico	2	1	4	5	3	7	6
IFOAM	1	7	2	3	6	5	4
Aus	1	6	3	4	7	5	2
Uganda	1	2	5	4	3	6	7
India	1	6	2	4	5	3	7
EU	1	2	3	5	4	7	6
US	1	2	3	4	7	6	5
FAO	2	1	3	4	7	6	5
Rank	1	2	3	4	5	6	7
Score	77	46	42	21	17	16	13

Table A2. Colour version of Table 5 in main text. Comparison of how different sustainable management practices identified by Altieri & Rosset (1996) are regulated in organic regulations. Red - the management practice is not discussed; orange - practice is discussed but not regulated, or its use is suggested but not required; green – its use is required. See Supplementary Table S5 for more details about how these practices are regulated.

	IFOAM	FAO	Austr.	EU	US	India	Mexico	Ugan.
Living mulch*								
Dead soil cover**								
Cover Crops								
Conservation tillage								
Alley cropping								
Agroforestry								
Living Barriers***								
Rotations								
Crop Associations								
Cultivar Mixtures								
Animal integration								

*a cover crop interplanted or undersown with the main crop
** mulching with dead biological or synthetic material
***a windbreak usually involving trees and/or shrubs

Table A3. Sensitivity analysis of the comparison of organic principles within regulations. Weighting method 1 uses relative word count as weighting factor; weighting method 2 uses the square of the relative word count as weighting factor; scoring 1 method uses scores of 0, 0.5 and 1; scoring method 2 uses scores if 0 or 1.

Method	Natural	Human	Animal	Soil	Local	Biodiv	Water
Researcher 1, scoring 1, unweighted	1	2	3	5	5	4	7
Researcher 2, scoring 1, unweighted	1	5	2	4	7	3	6
Researcher 1, scoring 1, weighting 1	1	2	3	4	5	6	7
Researcher 2, scoring 1, weighting 1	1	3	2	4	6	5	7
Researcher 1, scoring 1, weighting 2	1	2	3	4	5	6	7
Researcher 2, scoring 1, weighting 2	1	3	2	4	5	6	7
Researcher 1, scoring 2, unweighted	1	2	3	5	5	4	7
Researcher 2, scoring 2, unweighted	1	5	2	4	7	3	6

Table A4. Comparison of regulation of human wastes in different organic regulatory texts.

	US	**EU**	**FAO**	**IFOAM**	**Aus**	**India**	**Uganda**	**Mexico**
Sewage sludge	Not allowed	Not part of list of allowed substances, not allowed	Not mentioned specifically, included in human excrements	Not mentioned specifically, included in human excrements	After treatment; to non-edible crops & pastures; to crops for human consumption only through trickle irrigation & precluding contact with edible parts	From separated sources, monitored for contamination	/	Not allowed
Human excrements	/	Not part of list of allowed substances, not allowed	Only from separated sources, monitored for contamination, treated to eliminate risks, not on edible crops	Only on non-edible crops; exceptions may be made	/	Not allowed	Not allowed	If composted, not applied to edible crops
Municipal solid wastes (i.e. urban composts)	Not mentioned specifically, included in compost	Only from separated sources, after treatment, monitored for contamination, below defined limits of metal concentrations	Sorted, composted or fermented	From separated sources, monitored for contamination	Not mentioned specifically, included in compost	From separated sources, monitored for contamination	From separated sources, monitored for contamination	Only after treatment, monitored for contamination, below defined limits of metal concentrations

Table A5. Comparison of regulation of environmental best practices, as identified by Altieri & Rosset (1996, see reference in main article), in different organic regulatory texts.

Sustainable management practice	US		EU	
	Regulated	Wording	Regulated	Wording
Living mulch*	Not discussed	/	Not discussed	/
Dead soil cover/mulch	Use suggested	§205.206 Weed problems may be controlled through (1) Mulching with fully biodegradable materials	Not discussed	/
Cover Crops	Use required	§205.203 The producer must manage crop nutrients and soil fertility through rotations, cover crops, and the application of plant and animal materials. §205.205 The producer must implement a crop rotation including but not limited to sod, cover crops, green manure crops, and catch crops that provide the following functions that are applicable to the operation: (...)	Not discussed	/
Conservation tillage	Use suggested (unclear wording)	§205.203 The producer must select and implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of soil and minimize soil erosion.	Use suggested (unclear wording)	EU 2007, Article 12 - (a) organic plant production shall use tillage and cultivation practices that maintain or increase soil organic matter, enhance soil stability and soil biodiversity, and prevent soil compaction and soil erosion;
Alley cropping	Use suggested for perennial crops	Definitions - Perennial cropping systems employ means such as alley cropping, intercropping, and hedgerows to introduce biological diversity in lieu of crop rotation.	Not discussed	/
Agroforestry	Not discussed	/	Not discussed	/
Living Barriers**	Not discussed	/	Not discussed	/

Rotations	Use required	§205.203 The producer must manage crop nutrients and soil fertility through rotations, cover crops, and the application of plant and animal materials. §205.205 The producer must implement a crop rotation including but not limited to sod, cover crops, green manure crops, and catch crops that provide the following functions that are applicable to the operation: (a) Maintain or improve soil organic matter content; (b) Provide for pest management in annual and perennial crops; (c) Manage deficient or excess plant nutrients; and (d) Provide erosion control.	Use required	EU 2007, Article 12 -(b) the fertility and biological activity of the soil shall be maintained and increased by multiannual crop rotation including legumes and other green manure crops (…);
Crop Associations	Use suggested for perennial crops	Definitions - Perennial cropping systems employ means such as alley cropping, intercropping, and hedgerows to introduce biological diversity in lieu of crop rotation.	Not discussed	/
Cultivar Mixtures	Not discussed	/	Not discussed	/
Animal integration	Not discussed	/	Not regulated	EU 2008, preamble - The holistic approach of organic farming requires a livestock production related to the land, where the produced manure is used to nourish the crop production.

Table A5 continued.

Sustainable management practice	Australia		India	
	Regulated	Wording	Regulated	Wording
Living mulch*	Not discussed	/	Not discussed	/
Dead soil cover/mulch	Use suggested	3.8 Where used, mulches should be of natural materials. 3.8.1 Pests, diseases and weeds must be controlled by any combination of the following: (h) mulching and mowing	Use suggested	3.2.5 Weeds, pests and diseases should be controlled by a number of preventive cultural techniques which limit their development, e.g. suitable rotations, green manures, a balanced fertilising programme, early and predrilling seedbed preparations, mulching, mechanical control and the disturbance of pest development cycles.
Cover Crops	Not discussed	/	Use suggested	3.2.3 Diversity in crop production is achieved by a combination of: - an appropriate coverage of the soil during the year of production which diverse plant species
Conservation tillage	Use suggested (unclear wording)	3.5.1 The fertility and the biological activity of the soil must be maintained or increased by any combination of the following methods: (e) tillage techniques which preserve or improve soil structure.	Not discussed	/
Alley cropping	Not discussed	/	Not discussed	/
Agroforestry	Not discussed	/	Not discussed	/

Living Barriers**	Use suggested	3.4.2 Operators must develop 5% of their property as treed areas, grasslands or other reserves which are non-cultivated and nonintensively grazed within five years from the date the production unit attains in-conversion status. 3.4 An organic production unit can enhance biodiversity by: (c) provision of wind breaks and non-cultivated buffer zone areas.	Not discussed?	3.1.3 Areas which should be managed properly and linked to facilitate biodiversity: - Extensive pastures, meadows, extensive grassland, extensive orchards, hedges, hedgerows, groups of trees and/or bushes and forest lines. The certification programme shall set standards for a minimum percentage of the farm area to facilitate biodiversity and nature conservation.
Rotations	Use required	3.7.4 Crop rotations aid long-term soil fertility and ensure healthy plants. Operators shall include deep rooted and leguminous species within crop rotations.	Use suggested (crop diversity in space or time)	3.2.3 Diversity in crop production is achieved by a combination of: - a versatile crop rotation with legumes3.2.3.1. Where appropriate, the certification programme shall require that sufficient diversity is obtained in time or place in a manner that takes into account pressure from insects, weeds, diseases and other pests, while maintaining or increasing soil, organic matter, fertility, microbial activity and general soil health. For non perennial crops, this is normally, but not exclusively, achieved by means of crop rotation.
Crop Associations	Use suggested (unclear wording)	3.7 The proper choice of variety, stimulation of soil fertility, careful sowing and cultivation techniques (e.g. rotation, variety, use of mixed cropping, plant spacing, use of green manures) hinders the incidence of pests and diseases.	Use suggested (crop diversity in space or time)	3.2.3.1. Where appropriate, the certification programme shall require that sufficient diversity is obtained in time or place in a manner that takes into account pressure from insects, weeds, diseases and other pests, while maintaining or increasing soil, organic matter, fertility, microbial activity and general soil health. For non perennial crops, this is normally, but not exclusively, achieved by means of crop rotation.
Cultivar Mixtures	Not discussed	/	Not discussed	/

Animal integration	Not regulated	3.8 Livestock are an integral part of a broad acre organic farming system.	Not regulated	3.1.1 For a sustainable agro-ecosystem to function optimally, diversity in crop production and animal husbandry must be arranged in such a way that there is an interplay of all the elements of the farming management.

Table A5 continued.

Sustainable management practice	IFOAM		FAO	
	Regulated	Wording	Regulated	Wording
Living mulch*	Not discussed	/	Not discussed	/
Dead soil cover/mulch	Use suggested	4.5 Pests, diseases and weeds should be managed by the knowledgeable application of one, or a combination, of the following measures: (j) mulching and mowing;	Use suggested	Annex 1.A.6 - Pests, diseases and weeds should be controlled by any one, or a combination, of the following measures: - mulching and mowing;
Cover Crops	Use suggested	2.2 Operators should minimize loss of topsoil through minimal tillage, contour plowing, crop selection, maintenance of soil plant cover and other management practices that conserve soil. 4.3 Diversity in crop production is achieved by a combination of: (b) appropriate coverage of the soil with diverse plant species for as much of the year as possible.	Not discussed	/
Conservation tillage	Use suggested	2.2 Operators should minimize loss of topsoil through minimal tillage, contour plowing, crop selection, maintenance of soil plant cover and other management practices that conserve soil.	Not discussed	/
Alley cropping	Not discussed	/	Not discussed	/
Agroforestry	Not discussed	/	Not discussed	/
Living Barriers**	Not discussed	/	Not discussed	/

Rotations	Use required	4.3 Diversity in crop production is achieved by a combination of: (a) a diverse and versatile crop rotation that includes green manure, legumes and deep rooting plants; 4.3.1 Diversity in plant production and activity shall be assured by minimum crop rotation requirements and/or variety of plantings. Minimum rotation practices for annual crops shall be established unless the operator demonstrates diversity in plant production by other means.	Use suggested	Annex 1.A.5 - The fertility and biological activity of the soil should be maintained or increased, where appropriate, by: a) cultivation of legumes, green manures or deep-rooting plants in an appropriate multi-annual rotation programme;
Crop Associations	Use suggested (unclear wording)	4.3.1 Diversity in plant production and activity shall be assured by minimum crop rotation requirements and/or variety of plantings. Minimum rotation practices for annual crops shall be established unless the operator demonstrates diversity in plant production by other means.	Not discussed	/
Cultivar Mixtures	Use suggested (unclear wording)	4.3.1 Diversity in plant production and activity shall be assured by minimum crop rotation requirements and/or variety of plantings. Minimum rotation practices for annual crops shall be established unless the operator demonstrates diversity in plant production by other means.	Not discussed	/

Animal integration	Not discussed	/	Not regulated	Annex 1.B.2 - Livestock can make an important contribution to an organic farming system by: a) improving and maintaining the fertility of the soil; b) managing the flora through grazing; c) enhancing biodiversity and facilitating complementary interactions on the farm; and d) increasing the diversity of the farming system.

Table A5 continued.

Sustainable management practice	Uganda		Mexico	
	Regulated	Wording	Regulated	Wording
Living mulch*	Not discussed	/	Not discussed	/
Dead soil cover/mulch	Use suggested	2.6.2 Pests, diseases and weeds should be managed by the knowledgeable application of one, or a combination, of the following measures: - Mulching and mowing	Use suggested	ARTÍCULO 47.- Los operadores orgánicos que tengan en su unidad de producción hierbas no deseadas realizarán preferentemente su retiro manual o mecánico de la hierbas y utilizarán herramientas adecuadas, acolchados, cubiertas (contra biotransmisores), cultivos de cobertura tales como: leguminosas y vegetales silvestres.
Cover Crops	Use suggested	2.4.2 Diversity in crop production is achieved by a combination of: - appropriate coverage of the soil with diverse plant species for as much of the year as possible	Use required	ARTÍCULO 24.- De acuerdo con las condiciones y factores ambientales, así como las particulares de cada unidad de producción, se deberá prevenir o reducir la erosión del suelo utilizando técnicas agroecológicas apropiadas de conservación como son entre otras: III. Los cultivos de cobertura. ARTÍCULO 27.- Los operadores orgánicos, deberán aplicar prácticas agronómicas para que el suelo permanezca cubierto con una capa vegetal la mayor parte del tiempo, de acuerdo a sus condiciones agroecológicas.

Conservation tillage	Use suggested	1.2.2 Operators should minimise loss of topsoil through minimal tillage, contour ploughing, crop selection, and rotation maintenance of soil plant cover and other management practices that conserve soil.	Use suggested	ARTÍCULO 24.- De acuerdo con las condiciones y factores ambientales, así como las particulares de cada unidad de producción, se deberá prevenir o reducir la erosión del suelo utilizando técnicas agroecológicas apropiadas de conservación como son entre otras: IV. La labranza de conservación. ARTÍCULO 42.- La producción vegetal orgánica deberá estar orientada a: II. Fomentar e implantar prácticas de labranza y cultivo que mantengan, mejoren o incrementen la materia orgánica del suelo que refuercen la estabilidad y la biodiversidad edáficas, prevengan la compactación y la erosión del suelo;
Alley cropping	Not discussed	/	Use required (in areas where native vegetation is forest)	ARTÍCULO 26.- En las zonas donde la vegetación original o nativa la constituyan bosques o selvas, la operación orgánica deberá establecer en las áreas de cultivo, sistemas diversificados con dos o más estratos vegetales de especies nativas, especialmente en los cultivos perennes.
Agroforestry	Not regulated	2.6.2 Pests, diseases and weeds should be managed by the knowledgeable application of one, or a combination, of the following measures: - Diversified ecosystems. For example buffer zones to counteract erosion, agro-forestry, rotating crops, intercropping etc.	Use required (in areas where native vegetation is forest)	ARTÍCULO 26.- En las zonas donde la vegetación original o nativa la constituyan bosques o selvas, la operación orgánica deberá establecer en las áreas de cultivo, sistemas diversificados con dos o más estratos vegetales de especies nativas, especialmente en los cultivos perennes.

Living Barriers**	Not discussed?	1.1.2 The operators should maintain a significant portion of their farms in order to facilitate biodiversity and nature conservation of their areas - In general all areas which are not under rotation and are not heavily manured: extensive pastures, meadows, extensive grassland, extensive orchards, hedges, hedgerows, edges between agriculture and forest land, groups of trees and/or bushes, and forest and woodland	Use suggested	ARTÍCULO 24.- De acuerdo con las condiciones y factores ambientales, así como las particulares de cada unidad de producción, se deberá prevenir o reducir la erosión del suelo utilizando técnicas agroecológicas apropiadas de conservación como son entre otras: I. Las barreras vivas o muertas;
Rotations	Use required (crop diversity in space or time)	2.4.2 Diversity in crop production is achieved by a combination of: - a diverse and versatile crop rotation that includes green manure, legumes and deep rooting plants 2.4.3.1 Diversity in plant production shall be assured by a crop rotation and/or variety of plantings through interplanting. 2.6.2 Pests, diseases and weeds should be managed by the knowledgeable application of one, or a combination, of the following measures: - Choice of appropriate species and varieties appropriate rotation programs	Use required (crop diversity in space or time)	ARTÍCULO 38.- Las rotaciones de cultivos, asociaciones y/o cultivos mixtos e intercalados, deben ocupar un lugar prioritario en los planes orgánicos, como una estrategia para evitar agotar los nutrientes del suelo, ayudar al desarrollo de la resistencia natural a plagas y enfermedades del suelo. ARTÍCULO 39.- La planeación de las rotaciones, asociaciones y/o cultivos mixtos e intercalados, debe estar orientada a prevenir la erosión, mantener la fertilidad del suelo, reducir el lavado o lixiviación de nutrientes y los problemas ocasionados por plagas, enfermedades y hierbas no deseadas. ARTÍCULO 41.- El operador deberá plasmar en su Plan Orgánico, de rotación de sus cultivos, la naturaleza de las especies, la presencia de hierbas, las condiciones locales y las necesidades de producción o consumo, entre otras y para el caso de las parcelas utilizadas para pastoreo, las rotaciones deben incluir a las leguminosas, así como de la promoción de los sistemas agrosilvopastoriles.

Crop Associations	Use required (crop diversity in space or time)	2.4.3.1 Diversity in plant production shall be assured by a crop rotation and/or variety of plantings through interplanting. 2.6.2 Pests, diseases and weeds should be managed by the knowledgeable application of one, or a combination, of the following measures: - Diversified ecosystems. For example buffer zones to counteract erosion, agro-forestry, rotating crops, intercropping etc.	Use required (crop diversity in space or time)	ARTÍCULO 40.- Para el caso de que no sea posible la rotación, se debe promover la diversificación de especies mediante asociaciones y/o cultivos mixtos e intercalados, para mejorar la fertilidad del suelo y la biodiversidad.
Cultivar Mixtures	Use suggested	2.1.2 A wide range of crops and varieties should be grown to enhance the sustainability, self-reliance and biodiversity value of organic farms. Plant cultivars suitable for organic production should be selected to maintain both genetic diversity and biodiversity.	Not discussed	/
Animal integration	Not discussed	/	Use required	ARTÍCULO 28.- La producción animal orgánica deberá contribuir al equilibrio de la producción vegetal o forestal, satisfaciendo las necesidades de nutrientes de las especies vegetales.

*a cover crop interplanted or undersown with the main crop
** mulching with dead biological or synthetic material
***a windbreak usually involving trees and/or shrubs

Appendix B: Review of organic consumer motives

We included studies cited in (Yiridoe et al., 2005), Table 2, and (Schleenbecker and Hamm, 2013), Table 3, as well as studies reviewed by (Hughner et al., 2007) in our analysis. We also included other studies we found during a broad literature review. This does, however, not represent a systematic literature review, as we did not conduct a systematic literature search in scientific databases. Studies were included if they either reported (1) characteristics associated by consumers with organic products, (2) purchasing motivations of organic consumers. Studies that examined the relationship between general political and moral attitudes of consumers and the relationship with organic purchasing behaviour (e.g. de Magistris and Gracia, 2008; Tarkiainen and Sundqvist, 2005) were not included. Some studies did not actually examine organic consumers motives or perceived organic product characteristics directly, but they still interpreted their results in terms of purchasing motives (e.g. O'Donovan and McCarthy, 2002) and were therefore included in the analysis. Note that the majority (i.e. 20/34) studies included in this review are more than 10 years old (i.e. from before 2006), and most studies were conducted in the early 2000s (i.e. the same time that many organic regulations came into practice). But only 5 studies are from before the year 2000.

We assigned the key results of each study to seven different potential reasons why consumers buy organic, or potential characteristics consumers associate with organic food: (1) health (including food quality and food safety), (2) chemical-free, (3) environment, (4) animal welfare, (5) social. Studies received a score on 'health' if they identified personal health as a buying reason for organic consumers or as a characteristics associated with organic food. This included statements like "I buy organic food because it is good for my health", or product characteristics like "Organic food is healthier than conventionally grown food", but it also included notions of food quality (e.g. perceived better taste, higher nutritional content or freshness of organic food) and food safety[1], like "I buy organic food because I worry about health scares" or "I buy organic food because it has a high safety level of guarantee and control". 'Chemical-free' denoted statements or motives related to the absence of certain chemical substances, like "Organic food does not contain pesticides". 'Environment' and 'animal welfare' were related to environmental characteristics and animal welfare standards. While 'social' described notions like "To help poor farmers out there", or "It is more likely to be locally produced".

If possible the principles associated with organic food were ranked based on the importance of each factor for consumers in each study. Sometimes the ranking was based on statistical summary tables, and for example the %variation

[1] We combined the motives of 'food safety' and 'food quality' into the 'health' category, as these were not always easy to separate, for example, in statements like "I buy organic food because it is better for me."

explained by each factor, in other cases it was based on a qualitative description of results by the authors, e.g. “By far the strongest reason for buying organic food was health”, or “Secondary reasons for buying organic food were animal welfare, taste and local/regional production”. If a ranking was possible, the score of each factor represents its rank in that study. If a ranking of the factors identified in a study was not possible, every factor identified received a score of 1. Studies did not receive any score on a factor either if they did not examine or discuss this factor, or if they tested it but it did not show up as a significant motivation of organic consumers.

To calculate aggregate scores, the average score for each factor across studies was taken, and divided by the number of times a factor was identified as contributing to consumer’s perspectives on organic food. This step ensured that factors that were identified more frequently in studies – no matter their ranking within each study – received a lower score (e.g. ‘animal welfare’ was often ranked quite closely to ‘environment’ in studies, but because it was identified as a factor contributing to consumers perception of organic much less frequently than ‘environment’, it received overall a higher score). It is important to note that a lower score is positive in this scoring approach, as it implies a higher rank in consumer’s importance.

In total we could include 34 studies, providing 10 observations on product characteristics, and 25 observations on purchasing motives. Table B1 summarizes the results from this scoring analysis from all 34 studies, while Table B2 provides an overview of the studies included.

Table B1. Results of comparison of organic product characteristics and purchasing motives of organic consumers across 34 studies. See Table B2 for references of studies. / means the factor was not examined, * means the factor was tested but not found to be associated with organic products or purchasing motives.

	Health	Natural	Environment	Animal	Social	Variable examined
study1	1	/	/	/	/	product characteristics
study2	/	1	2	3	/	product characteristics
study3	1	2	4	/	3	purchasing motives
study4	/	1	2	3	/	purchasing motives
study5	1	/	3	/	/	purchasing motives
study6	1	/	/	/	/	purchasing motives
study7	1	/	2	3	/	purchasing motives
study8	2	1	3	/	/	purchasing motives
study9	1	/	*	/	/	purchasing motives
study10	1	/	/	2	/	purchasing motives
study11	1	/	1	/	/	purchasing motives
study12	1	/	1	1	/	purchasing motives

study13	2	1	/	/	/	product characteristics
study14	1	/	2	/	/	purchasing motives
study15	1	1	2	/	/	product characteristics
study16	2	1	3	/	/	purchasing motives
study17	1	2	/	/	3	product characteristics
study18	1	/	2	3	/	purchasing motives
study19	1	/	3	2	/	purchasing motives
study20	1	/	3	2	/	purchasing motives
study21	1	/	/	/	/	purchasing motives
study22	1	2	3	4	4	purchasing motives
study23	1	2	3	/	/	purchasing motives
study24	2	/	1	/	/	purchasing motives
study25	/	2	1	/	/	product characteristics
study25	1	3	2	/	2	purchasing motives
study26	2	1	3	/	5	purchasing motives
study27	1	/	2	*	3	purchasing motives
study28	3	/	1	2	/	product characteristics
study29	1	/	/	/	/	product characteristics
study30	1	/	2	3	/	purchasing motives
study31	1	2	3	4	5	product characteristics
study32	1	2	/	4	3	product characteristics
study33	/	/	3	1	2	purchasing motives
study34	1	/	/	/	/	purchasing motives
Score	**0.76**	**0.92**	**1.20**	**2.32**	**2.82**	**product characteristics**
Rank	**1**	**2**	**3**	**4**	**5**	
Score	**0.61**	**1.23**	**1.33**	**1.71**	**2.55**	**purchasing motives**
Rank	**1**	**2**	**3**	**4**	**5**	

Table B2. Studies included in the review of consumer motives.

	Author	Country	Region	Year	Urban	Design	Subjects	Variable examined
study1	Radman (2005)	Croatia	Europe	2002	urban	quantitative	general consumers	product characteristics
study2	Aarset et al. (2004)	FR, DE, NO, ES, UK	Europe	1998/99	national	qualitative	general consumers	product characteristics
study3	Chang and Zepeda (2005)	Australia	Oceania	NA	rural	qualitative	general consumers	purchasing motives
study4	Chen (2007)	Taiwan	Asia	NA	national	quantitative	general consumers	purchasing motives
study5	Chryssohoidis and Krystallis (2005)	Greece	Europe	NA	urban	quantitative	organic consumers	purchasing motives
study6	Dahm et al. (2009)	USA	USA	NA	urban	quantitative	general consumers (students)	purchasing motives
study7	Davies et al. (1995)	Ireland	Europe	1989-93	urban	quantitative	general consumers	purchasing motives
study8	Ekelund (1989)	Sweden	Europe	NA	NA	quantitative	NA	purchasing motives
study9	Gracia and de Magistris (2008)	Italy	Europe	2003	urban	quantitative	general consumers	purchasing motives
study10	Harper and Makatouni (2002)	UK	Europe	1999	urban	qualitative	general consumers (parents)	purchasing motives
study11	Hill and Lynchehaun (2002)	UK	Europe	NA	NA	qualitative	general consumers (women)	purchasing motives
study12	Hjelmar (2011)	Denmark	Europe	2008/09	NA	qualitative	general consumers	purchasing motives
study13	Hoefkens et al. (2009)	Belgium	Europe	2006/07	regional	quantitative	organic vs. general consumers	product characteristics
study14	Hutchins and Greenhalgh (1995)	UK	Europe	NA	urban	quantitative	general consumers	purchasing motives
study15	Lea and Worsley (2005)	Australia	Oceania	2004	urban	quantitative	general consumers	product characteristics
study16	Lockie et al. (2004)	Australia	Oceania	NA	national	qualitative	general consumers	purchasing motives
study17	Magnusson et al. (2001)	Sweden	Europe	1998	national	quantitative	general consumers	product characteristics
study18	Magnusson et al. (2003)	Sweden	Europe	1998	national		general consumers	purchasing motives
study19	Makatouni (2002)	UK	Europe	2000	urban	qualitative	organic consumers	purchasing motives

							(parents)	
study20	O'Donovan and McCarthy (2002)	Ireland	Europe	NA	NA	quantitative	general consumers	purchasing motives
study21	Ozguven (2012)	Turkey	Europe	2012	urban	quantitative	general consumers	purchasing motives
study22	Padel and Foster (2005)	UK	Europe	2002	urban	qualitative	organic consumers	purchasing motives
study23	Roitner-Schobesberger et al. (2008)	Thailand	Asia	2005	urban	quantitative	general consumers	purchasing motives
study24	Saba and Messina (2003)	Italy	Europe	NA	national	quantitative	general consumers	purchasing motives
study25	Sangkumchaliang and Huang (2012)	Thailand	Asia	2009	urban	quantitative	organic consumers	product characteristics, purchasing motives
study26	Schifferstein and Oude Ophuis (1998)	Netherlands	Europe	1988	national	quantitative	organic vs. general consumers	purchasing motives
study27	Sirieix et al. (2011)	China	Asia	NA	urban	qualitative	organic consumers	purchasing motives
study28	Stobbelaar et al. (2007)	Netherlands	Europe	NA	urban	quantitative	general consumers (adolescents)	product characteristics
study29	Tsakiridou et al. (2008)	Greece	Europe	NA	urban	quantitative	general consumers	product characteristics
study30	Wandel and Bugge (1997)	Norway	Europe	1993	national	quantitative	general consumers	purchasing motives
study31	Zagata (2012)	Czech Republic	Europe	2011	national	quantitative	organic consumers	product characteristics
study32	Zakowska-Biemans (2011)	Poland	Europe	2007	national	quantitative	general consumers	product characteristics
study33	Zander and Hamm (2010)	DE, CH, AT, UK, IT	Europe	NA	NA	quantitative	organic consumers	purchasing motives
study34	Zanoli and Naspetti (2002)	Italy	Europe	NA	NA	qualitative	organic vs. general consumers	purchasing motives