Studying the Effect of Organic Farming on Rural Landscapes: Issues of Methodology and Scale

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Abstract

Implying changes in land use practices, the conversion from conventional to organic farming has a potential effect on the spatial arrangement of land cover and thus on structure and content of natural and semi-natural landscape elements. Several studies point to that organic farming has a positive effect on the content of natural and semi-natural elements in Danish and other European landscapes. However, these findings seem biased by inadequate sampling methods and narrow spatial and temporal study scales. On the contrary, the few studies using more comprehensive samples and broader scales, indicate that variations in the content of natural and semi-natural landscape elements are influenced by regional and local biophysical variations in relation to the localisation of organic farms rather than by organic or conventional farming as such. Consequently, in the context of a current Danish research project on this issue, this paper argues for two supplementing methodological approaches. The first, using national datasets on landscape features, farm characteristics and biophysical conditions. The second, using aerial photos for the last 5 decades together with agricultural statistics, questionnaires and biophysical base maps within larger continuous case areas.

Introduction and background

With special focus on natural and semi-natural landscape elements[1], this paper reviews existing Danish and other European studies on relationships between organic farming and landscapes with special focus on natural and semi-natural landscape elements. The findings from these studies are evaluated in the context of applied data, methods and study scales. On basis of this evaluation it is argued that particularly sampling methods and choice of temporal and spatial study scales are critical issues for the design of an appropriate methodological framework when studying relations between organic farming and landscapes.

Agricultural production is closely tied to its land base. Spatial configuration of soil quality, topography and constraining or promoting landscape elements influence agricultural strategies. In contrast, agriculture also significantly influences landscape patterns as farmers form them to better support their production needs. Throughout history socio-economic, cultural and political changes together with technological improvements affected land use options and led to alterations of landscapes. Consequently, alterations in agricultural practices related to the conversion from conventional to organic farming imply a potential effect on landscape patterns.

In Europe organic farming has a history of more than 75 years. Following a rising awareness of the negative environmental effects of conventional farming, from the late 1980s state subsidies for organic farming in most EU-member states led to a considerable increase of organic farming (Yussefi and Willer

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1 In the context of this paper the terms natural and semi-natural embrace uncultivated undisturbed or extensively used landscape elements like bogs, heath, ditches, hedgerows, meadow etc.

2003). Thus, at present organic farming constitutes an important actor in many European countries, not least Denmark where currently roughly 6,5% of all arable land is farmed organically.

In the societal and political sphere a general expectation exists that organic farming benefits nature content in rural landscapes. Due to its holistic system approach it is seen as a tool to counteract the accelerated negative impact on Danish and other European landscapes that followed intensification and industrialisation of agriculture, particularly after World War II. E.g. Wilhjelmudvalget (2001) points to organic farming as an instrument for more efficient protection of natural and semi-natural elements in Danish landscapes. Yet, though principles for organic farming include the maintenance and protection of plant and wildlife habitats (IFOAM 2002) in most countries standards and rules for organic farming do not specifically concern natural or semi-natural landscape elements.

A potential relation between organic farming and quantity of natural and semi-natural landscape elements however exists and reasons are in principle twofold. First, qua its definition and ensuing standards and regulations, organic farming induces changes in agricultural practices that have a potential effect on landscape patterns and structure. Due to a ban on chemical fertiliser and pesticides organic farming is forced to maintain nutrient balances through crop rotation, possibly leading to a larger heterogeneity in land cover and thus more and smaller fields with longer field margins, which are potential small-scale habitats for wild flora and fauna (Frederiksen 2001). Further, in order to prevent plant diseases and pests without chemical inputs, organic farming possibly promotes the creation and maintenance of small biotopes as habitats for natural predators (van Elsen 1997; van Elsen 2000). Potential reverse effects of organic farming on landscape configuration have also been suggested. The necessity to, to a larger degree maintain supplies of nutrients and matter from within the production system could force organic farmers to intensify land use on formerly uncultivated or marginal land (Frederiksen 2001). As a consequence, although organic farmers may not be directly forced to maintain or improve certain aspects of landscape patterns through production standards, differences in agricultural practices can have a potential effect on landscape patterns. However, such effects of conversion to organic farming will be subject to regional variations and to variations between different production types. E.g. Langer (1997) argues that in Denmark the conversion of pig breeding or crop producing farms will have much more marked effects on the landscape pattern than the conversion of dairy farms.

Second, recent research indicates that land use practices and thus their effect on the landscape pattern have to be seen within a broader framework, embracing socio-economic and cultural parameters (Brandt, Primdahl et al. 1999; Ellis, Heal et al. 1999; Primdahl 1999; Kristensen, Thenail et al. 2001). E.g. based on an analysis of landscape changes within two parishes in western Denmark, Busck (2002) argues that other landscape functions than only agricultural production need to be included in analyses of farmers' landscape management decisions. Busck's results indicate that values largely influence farmers' landscape practice. Similarly Madsen (2001) demonstrates that farmers' reasoning concerning the location of afforestation areas is very complex and includes their socio-economic situation and cultural background. Though research comparing organic and conventional farmers with regards to socio-economic and cultural differences is scarce, such differences may certainly exist, at least in a local or regional context and thus be reflected in variations within landscape practices.

In conclusion, agricultural practices as well as socio-economic conditions and cultural background directly or indirectly influence the way farmers manage the landscape on their farms. Differences between organic and conventional farmers with respect to these parameters therefore imply potential variations in landscape patterns between organic and conventional farms (Stolze, Piorr et al. 2000; Frederiksen 2001). On basis of the above argumentation of the potential effect of organic farming on rural landscapes, the following section presents a number of studies and their findings in the context of used methods, field site sampling and applied spatial and temporal scales.

Review of existing studies

Denmark

Larsen and Clausen (1995) investigate densities of small biotopes[2] on 30 organic farms located within two larger areas on Zealand and compare results to conventional farms from another study on small biotopes in 13 case areas in east Denmark (Biotopgruppen 1986). Their study is based on aerial photo interpretation and registration in the field. Furthermore, historical aerial photos are used to examine changes in field sizes on organic farms. Results point to markedly higher densities of small biotopes on organic farms, constituting 6,5% of all land compared to 4% on conventional farms. Additionally, results also show that field units are smallest on organic farms and have since the 1950s only become slightly larger. Several explanations for these differences between organic and conventional farms are put forward comprising divergent agricultural production, organic standards and farmers' attitudes. But these explanations lack empirical foundation. Furthermore, it is supposed that organic farms are primarily located in areas that in advance are rich in small biotopes. However, this hypothesis can not be underpinned, as the spatial scale of the study is restricted to single farm units and does not encompass the surrounding landscape or a comparison between regions. Furthermore, the investigation of changes is restricted to field sizes on organic farms and can thus not elucidate whether these tendencies are only characterising organic farms.

As part of a larger study on divergences between organic and conventional farming Tress (1999) investigates extent and management of natural and semi-natural landscape elements in two Danish counties[3]. Tress's investigation is based on questionnaires with all responding (133) organic farms and a stratified random selection (330) of conventional farms in the two counties. Differences are most pronounced on the cultivated areas, where organic farms have a larger variety of crops and generally more grassland. However, results also point to a generally higher amount of uncultivated land on organic farms. Moreover, organic farms have higher densities of linear biotopes (esp. hedgerows) while densities of area biotopes (e.g. ponds, groves) are higher on conventional farms. Results also indicate organic farmers being slightly more active in landscape management than conventional farmers. Yet, it is important to note that while differences in the quantity of landscape elements between organic and conventional farms are apparent, they are generally much more marked in relation to other variables. E.g. type of agricultural production, farm type[4] and farm sizes showed much more pronounced relationships to quantities of landscape elements than the division into organic and conventional farming. Additionally, there are large differences in both biophysical and agricultural characteristics between the two counties, pointing to the importance of regional variation. Using questionnaires, Tress is able to include a relatively large number of farms in her study, making the findings more general than results from Larsen and Clausen (1995). Still, as data on biophysical conditions on the studied farms were not included, the investigation is not capable of elucidating whether the documented differences in densities of natural and semi-natural landscape elements are biased by the studied farms' biophysical environment rather than related to organic or conventional production. Further, the spatial scale of the study is limited to the single farm units, preventing to relate landscape patterns on the farm to patterns in their surroundings. Even though information on recent interventions in the landscape is included, in general, the time scale of the study is limited to an up-to-the-minute account.

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[2] The term small biotope here embraces small uncultivated landscape elements, e.g. hedgerows, ponds, ditches, field boundaries (Agger, Brandt et al. 1986).

[3] Tress used the counties of Vestsjælland in eastern Denmark and Ribe in western Denmark in order to represent two regions with very different biophysical conditions for agriculture.

[4] Tress (1999) distinguishes between full time, part time and hobby farmers.

In the third Danish study Ackermann (2003) investigates content of natural and semi-natural landscape elements for all 17 organic and all 11 conventional farms within a continuous case area in southern Jutland. On basis of aerial photos, landscape elements are registered for 1990, 1995 and 1999. Results indicate that spatial variations in content of natural and semi-natural landscape elements are primarily related to local variations in biophysical conditions and not to organic vs. conventional farming methods. Furthermore, a questionnaire survey and in depth interviews revealed that attitudes towards landscape values are related to the single farmer's socio-economic and cultural background rather than to organic vs. conventional farming strategies.

Sweden

In relation to the discussion of spatial scale it is relevant to mention a smaller Swedish study (Lindkqvist 2002). For 27 organic and 27 conventional farms distributed equally over nine regions representing three basic rural landscape types[5] the study focus is partly on differences in landscape patterns between organic and conventional farms and partly on whether landscapes surrounding organic farms are different from landscapes surrounding conventional farms. The study is thus elaborated at both farm scale (single farm units) and landscape scale (5x5 km squares). The investigation is based on a GIS[6]-analysis containing data from topographical maps and aerial photos. The fact that the conducted farms were selected within the same nine regions, each representing a principal Swedish landscape type with its characteristic biophysical conditions, does to some extent overcome the bias from a more random selection used in other investigations.

Results indicate slightly larger amounts of semi-natural and natural landscape elements on organic farms. However, these differences are not statistically significant and seem influenced by a few outliers among the organic farms. Additionally, an investigation at landscape scale showed no clear differences between landscapes surrounding organic and landscapes surrounding conventional farms. Yet, at regional scale, differences between landscape types are very pronounced. Results thus underpin the assumption that differences in the quantity of natural and semi-natural elements in rural landscapes are related to regional differences in biophysical conditions rather than influenced by organic vs. conventional production forms.

UK

A British study evaluates whether the impact of organic farming on rural landscapes differs from that of conventional farming and whether these impacts are beneficial to the landscape (Entec 1995). 24 organic and 24 conventional farms within both upland and lowland landscapes of England and Wales are included in the study. Furthermore, the study distinguishes between horticultural and mixed farm types and long term and short term organic farms[7]. Among other criteria, the amount and type of hedgerows, the number and type of hedgerow trees and the field sizes were used as measures for nature content of rural landscapes. Results show that in lowland areas mixed organic farming has a noticeable positive effect on landscapes mainly due to pronounced differences to the intensive conventional farms. Because of a generally less intensive character of farming, in upland regions there is little discernible difference in effects on landscapes between organic and conventional farms. The length of time through which farms have been farmed organically did not prove to influence farmers' landscape practices.

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5 Lindqvist (2002) uses forest landscape, plain landscape, and combined plain and forest landscape as the three typical Swedish rural landscape types.

6 Geographical information system

7 Long term organic farms = farms which have been organically farmed for 10 years or more; Short term organic farms = organically farmed for 2-5 years.

The study suggests that the degree to which farmers positively affect the landscape is more a matter of the attitude and initiatives of the particular farmer and not the direct result of whether a farmer adopts an organic farming system or not. It also suggests that organic farmers are more likely to adopt farming and land management practices, which are beneficial to the landscape and the environment as a whole. Thus, farmers who choose organic methods provide net benefits to the landscape largely because of their awareness of the environment in general (Entec 1995).

However, these suggestions are not empirically underpinned. The study is based on quantifiable measures and issues related to farmers' perceptions or values are not addressed. Furthermore, even though sampling methods pay attention to biophysical variations between upland and lowland landscapes, biases related to local variations are not further considered.

Other European countries

A method for the assessment and comparison of landscape features between conventional and organic farms was developed by the EU Concerted Action "The landscape and nature production capacity of organic/sustainable types of agriculture."(van Mansveld and van der Lubbe 1999). The aim of the EU Concerted Action was to produce a tool that allows comprehensive (holistic) interdisciplinary evaluations of farms and their nature and landscape production potentials. A system of six sets of criteria[8], covering all relevant aspects of farm-landscapes was used to evaluate the contribution of organic and conventional farms to landscape quality in the following European countries: Netherlands, Germany & Sweden (van Mansvelt, Stobbelaar et al., 1998); Tuscany (Rossi and Nota, 2000); Ireland (MacNaeidhe and Culleton, 2000); Crete (Stobbelaar, Kuiper et al. 2000);Andalusia, Netherlands, Portugal and Crete (Kuiper 2000); Netherlands (Hendriks, Stobbelaar et al. 2000) and Norway (Clemetsen and van Laar 2000). The evaluation was carried out by groups of experts visiting the particular farms. The different criteria were then addressed through field observations and group discussions. Results are thus not as quantifiable as it is the case in the other presented studies. Still, with respect to natural and semi-natural landscape elements or biotopes, the investigations end up with measures that allow the comparison of numbers and/or densities of such elements on the investigated farms.

Almost all investigations using this approach point to organic farms considerably increasing the content of natural and semi-natural landscape elements or biotopes compared to their conventional counterparts or the surrounding conventionally farmed landscape. However, due to very small samples (2-8 farms per region), results can not be generalised. Furthermore, the rather subjective selection of investigated farms must be expected to, to a high degree, bias results. E.g. for a comparison of landscape features on organic and conventional farms in the Netherlands, Germany and Sweden, the organic ones were selected as well known for their long-time management in favour of landscape production (van Mansvelt, Stobbelaar et al. 1998).

It is argued that the concept of organic agriculture as such includes all instruments to produce quality landscapes and it is put forward that the successful implementation of these options depends on the farmers' attitude and motivation, which often are more pronounced among organic farmers (van Mansvelt, Stobbelaar et al. 1998). However, these finding have not been systematically investigated and little attention is paid to limitations due to subjective selection and small samples. Furthermore, applied temporal scales only give an up-to-the-minute account and are thus not able to reveal whether organic farming does increase the content of natural and semi-natural landscape elements over time.

[8] The used criteria are environmental studies, ecology, economy, sociology, psychology, physiognomy and cultural geography (Rossi & Nota 2000).

Critical issues for further research

Table 1 summarises the different studies with respect to methodology and results. Methodological approaches differ widely, as do consequences for sample-sizes, precision and quantifiability of results. However, all investigations have in common that they somehow address the content of natural and semi-natural landscape elements on the investigated farms. The table and the above presentation of different studies indicate that the application of narrow spatial and temporal scales together with small and/or subjectively stratified samples direct results towards a positive relation between organic farming and content of natural and semi-natural landscape elements. In contrary, results from those studies using broader spatial and temporal scales and/or sampling methods, which pay attention to local and regional biophysical variations, point to much weaker or no relations.

This is not to reject the studies indicating a positive relation. To examine relationships between organic farming and content of natural and semi-natural landscape elements is not necessarily the primary aim of all studies presented here. E.g. the aim of the EU Concerted Action "The landscape and nature production capacity of organic/sustainable types of agriculture." was primarily to elaborate a common tool for evaluations of farms' nature and landscape production potential, not to make up relations between organic farming and rural landscapes. Furthermore, organic farming and thus its effect on rural landscapes may vary largely between different European regions. However, without discussing the obvious limitations related to specific methodological designs, others, e.g. Mander, Mikk et al. (1999) and Stolze, Piorr et al. (2000), refer to the findings of the EU Concerted Action and other studies as supporting positive relations between organic farming and landscapes' nature content.

Table 1: Summary of methods, sampling-strategies, study scales and results in existing studies.

authors and year	coun-try region	method	No. of farms		sampling method	applied study scales		relation between org. farming and landscapes' nature content***
			org	conv		spatial*	temporal**	
Clausen and Larsen 1995	DK	field registration, aerial photos	30	-	random sample within two larger areas	F	M (40 years for org. field sizes)	++
Tress 1999	DK	question-naires	133	330	all org. farms and stratified random sample of conv. farms	F	M (several years for landscape activities)	+
Ackermann 2003	DK	aerial photos, question-naires	17	11	all farms within one case area	F & L	10 years	-/+
Lindkqvist 2002	SE	aerial photos, digital maps	27	27	stratified random sample within 9 regions and 3 landscape types	F & L	M	-/+
Entec 1995	UK	field registration, question-naires	24	24	stratified sample within 2 regions/ 13 counties	F	M	++
van Mansvelt, Stobbelaar et al. 1998	NL, D, SE	field observation	12	15	subjective stratified sample	F	M	+++
Rossi and Nota 2000	Tusca-ny	field observation	2	-	subjective stratified sample	F & L	M	+++
Mac Neaidhe and Culleton 2000	IR	field observation	2	2	subjective stratified sample	F	M	+++
Stobbelaar, Kuiper et al. 2000	Crete	field observation	2	-	subjective stratified sample	F	M	+++
Kuiper 2000	Anda-lusia, NL, PT, Crete	field observation	5	2	subjective stratified sample	F	M	++
Hendriks, Stobbelaar et al. 2000	NL	field observation	4	4	subjective stratified sample	F	M	+++
Clemetsen and van Laar 2000	N	field observation	2	-	subjective stratified sample	F	M	+++

* L = landscape F = farm

** M = up-to-the-minute account (no temporal dimension)

*** -/+ = no clear relation; + = slight relation; ++ = clear relation; +++ = very clear relation.

Yet, small samples limit the validity and generalisability of results, even at a local scale. Additionally, sampling strategies, which do not take into account spatial variations in biophysical conditions, may obscure the influence of an uneven spatial distribution of organic farms in relation to biophysical characteristics. The same may be valid if sampling strategies pay limited attention to the effect of variations in production types, farm types and farmers' socio-economic and cultural situation, which may be related to landscapes' nature content. Further, the most relevant question is not whether densities of particular landscape elements are higher on organic farms than on conventional farms but if organic farms contribute more positively to the nature content of the landscapes they are located in. However, keeping spatial study scales to farm units hinders conclusions about the influence of organic farming at landscape scale. Finally, as landscapes are dynamic systems that change over time, an examination of the effects of organic farming on the rural landscape will achieve more validity when applied within a broader time scale. Otherwise, results will only give an up-to-the-minute account unable to reveal whether organic farming is related to an increase in landscapes' nature content compared to conventional farming.

It may be a difficult task to incorporate all these methodological considerations into one investigation. However, the above review on existing studies forms the basis for the methodological design of a current PhD project on landscape changes following conversion to organic farming in Denmark. The project focuses on the spatial distribution and amount of natural and semi-natural landscape elements, which in the last 50 years, due to industrialisation and mechanisation of Danish agriculture, have experienced a radical decline (Agger and Brandt 1988).

Considerations on sampling strategies, spatial and temporal scales and convenient data can be addressed in two ways. First, a large-scale investigation can be elaborated on the basis of national datasets for topographic and soil conditions together with digital maps on natural and semi-natural landscape elements and agricultural statistics at farm scale. Such analysis enables to spatially relate content of natural and semi-natural landscape elements to biophysical conditions, agricultural production, farm sizes and organic and conventional farming methods at the level of the single farm properties. The advantage of such analysis is the option to include both production and biophysical parameters at a large spatial scale. Drawbacks are the general inaccuracy of such national datasets. Furthermore, the spatial reference does not completely reflect the land area the respective farms' are managing, as farm properties do not include rented land. Finally, the temporal scale will be limited to an up-to-the-minute account. Nevertheless, such analysis will indicate the respective influence of production and biophysical factors on the content of natural and semi-natural landscape elements.

The second approach, which will be used in the current study, is a more detailed analysis for 4 case areas with a relatively high density of organic farms. Each case area, covering roughly 30km², represents a characteristic Danish landscape type with respect to biophysical conditions and historic development[9]. For all landscapes and for the organic and conventional farms within the areas, natural and semi-natural landscape elements will be registered in a GIS on basis of aerial photos. In order to apply a broader temporal scale to the study, registrations are carried out for 2002, 1999, 1995, the early 1980s, and mid 1950s. Information on landscape management and farm and household characteristics are derived from questionnaires conducted to all organic farms and a corresponding collection of conventional farms within the case areas. Furthermore, data from agricultural statistics and biophysical base maps are added to the analysis. The integration of this multitude of information will give a more comprehensive picture of if and how organic farming is related to spatial variations in the rural landscape's content of natural and semi-natural landscape elements at both farm and landscape scale. The application of a broad time

[9] Chosen landscape types are: 1) Hilly moraine landscape in the periurban area of Copenhagen in northern Zealand, 2) Intensively cultivated hill island landscape in western Jutland, 3) Intensively cultivated moraine landscape along a river valley in eastern Jutland, 4) Intensively cultivated hilly moraine landscape in western Jutland.

scale enables the investigation of the spatial development of natural and semi-natural landscape elements in relation to the appearance of organic farms and to the structural development of agriculture in general.

In total app. 150 farms distributed over the 4 case areas will be included in the study. Of course it will not be possible to extrapolate findings to the whole country. However, through the application of broader spatial and temporal scales, the study will overcome some of the methodological drawbacks of earlier research and thus contribute to the understanding of relations between organic farming and landscapes.

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