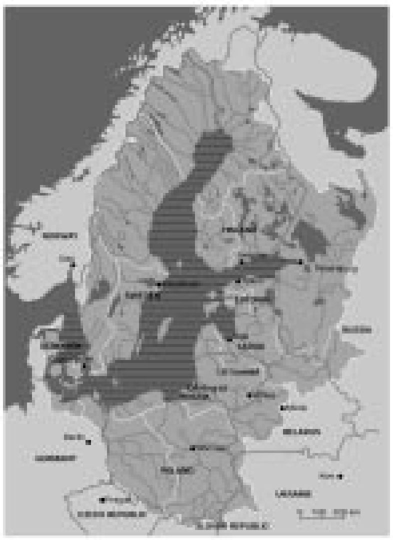
Ekologiskt lantbruk nr 43 • OCTOBER 2005

POSSIBILITIES FOR AND ECONOMIC CONSEQUENCES OF SWITCHING TO LOCAL ECOLOGICAL RECYCLING AGRICULTURE

John Sumelius (ed.)



Baltic Ecological Recycling Agriculture and Society (BERAS) Nr. 3

Baltic Sea Region
INTERREG III B

Centrum för uthålligt lantbruk

Ekologiskt lantbruk – 43
Possibilities for and Economic Consequences of Switching to Local Ecological Recycling Agriculture

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Ecological Agriculture – 43
Possibilities for and Economic Consequences of Switching to Local Ecological Recycling Agriculture

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ISSN 1102-6758
ISRN SLU-EKBL-EL--29--SE
ISBN: 91-576-6857-4
Antal sidor: 68
Ämnesord/*Key words: Organic farming, Organic food, Local food, Sustainability, Resource management, Food systems, Rural development, Costs, Farm management*

LOCAL FOOD OPTIONS – a linear programming perspective on three organic farms in South Savolax, Finland

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Abstract
The options for three case farms to maintain and increase localized organic food production and circulation were analysed, and a standard linear programming method was used. Several scenarios were developed for each case farm; as a result, possibilities for co-operation between farmers through local markets could be analysed. Trade between farmers was observed to be a major component of local production and consumption. Several possibilities for increasing organic production were found. Making fuller use of the capacities of animal sheds, machinery, land and labour was possible by increased trade between farmers. The sensitivity of activities at the farms to price and support variations were studied indirectly by looking at validity ranges and sensitivities to changes. Numerous constraints were analysed, both institutional and environmental. The institutional constraints consisted of the markets and existing regulations; environmental constraints were based mainly on agronomics. The income foregone from different organic constraints was calculated.

Introduction

Localizing food systems has been proposed as a sound solution for improving the economy in remote rural areas and the recycling of nutrients at the local level. In this report we analyse farmers' options for localizing production within the framework of organic farming. The report originates from the BERAS project, where localized organic farming is assumed to decrease the externalized environmental effects through localizing the factor inputs and outputs.

There is growing interest in research, and a range of studies deals with local production and consumption issues in food systems. Many of the studies investigate environmental effects, e.g. Gilg and Battershill (2000) and Sundkvist et al. (2001), consumers' attitudes, e.g. Weatherell et al. (2003), and possible effects on local economies, e.g. Williams (1996). Primary enterprises (including farming) are traditionally considered a basic sector for local economy that creates external income. The role of net income has also been emphasized. The net income of an economy is determined by total external income, times a multiplier, minus total external spending (Williams 1996). In the area of farming, studies dealing with distribution channels and co-operations between farmers or farmers and consumers can be found. However, the studies look at the

Shortenings

LP	– Linear-programming
GM	– Gross margin
CAP	– Common Agriculture Policy of European Union
EC	– European Commission
UAA	– Utilized Agricultural Area
LU	– Livestock Units

possible advantages and disadvantages of the "initiative" rather than the economic effects at farm level.

The principles of organic farming give rise to several choices for reducing the burden on environment and livestock. One objective is to have a balance between animal production and land, such that nutrients are returned from animal production to the land and vice versa. This is strengthened, for instance, by not allowing nitrogen and phosphorous as mineral fertilizer but only allowing organic fertilizers. Both conventional and organic systems can be seen as recycling ones, but the conventional type might consume more energy. Several pesticides are also banned in organic farming such as all synthetic pesticides and herbicides. Organic farmers thus save part of the costs of fertilizers and pesticides. Economically, organic farming is facing more stringent constraints on the input side leading to lower production. But they have a less stringent output side with a possibility to sell products to a higher price through organic certification, which conventional farms cannot do.

What can farmers do to enhance local food systems? What would be the effects of this on the economy of the organic farmer? What are the possibilities for and constraints on organic farmers with respect to meeting the need for localizing production and consumption? What is the effect of not allowing any purchases of feed at the farm level? This last question is a strict interpretation of fundamental organic farming. These questions will be partly answered by utilizing a linear programming farm model. Three selected cases (real farms) were analysed in depth: a farm that produces forage, a dairy farm and a beef farm. The farms are located in the same municipality, Juva, in central eastern Finland.

The Juva region is 134 600 hectares in area of which 74% (87 000 ha) is forest and only 8% (9 000 ha) is agricultural land. Approximately 20 000 hectares is water. The Juva region is predominantly rural with a population density of only 6.8 inhabitants/km^2 (about 7 500 inhabitants in total). The area is categorized as a C1 support area (A being the most favourable farming area and C3 the least, see http://www.mmm.fi/english/agriculture/support.htm). Agricultural production is constrained by natural conditions such as a short growing season, little precipitation (but with high variability during the growing season) and small, scattered fields. Juva is on the border of wheat production area and therefore early varieties are preferred. The short growing season forms the soils and forest area is very dominating. Cereal production is mostly for fodder (90% of the cereal area, 2002). The area is favourable for animal husbandry and especially ruminants. Dairy farms comprise nearly 50% of the farms (410 farms, 2002). The farms have on average 19 hectares of agricultural land and 74 hectares of forest (2000).

Total agricultural land area in the municipality of Juva is 8 900 hectares, of which 1 334 hectares or about 15% is under organic management. About 55 of the farms are organic, and their average size is 24 hectares of agricultural land (i.e. excluding forest). The organic farms are therefore slightly larger than the conventional farms. Organic farming in the region is predominantly based on animal husbandry and the land use is nearly 60% grasslands; if including cereals 90% is grass. In 2002 it appeared that the diversity of land use in Juva was lower on organic farms than on conventional farms (Table 1).

Table 1. Land use of organic farms and all farms in Juva (2002).

	Organic farms (ha)	(%)	All farms (ha)	(%)
Ley	762	57	4016	45
Cereals	448	34	2971	33
Fallow	62	5	545	6
Horticulture	10	1	143	2
Other	52	4	1226	14
Total	1335		8901	

The linear programming method

The linear programming (LP) model is a method that can represent the whole farm planning. The LP-model shows how the farmer could respond to changes in policies and markets. In the short run the variability of costs are in the annual factors while the land, machinery and building capacities are fixed. In the long run also these factors are assumed to be variable. We have chosen to look mainly at the short-term changes. The feasibility area is formed from a combination of the farm's existing production possibilities.

The theoretical model is
$\max\{Z=c'x\}$
s.t. $Ax \leq b,\ x \geq 0$

where Z is the sum of gross margins and costs, x is the vector of activities, c is the vector of gross margins or cost per unit of activity, A is a matrix of coefficients and b is the vector of constraint values. The later part in s.t. states the non-negativity of activities.

Empirical model construction

The linear programming model maximizes the sum of gross margins and costs of farm activities. These consist of crop production activities, animal production activities and other related agricultural activities. Gross margins for all the activities were calculated separately and then applied for the linear programming model. Gross margins should cover costs of own labour, capital and investments. The prices of intermediates were not given but costs were included. The buying and selling of farm products and subsidies/payments were picked out as separate activities for the purpose of creating sensitivity analyses. The activities were subjected to constraints. The number of the constraints depended on the individual farm and is based on a questionnaire. The constraints basically consisted of available land, labour and feeding ratios. Additional constraints concerning crop rotations, buying possibilities and machinery/buildings capacities were added, as were some institutional constraints. The legislated environmental constraints were also imposed.

In theory, the direct payments (coupled ones), which are based on production factors like acreage, do not affect the choice of intensity of crops. However, some of the direct supports affect the choice of crops since they differ between crops. An example of this is the CAP support, which is different for cereals and protein crops, for instance. The supports also vary between countries and regions. In our model the supports were included and tied to the elements of achieving them. The supports that affect choice of crops or animals were included in a way that allows them to be analysed from a sensitivity point of view, which means as separate activities tied to the support gaining ones. The prices are similarly included in the model to achieve additional information about validity ranges and sensitivity.

The modelling started by using the existent amounts of activities as the reference point. Thereafter one additional change is made for each scenario. Scenarios were created such that from the reference point the next run is done in a manner allowing for all activities to be chosen freely by the model, then additional constraints were added accordingly to capacities and assumed markets. In this way we determined the importance of each constraint. Next, the binding activities were investigated further by adding purchasing possibilities on feeds and labour etc. Changes in supports and prices were added in order to get additional information about how stable the solutions are. As well, the scenarios showed the consequences of institutionally, biologically and technically constrained production.

Data

Information about activities, gross margins and constraints was gained by farm interviews. A questionnaire was developed for a purpose of data collection and consisted of questions concerning family labour use, land use, animal structure and feeding ratios, yields, prices and distribution channels, variable and fixed costs, revenues and other issues connected with management and marketing of farm products. The choice of farms was based on production lines, organic farming activity and participation in a local food system. Data was collected for the year

Table 2. Basic information about case study farms.

	Farm 1	Farm 2	Farm 3
Organic certification since	1985/95	2002	1996
UAA (ha)	16.8	42	90
Forest area (ha)	43	77	30
Main product line	Dairy	Forage	Beef
Other activities	Employment	Baling service	
Total LU	9.4	0	108
Animal density	0.56	0	1.2
Labour: Full time	1	1	3
Seasonal workers	1	0	3

2002 and consisted of detailed information about resources, technologies, costs and revenues, and structure of production. Attention was given to product flows, mainly the distribution of farm products.

Processing and results

Labour per hectare of cultivated crops was determined with use of published standards and surveys. The prices of the organic forage products (silage, hay) were taken from the questionnaire. Calculation of the prices according to fodder unit of cereals was used if information about price was missing. The yields were taken from the questionnaire and represented the approximated average yields that the farmer can give. No heterogeneity is assumed between fields, which is a strong and incorrect assumption but by using average yields greater accuracy was achieved. Furthermore, by changing the yield assumptions the stability of the calculations was verified.

Farm 1:a dairy farm

Farm 1 has been in organic production for 20 years. The land was converted in 1985 and the cattle ten years later. The farm now has 17 hectares of arable land and 43 of forest. There were 8 dairy cows on the farm and milk is the main product. In addition, the farm engages in direct selling of potatoes and rye flour from own grain (milled in a nearby mill). One of the family members worked full time on the farm and one works during summer in crop production. Additional labour is arranged for some of the seasonal work (hay, straw and potato harvesting).

The land use was fully adjusted to dairy production and the farm is close to being self-sufficient in fodder production. The farmer bought only some minerals and proteins (organic rapeseed). The rest of the land was utilized for cash crops: potatoes (0.2 ha) and rye (1.63 ha). The crop products were packaged on the farm and distributed directly to consumers.

Animal production consisted of dairy cows. Bull calves were sold to a beef farm for meat production. Cow calves that were not used for replacement were sold to a slaughterhouse. Feeding in winter consisted basically of silage for free, a mixture of barley, oats and peas, and in summer, pasturing and a mixture of grains and legumes. The farmer used his own straw from cereal fields for bedding, as well as bought peat.

The farmer had made no recent investments in buildings or machinery. Investments for wastewater and manure storage were made eight years ago. One year later, a one-quarter share of a harvester was bought. Some farm services (baling of silage and hay) were used to be purchased.

Constraints

The total labour was calculated to be 4 000 hours. Herd rotation allowed replacement from own calves only. The replacement was assumed to be 25%. The cowshed capacity was 11 cows.

Scenarios

Five scenarios in addition to the reference scenario, which is the actual situation at the farm, are presented. The unconstrained land-use scenario allows the model to choose the most profitable activities existing on the farm but the area of directly sold potatoes was limited to its reference value. The crop rotation and fodder purchase possibilities (FPP) scenario introduces new activities concerning fodder purchases while limiting land use to the maximum area for cereals, rye and potatoes. A fallow land possibility was added as an alternative land use activity for the next scenarios. The limited FPP scenario was derived from the previous scenario and its purpose was to present the consequences of constraining fodder purchases (up to 30% of total fodder units). The last two scenarios (GM2: gross margin 2) shows the effects of introducing gross margin 2 (labour included in variable costs: 11.35 Euro/h), which meant a crucial change in the model construction.

Results of the scenarios

Table 3. Results for dairy farm.

	Reference	Unconstrained land use	Crop rotation and FPP	Limited FPP	GM2 and FPP	GM2 and no FPP
Total GM, Euro	-	+3000	+6600	+5500	-13600	-14100
Labour use, h	1380	1670	1830	1820	1530	1070
Dairy cows	8	10	11	11	9	6
Silage, ha	5.9	7.4	7.4	8	6.5	4.3
Barley & grass, ha	2.5	1.9	0	0	1.2	1.1
Oats & peas, ha	2.2	1.9	0	0	0	1.1
Oats, ha	0.7	0.8	0	0.9	0.7	0.5
Rye, ha	1.6	0.2	4.2	2.3	4.2	4.2
Fallow land, ha	-	-	0	0	0	2.9
Bought cereals, kg	-	-	7400	8500	5100	-
Bough silage, bales	-	-	38	0	0	-
Land shadow price		1750	900	1440	650	670

In the scenarios, the tendency was to use the land for cereals as little as possible. The purchasing possibility introduced in the "Crop rotation and FPP" scenario clearly improved the total gross margin (for more than 6000 Euro compared with the "Unconstrained land use" scenario). Silage crops were relatively more competitive, which could be seen in the "Limited FPP" scenario. As well, the alternative use of land for fallow land did not eliminate silage from land use. It seems silage performed relatively better or had a higher price to purchase. The opposite could be said about the cereals. The sensitivity analysis of the scenario showed that the price for cereals could still be increased by 20% and in the case of oats & peas (a mixed cropping) nearly doubled. Labour was not a limiting factor in this farm case. The model therefore suggested an increase in dairy production that would require relatively large amount of labour.

Cash crop activities were a special issue in the scenarios. The potato area had to be limited in all the scenarios since it would be the most preferred by the model. The main reason was high price through the direct sale channel. Because potatoes for food were a very special crop on such a farm and because of the type of marketing, the missing knowledge about maximum production and distribution capacity was a crucial factor in constraining their production. In the case of rye, the maximum capacity was adjusted to the crop rotation. The "rye for flour" activity operated to be rather competitive when fodder purchasing possibility was allowed, and this activity reacted to changes in the model scenarios.

The "GM2 and FPP" scenario did not choose dairy activity to the maximum capacity of the cowshed. One of the fodder cereals was already included and no silage was bought (compared to the similar scenario "Crop rotation and FPP"). Fallow land was not included, which was a positive indication about the competitiveness of the farm production activities. Correspondingly, the "GM2 and no FPP" scenario could be compared with the "Unconstrained land use" scenario except for that the maximum area of rye was constrained. The dairy activity was a less competitive activity compared to the rye production. Fallow land was included since the area for cereals was limited and silage crops were adjusted by the model to decreased dairy production. (No selling activity for silage was included in the scenarios for this farm.)

Farm 2:a forage producer

The farmer started his farm in 1995. The farm had 42 hectares of arable land of which 23 were rented. The forest area was 77 hectares. The farm was converted to organic production in 2002. The farmer worked full time on the farm and did contractual work for neighbouring farms in the form of baling of silage and hay. This additional activity comprised 600 working hours in the growing season, amounting to approximately 1000 hours in total.

The agricultural activities were concentrated only on crop production. The farmer stopped dairy production in 2000. Silage (silage bales) and fodder cereals were the main crops and these were sold to neighbouring farmers. Important recent investments had been a tractor in 2001 and a silage wrapper and baler in 2002. The farmer owned 60% of the wrapper and baler. As well, the farmer had invested in other crop production machinery in the last five years (harrow, rock picker, wagon, plough) which he often shared with other farmers.

Constraints

The labour limit for the growing season was 1000 hours. Minimum obligatory area of fallow land 10% was included in the crop rotation. The maximum use of the wrapper and baler was 420 h/year and 360 h/year, respectively.

Scenarios

The scenarios were basically aimed at determining the consequences of crop rotation constraints as well as the competitiveness of fodder cereals. Particularly, respons to the selling activities and fallow land to price changes was observed. The "No constraint" scenario presented results for land use without constraints and with prices of crops reported in the questionnaire (cereals 0.168 Euro/kg). The theoretical "No CAP silage" scenario showed the effects of excluding CAP payments for silage crops. The "Rotation constrained" scenario aimed to balance cereal and silage production by requiring that the areas for silage and cereals should be equal. In the "Increased labour" scenario the impact of increasing labour availability was examined. The labour was increased by 200 hours.

Results of the scenarios

Table 4. Results for forage farm

	Reference	No constraint	No CAP silage	Rotation constrained	Increased labour
Total GM, Euro	-	+3900	+3100	+3400	+11300
Labour, h	1000	1000	1000	1000	1200
Silage, ha	17.2	37.8	0	7.3	11.3
Barley & oats, ha	9.3	0	0	0	0
Oats, ha	5.4	0	12.8	7.3	21
Oats & peas, ha	5.0	0	0	0	0
Fallow land, ha	5.1	4.2	29.2	27.3	9.7
Contract work, bales	1300	1200	2400	2285	2223
Shadow price: land Euro		513	526	520	583
Shadow price: labour	30	30	25	27	27

The farmer had limited labour and this seemingly led to greater competition between farm crops and silage baling activity. From this point of view the production of organic fodder cereals seemed to be the least competitive activity on the farm. This could be caused either by low prices or low yields. Moreover, the farmer had no animal production activity that would give added value to the fodder crops he produced. He had to sell all the fodder at prices that have been decreasing in recent years.

Optimization without the constraining of land use resulted in silage production only. The rest of the labour capacity was utilized for contractual baling. Total GM rose by about 4000 Euro from the reference model. In the theoretical scenario "No CAP silage" one could expect that cereals would be fully included in the solution if the silage crop would lose a significant part of income and hence its competitiveness would decrease. Nevertheless, the optimal solution chose the baling activity to be at the maximum of machinery capacity and fallow land as land use. According to the sensitivity analysis the price of the farm's silage bales would have to increase by more than 30% to include silage in the production. The total GM decreased by 800 Euro.

The solution for the "Rotation constrained" scenario resulted in increased fallow land area rather than an increase in cereal production, which must happen if silage area increases. (The CAP payment for silage was included again.) The baling activity was again highly preferred by the model.

The competitiveness of cereals was improved by increasing labour availability in the "Increased labour" scenario. Because the silage and the baling activity were constrained by machinery capacity, the rest of labour could be applied to more labour demanding activities (cereals) than fallow land. The constraint concerning crop rotation was diminished in the sense of including fallow land in the rotation. (The area for cereals should be greater than the area for fallow land plus silage.)

Farm 3:a beef farm

The farmer bought the farm in 1994. In 1996 the land was certified as organic and one year later the animals were certified. The farm had 90 hectares of arable land of which 50 were rented. Forest land area was 30 hectares. Production was concentrated on beef and forage. In addition, the farmer cut and baled silage for neighbouring farmers during the season, amounting to 80 hours of labour a year.

The farmer invested considerably in the last five years. He extended the animal shed to a capacity of 300 animals and bought more field machinery. The number of animals was doubled at the same time. He worked full time on the farm together with another family member and one employee. His spouse helped seasonally and the farmer also employed two seasonal workers in summer and one in winter.

The land was utilized mainly for perennial and annual silage (more than 50 ha). Some land was grazed. The only cereal grown on the farm was oats (around 20 ha). The farm also had natural permanent pastures that was utilised for extensive grazing.

The farm raised young bulls for beef production. There were approximately 108 LU in total on the farm. The farmer bought beef calves at the age of 3 months from neighbouring organic dairy farms. Part of the feed was bought: cereal side-products from mills, concentrates, minerals, proteins and some of silage bales. Nearly all the feed was organic, only the protein feed was half conventional. Most of the bedding material was bought (peat, wood shavings, some straw). The bulls were sold after 21 – 24 months of fattening. Some of the beef was sold through direct sales (nearly one third of beef sale income). In this case the bulls were slaughtered, butchered and the beef packaged and then distributed to shops. The shops were located in the Mikkeli region, mostly near the farm. The local slaughterhouse offered a complete service including distribution to the shops; however its service costs doubled just in the year of observation.

Constraints

The total labour capacity amounted to 6500 hours. The animal shed capacity was set for 300 heads.

Scenarios

The scenarios for this farm were set up with several intentions. First the reference scenario was calculated with the original settings. Then the free run was performed but with a crop rotation constraint limiting the area of oats. Another scenario included a labour-purchasing possibility to see to what extent the production could be increased. As well, a scenario where labour was included in variable costs was performed ("GM2" scenario). A direct selling possibility for beef was included in all the scenarios. Sensitivity to changes in cereal and silage prices was also investigated.

Results of the scenarios

Table 5. Results for beef farm.

	Reference	**Oats area constrained**	**Labour purchase**	**GM2**
Total GM, Euro	-	+8400	+23 100	-67 600
No. of bulls	184	192	300	192
Perenial silage, ha	40.1	0	0	0
Annual silage, ha	10.4	61	50	61
Annual pasture, ha	3.5	2	13	2
Oats, ha	23	27	27	27
Oats sales, kg	6900	18 000	0	18 000
Oats bought, kg	0	0	25 300	0
Silage bought, bales	66	29	895	29
Labour bought, h	-	-	2650	0
Shadow price: land Euro		603	701	611
Shadow price: labour		17	11	5

Farm 3 had relatively high yields of silage crops and oats. The daily growth of the animals was also relatively good. The model suggested maximizing the number of cattle and the area of oats. The buying of silage for the fodder producer was not causing changes in activities but this must be interpreted carefully since there was no other alternative use of land in the model if area of oats is limited. This was corrected by adding fallow land for alternative landuse. However, fallow land was not chosen in this case.

Buying extra labour and extending beef production was an option suggested by the model. However, this was valid only for scenarios operating with gross margin 1 (without labour costs included in the variable costs). Including labour costs to the variable costs (the "GM2" scenario) did not even suggest fully utilizing the existing labour capacity. The shadow price of the labour would be 5 Euro. If beef production were to be expanded to maximum capacity then extra purchases would be needed in the form of straw, silage and cereals. This would also require that enough organic straw, for example, be available in the region. Similarly, the purchases that were not included in the model such as calves, rapeseed etc. should be available. Direct selling of meat versus conventional selling was added to the scenarios. The second alternative was chosen as more profitable. This result was very sensitive according to the analysis (allowable increase/decrease in price only 0.002 Euro per kg). Nonetheless, direct selling would make sense if there were expectations of lower or unstable prices through the conventional channel.

Discussion

Generally trade between farmers improves the local economy. However, the dairy farm (Farm1) was closest to the goals of organic farming in the reference state. In the reference state this farm hardly purchased any fodder from other farms. (Only some services were bought.) In one scenario the farmer could increase his livestock and purchases of fodders, respectively, which would improve the sum of gross margins at the farm. This would imply that labour is available and that the capacity of the cowshed is being utilized. Moreover, if there would be sufficient markets the farmer could expand the direct selling of potatoes and rye flour.

The fodder producer (Farm 2) was more dependent on trade with other farmers. In the event of no trade, the farmer could choose to maintain more set-aside and labour opportunities outside the farm. There is, however, a scope for selling services and fodders to neighbouring farms. With the current assumptions, the best alternative was to produce and sell forage and baling services. Producing cereals was less competitive for this farm.

The beef farm (Farm 3) had the possibility to expand, as regards livestock. This would require purchasing both labour and fodder. In the current situation the farmer purchased already 30 tonnes of straw and some silage. In a possible expansion the dependence on increased purchases could cause insecurity, and the marketing of products would need to be analysed further. However, the expansion would add to the local economy since it would increase labour opportunities, fodder use and products for sale. Nevertheless, the organic requirements that are now appearing (8/2005) do not allow for such expansions (EC No 1804/1999). An increasing demand of organically produced feeding stuffs is occurring according to EC, but the availability of organically produced protein crops is a problem still to be solved. An even bigger task is how to find available straw for bedding material since this is also needed mostly for soil improvement in both conventional farms and even more so in organic farms. The purchasing of organic fodder is not actually limited. But to some extent it can be limited by missing or not well functioning markets for organic fodder or by the history/management of an organic farm (minimum reliance on external suppliers, balance between crop and animal production). At the time, the farmer was utilizing the capacities well since the farm is dependent on rented land. In the event of losing some of the rented land the number of livestock could be problematic from a fodder and environmental regulation point of views. A more environmentally secure approach therefore would be to have number of livestock correspond to the land area owned.

All investigated farms contributed to the local market, for which trade between the local farmers was the single most important element. Supporting the local market would require following up information on the demand for different products. A possible co-operation model for organic farming that can improve the performance of farms together as well as increase local demand (with milk and beef still remaining more as export products) is shown in this report.

Fertilizers that should replace the outtake were not considered and therefore a lack of nutrients, especially phosphorous, could develop for certain crops after some years. This concerns particularly the livestock farms since there the outtake of nutrients is higher. This should be investigated further in follow-up research.

Other considerations include:

- The CAP reform with a decoupling of supports and payments will have consequences, especially where productivity is low.
- Could low yields of organic cereals play a role for local production?
- Sharing of mechanization, though common in Juva, can be problematic for some farms.

What will happen when farmers can only buy fully organic feed? This should also be analysed further as an important factor for the future development of organic farms in the area.

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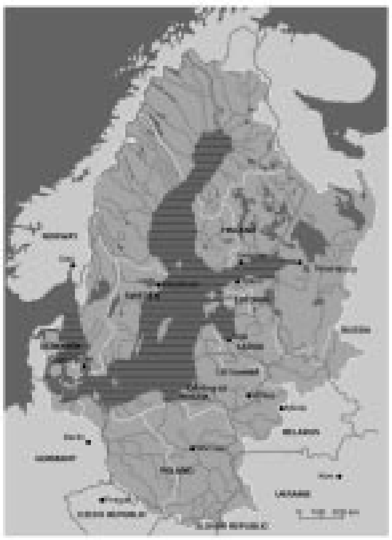

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