DIVERSIFOOD

Embedding crop diversity and networking for local high quality food systems

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Relationship between the diversity of local crop production and food sales in Finland

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- ☒ **PU:** Public (must be available on the website)
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Abstract

Diversification of plant production improves the resilience to climate change. It may also increase the number of food products offered to consumers, especially if producers have access to the local food markets. However, what other connections diversified plant production may have in the food chains? It is important to produce more information on the possible effects since there is a big tendency to diversify plant production in many countries. The final aim of the research was to study whether there are connections between the diversity of cultivation and consumers buying the food. The study took place in Finland and consisted of different steps. Firstly we examined the diversity of crop production in 310 municipalities in Finland with the tool of **crop species diversity index** (**CSDI**), and thereafter selected municipalities which economically status were the same but they had either high or low CSDI. Food selling data was requested from the local supermarkets of 18 municipalities forming nine pairs, each having a municipality with high and low CSDI. The food data was obtained from selected fresh or minor processed food items (fruits, vegetables, tuber crops, flour & starch items, flakes & grifts; and crisps & mueslis) over three years. The main assumption was that an increase of plant production would have a connection to food sales. The results showed that CSDI between 2012– 2016 was the highest in South-Finland and lowest in North Finland. CSDI and the amount of people living in municipalities as well as CSDI and total income were positively correlated with each other. However, what was not expected was that the sales of all food items capita^{-1} year^{-1} were lower in municipalities with high CSDI, and the selling were higher with the low CSDI. This may be because the municipalities with higher CSDI were somewhat larger in size and more people were living there. Therefore, people living in the municipality with high CSDI might have more possibilities for food shopping and they may buy less. Another explanation would be, that people in municipalities with low CSDI might work more at home and therefore consume and buy more food. However, to understand partly unexpected results would need more studies. The municipality based CSDI showed to be a useful tool to monitor crop diversity and facilitate the comparison between data from different sources.

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1. Introduction

Loss of diversity among the entire food system are widely recognised. In addition, the energy obtained from food has argued to rely on quite narrow genetic resources. A suggestion was made, that only wheat, rice and maize would supply as much as 40 – 60 % of the energy needed for the human life (Anon. 2009). However, the actual number may be as much as 75 species, of which one crop covers at least five percent of the nutrition required in one county (Prescott-Allen & Prescott-Allen 1990). Recently, it was found that globally the diversity may have been increased during the last 50 years, but the tendency that similar type of crops are cultivated in different regions, has increased (Martin et al. 2019).

1.1. Crop diversity and its importance in Finland

The diversity of crop production and rotations have been studied in Finland in some extend. Six different rotation types could be distinguished according to the major crops cultivated which were cereals, grasslands, environmental fallow, perennial crops and diverse groups of break crops. It was found, that the major drivers for crop rotation and aims towards diversity were economic incentives, also the size of the farm had an effect: the more the farm had arable land, the more interested farmers were on crop diversification (Peltonen-Sainio et al. 2017). The diversity of cultivars of major cereals was assessed with Shannon diversity index. It was found that, there was a positive relationship between seed yield of feed barley and the index, but the same was not found from the other crops (Himanen et. al. 2013)

Possibilities to enhance the self-sufficiency of crop-derived feed protein instead of imported soyabean (*Glycine max*) would be practical way to improve cropping diversity. It was estimated that the potential areas of protein rich crops, namely field bean (*Pisum sativum*), faba bean (*Vicia faba*), turnip rape (*Brassica rapa* L.) and oilseed rape (*B. napus* L.) could be increased by a couple of times of their current areas (Peltonen-Sainio & Niemi 2012)

Climate change is proposed to cause more favourable conditions for various crops (Peltonen-Sainio & Niemi 2012), but is also challenging the current production practises. More diversified crop production can reduce the sensitivity to disturbances and may enhance the adaptation to fluctuating conditions in the future. The importance of 'response diversity' of crops was risen as one of the most important factor when searching more resilient production systems. Studies on cultivar diversity demonstrated, that actually the response of different barley varieties to fluctuating weather conditions showed greater homogeneity with the new cultivars comparing to the older ones (Kahiluoto et al. 2014). This means that although there is continuous flow of new varieties to the market, they all response more or less the same way and do not improve the resiliency of crop production. In contrast substantial high response diversity was observed among different forage crops, although none of the studied species successfully responded to all of the critical weather conditions. Therefore a suggestion to combine different species and cultivars to improve the yield performance and grass production was given (Mäkinen et al. 2015).

Attempts were made to understand the relationship between farm diversity and the production efficiency. The diversity of agriculture was assessed by eight different land-use categories, namely cereals, other field crops, vegetables and berries, flowers and ornamentals, seeds, perennial crops, fodder and other crops, and the diversity was calculated by Shannon-Weaver index. However, only very weak or no correlations could be observed, implicating that there may not be any association between these parameters (Kuosmanen 2012). An opposite study was made to test the general assumption that diversity reduces efficiency. Only farms having more than 30 ha were included to the study. The results indicated that there is either no or a weak negative trade-off, which have no economic importance. Therefore, diversity may be used as a tool to improve the resilience without causing no constrain to resource-use efficiency (Kahiluoto and Kaseva 2016).

1.2. Connection between the environment and local food

Sustainability of local food production was studied by Life Cycle Assessment (LCA) including several production chains, companies and regions. It was observed that local food production may support ecosystems services in many different ways, for example through enhanced biodiversity and improved recycling of resources. Biodiversity and eutrophication impacts were partly higher and partly lower than same type of products in Finland, the most important factor causing negative impacts were the logistics and long distances in Finland (Räsänen et al. 2014).

Consumer's buying behaviour was investigated in a 6-year study where the diet was taken into account more broadly than just focusing on single food components. The analyses were carried out separately for movers and non-movers inhabitants. It was observed that the socioeconomic status of the neighbourhood was associated to the dietary habits of the residents (Lagström et al. 2019). In another study the importance of different motives such as health, pleasure, convenience, price, familiarity and ethicality were assessed on food choices. The results show that a greater intake of vegetables and fruits were related to better education and income, and *vice versa* the consumption of energy-rich foods were associated negatively with education. Price and familiarity of the products were considered more important among the people with lower socio-economically status. It was also stresses that the individual priorities rather than the absolute importance of food choices are important factors producing differences between consumers with lower and higher socioeconomic status (Konttinen et al. 2012).

Big data provides an interesting source to study crop diversity (Keskitalo et al. 2012, Himanen et al. 2013, Peltonen-Sainio et al. 2017), and consumers' buying behaviour (Anon. 2018). Actually, different groups of food items could be distinguished based on what consumers selected to their food bags. Namely, those which can be used to prepare ordinary home-made foods, those which are easy to warm-up or are semi-finished food, those which are good for snacks, can be used for baking, or are needed for family parties or when having fun with the friends (Anon 2018).

Diversification of plant production may have different connections to the society but still rather little is known on various influences to food chain, although there are many attempts to diversify the production. The final aim of the research was to study whether there are connections between the diversity of cultivation and consumers buying the food. The study consisted of different steps. Firstly we examined the diversity of crop production in 310 municipalities in Finland with the crop species diversity index (CSDI), and thereafter selected municipalities which economically status were the same but they had either high or low CSDI. Food selling data was requested from the local supermarkets from totally 18 municipalities forming nine pairs, each having a municipality with high and low CSDI. The food data was obtained from selected fresh or minor processed food items (fruits, vegetables, tuber crops, flour & starch items, flakes & grifts; and crisps & mueslis) over three years. In addition, the potential of CSDI as a tool to monitor the production diversity was discussed.

2. Materials and Methods

2.1. Data on field parcel and crops species diversity

The data on the use of field parcels and the crops cultivated during 2012 – 2016 was obtained from the Agency of Rural Affairs (Mavi). In the dataset the total number of different crops and uses of field parcels were about 200, also some variations on the descriptions between the years occurred. Some harmonisation was needed to be able to compare the years with each other. Eventually about 60 crops or group of crops were chosen to the dataset, which were used to calculate the crop species index (CSDI) based on Shannon index (Shannon 1948) for each municipality in Finland.

The model for CSDI was assessed as described below and earlier (Jauhiainen & Keskitalo 2012), where S is the total number of crop species, i refers to the crop, N is the total number of field parcels, p_i is the share of the field parcel where the crop is growing of the total number of the parcels.

$$H' = -\sum_{i=1}^{S}(p_i \ln p_i) - [(S-1)/2N]$$

2.2. Formation of pairs of municipalities

Pairs of municipalities were created taking into account the following information about municipalities: population, population density, average total income and proportion of employees. The aim was, that within each pair, the background of municipalities were the same, and they should locate near each other, but the diversity of the surrounding plant production were as opposite (low vs high).

Twenty-four pairs of municipalities could be found according to the criteria, six pairs of municipalities located in each of the areas (South- West-, East- and North-Finland).

2.3. Sales data of food in the selected municipalities

From the 24 possible pairs of municipalities; the sales data was obtained from nine pairs and totally from 18 municipalities: three pairs located in South-Finland and two in West-, East-, and North-Finland, each. The reason for the reduced number from 24 to 18 municipalities was that, there was no supermarket in each municipality or the size of the store differed too much.

The monthly data sales for 2015 – 2017 was obtained from S Group statistics. S Group is a Finnish network of companies operating in the retail and service sectors. It has more than 1,600 different outlets including also the food sector. The food groups studied were selected so that, they were minor processed or fresh, and could have been produced locally. The six food categories selected were fruits, vegetables, tuber crops, flours & starch items, flakes & grifts, and crispies & mueslis.

2.4. Analysis on the relation between CSDI and food sales of nine pairs of municipalities

Among the nine pairs of municipalities, the variance component model was applied to model how much of the variation each variable explained. The variables were: year, location (East, North, South and West-Finland), economical status of the municipality (between the pairs of municipalities), cultivation diversity within the municipality, monthly variation of the sales, monthly variation of the sales x location interaction, monthly variation of the sales x cultivation diversity interaction, and unexplained variation.

2.5. Observations on the diversity of products among item groups

The diversity i.e. the number of products belonging to fruits, vegetables, tuber crops and flour, starch flakes & grifts together were counted from three pairs, totally from six municipalities located in South-Finland.

3. Results and discussion

3.1. Uses of field parcel and crops species diversity

The number of crop species cultivated in Finland between 2012 and 2016 varied from about 100 to more than 122 and was increasing during the studied period. In addition to the specific crops, other uses of land increased from 55 to more than 70 classes during the studied period. Other uses of land were mainly mixtures of crops or they were cultivated as environmental fallow without any specifications. The nomenclature of crops was harmonised, because there were some differences on it between the years. Due to harmonisation it was possible to compare the data over the years needed to calculate the CSDI.

CSDI (crop species diversity index) was calculated to each of the 310 municipality in Finland between 2012 – 2016. The CSDI varied from below 0,5 to more than 2 (Fig 1). In addition, CSDI was calculated to four larger areas, where the field uses and production of agriculture were quite similar. South-Finland is specialised mainly for the production of seed crops, West-Finland for seed and animal production (pigs and chicken), East- and North-Finland for grass, milk and meat production. The CSDI varied from about 1,5 (East and North-Finland) to near 2 (West- and south-Finland). It was also found that the CSDI decreased from South to North-Finland ($r=-0.56$, $p<0.001$), and from West to East-Finland ($r=-0.26$, $p<0.001$).

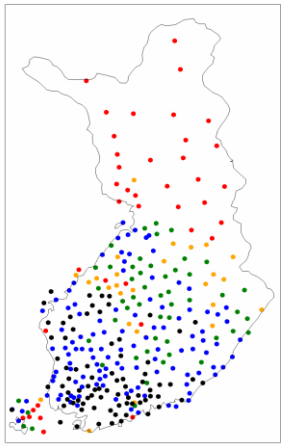

Fig.1. Crop species diversity index (CSDI) in 310 municipalities in Finland between 2012 - 2016. Each colour represent different CSDI as follows; red < 1,25; 1,25 < yellow < 1,5; 1,5 < green < 1,75; 1,75 < blue < 2; 2,0 < black.

To get more understanding on the structure of municipalities in Finland, total income per capita and the population amount of municipality were studied. It was observed that the income per capita in the municipality decreased from South to North-Finland ($r=-0.41$, $p<0,001$), and from West- to East-Finland ($r=-0.50$, $p<0.001$). In addition, the population amount in municipality slightly decreased from South- to North-Finland ($r=-0.12$, $p=0.04$).

Between CSDI and income and between CSDI and population amount the correlations were $r=0.27$ ($p< 0,001$) and $r=0.38$ ($p< 0,001$), respectively. Comparisons were made also between two groups, of which each consisted about half of the total number of municipalities. Especially among the southern group of municipalities, below 62 ◦N, the correlation between CSDI and population was stronger ($r=0,42$, $p<0,001$).

3.2. Formation of pairs of municipalities

Nine pairs of municipalities were chosen to the study based on the criteria described in materials and methods and from where the food sales data could be obtained (Fig 2). The mean CSDI among the municipalities having 'low' index were between 1,00 and 1,92 and the CSDI among the municipalities having 'high' index were 1,5 – 2,2. The difference between CSDI among the pairs were 0,1 - 0,8 (Fig 2).

Area in Finland	No of pairs	Municipality with low CSDI	Municipality with high CSDI	Difference of CSDI among the pair of municipality
		symbol	symbol	
South	1	●	●	0,4
	2	●	●	0,4
	3	●	●	0,1
West	4	●	●	0,8
	5	●	●	0,8
East	6	●	●	0,3
	7	●	●	0,4
North	8	●	●	0,6
	9	●	●	0,5

Fig 2. Pairs of municipalities and symbols in colour illustrating the CSDI.

3.3. Sales of food in the selected municipalities

Average monthly sales per capita (kg) were studied on the food items in the supermarket located in the selected municipalities in South- (S-F), West- (W-F), East- (E-F) and North-Finland (N-F) during 2015 – 2017. The annual sales of fruits were the highest, about 19 kilograms per person, also the sales of vegetables and tuber crops were more than 10 kilograms per person. Flours & starch, flakes & grifts, crispies & mueslis were sold significantly less (from 4,6 to below 2,0 kg capita^{-1} year^{-1}, each).

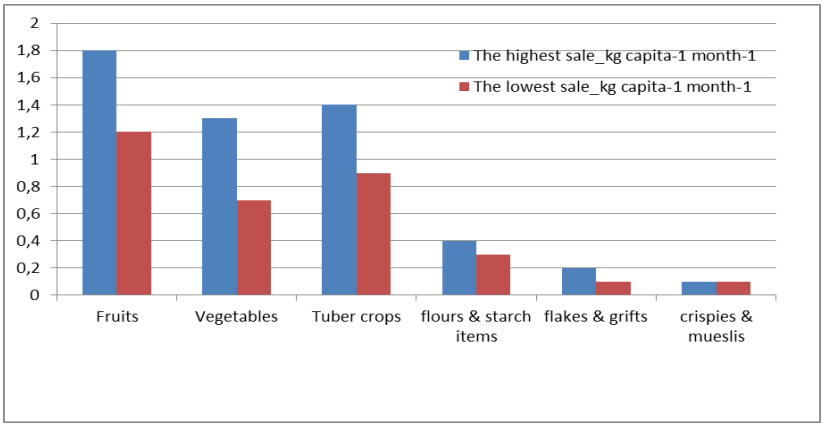

Fig. 3. The highest and lowest monthly sales (kg capita^{-1} month^{-1}) of selected food items in Finland. The sales represent the mean between 2015 -2017.

The lowest monthly sales of fruits, vegetables and root crops per capita were about 52 – 67 % of the highest monthly sales, whereas the lowest monthly sales of flours & starch items, flakes & grifts, and crispies & mueslis per capita were about 67 – 79 % of the highest monthly sales. The monthly sales for fruits are illustrated in Fig 4. The same type of analyses were made also for vegetables, tuber crops, flour & starch items, flakes & grisps and for crispies & mueslis.

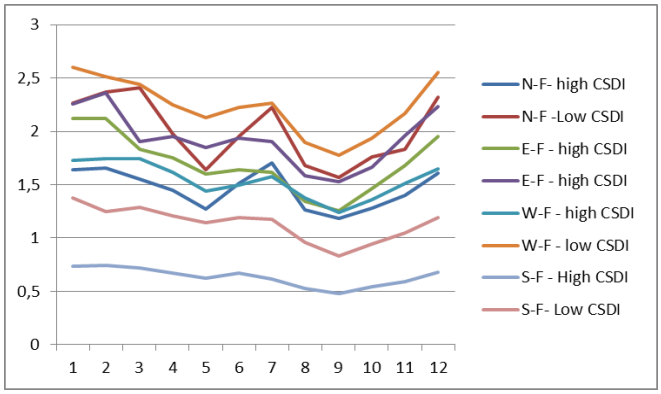

Fig 4. Average monthly sales of fruits per capita (kg) in the supermarket situated in the selected municipalities having high and low CSDI in South- (S-F), West- (W-F), East- (E-F) and North-Finland (N-F).

Differences of sales between areas could be observed. In every food items, the sales were the lowest in supermarkets located in South-Finland. The sales for fruits, vegetables and tuber crops were the highest in West-Finland and for flours & starch items, flakes & grifts, and crispies & mueslis in East-Finland. The total sales of all studied items in South-Finland were only about half of the mean annual total sales of other parts of Finland. The lowest annual sales per capita of fruits, vegetables and root crops were about 45 – 55 % of the sales in the highest selling area, whereas the lowest annual sales per capita of flours & starch items, flakes & grisps, and crispies & mueslis were only 10 – 32 % of the highest selling area.

3.4. Relation between CSDI and food sales in municipalities

The difference of the sales between municipalities with high and low CSDI could be observed. The total annual sales per capita in municipalities with high CSDI were from 66 % to 83 % of that in the municipality with low CSDI for each of the food items.

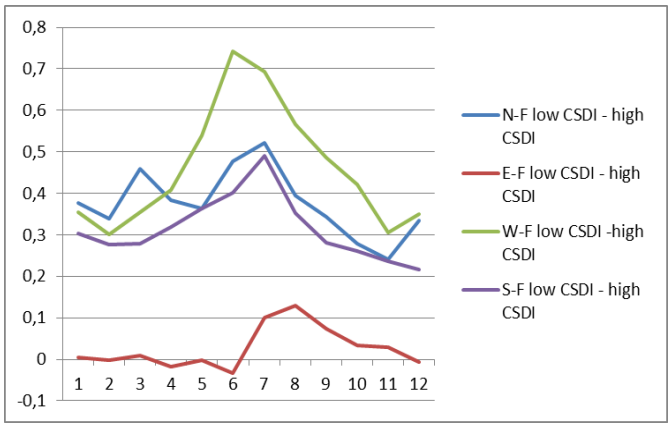

Fig 5. Differences of the monthly sales (kg per capita) of vegetables between municipalities with low CSDI and high CSDI in South- (S-F), West- (W-F), East- (E-F) and North-Finland (N-F). The same type of analyses were made for vegetables, tuber crops, flour & starch items, flakes & grisps and for crispies & mueslis.

Among the nine pairs of municipalities, the variance component model was applied to model how much of the variation each variable explained. The economy of the municipality had the strongest effect to the sales of the selected categories, describing about 52 % of the variation. But, it was interesting, that the crop species diversity had an effect to different categories as well. For crispies & mueslis, and fruits, the diversity explained about 23 % and 14 %, respectively, of the variation observed in the sales.

The diversity of crop species had the weakest effect on the offer and sale for tuber crops, explaining only about 5 % of the variation. The rest of the food items such as vegetables, flours & starch items, and flakes & grifts, the crop diversity described about 6 – 9 %. Overall, the diversity explained about 11 % of the variation. About 17 – 39 % of the variation remained unsolved.

Table 2. The proportion of variance (%) each variable explained on the sales of selected food items. Total variation =100 %. Monthly sales between 2015 – 2017 were included from each of the 18 supermarkets representing eight pairs of municipalities.

Variable components	Fruits	Vegetables	Tuber crops	Flours & starch items	Flakes & grifts	Crispies & mueslis	Mean
Year	0.0	0.0	0.0	<1	0.0	0.0	<1
Area of Finland	0.0	0.0	0.0	<1	0.0	0.0	<1
Economy and progress of municipalities	51	46	52	52	56	58	53
CSDI	14	9	5	7	6	23	11
Monthly variation of sales	5	11	4	2	1	2	4
Unexplained variation	31 %	34 %	38 %	39 %	37 %	18 %	33 %

3.5. Diversity of products among each item groups

From each item groups (fruits, vegetables, tuber crops, and flours, starch items flakes & grifts together the number of sub-products in the standard products was counted in the supermarket. The standard products were those, which should be found from every supermarkets, and the number were 11, 24, 11 and 54 for fruits, vegetables, tubers, and for flours, starch, flakes & grifts together, respectively. For example, apples, bananas, citrons, etc. included to fruits; tomato, onions, paprikas, etc. to vegetables; potatoes, carrots, red beets, etc. to tuber crops; and flours, seeds, flakes and starch products of different seeds crop to the flours, starch items flakes & grifts.

The total number of different sub-products (for example, different apples + different bananas + different citrons, etc.) varied from 11 - 44 within fruits; from 17 – 91 within vegetables; from 8 – 35 within tuber crops and from 33 - 133 among flours, starch, flakes & grifts item, depending in the studied region and supermarket. For some item groups, there were tendency that the number of products were lower in supermarkets located in municipality with high CSDI, but it was weak and more observations would be needed to understand the possible relationship.

4. Discussion

Interestingly, the study managed to catch items which were grouped to different shopping bag profile in the earlier study, also carried out with the data from S-markets (Anon 2018). Fruits, vegetables and tuber crops were found from consumers' shopping bag which were assumed to prepare common home-made food or from a bag, which contained food suitable for snacks but not for real meal. Crispies & mueslies were connected consumers' profile, which preferred easy-to make or to warm-up foods. Flours were found from shopping bag of people, which are eager to bake.

To answer the question, whether there are connections between the diversity of cultivation and consumers buying the food, the sales of all food items capita^{-1} year^{-1} were lower in municipalities with high CSDI, and the selling was higher with the low CSDI. The results were not expected. The possible reason may be that the municipalities with higher CSDI were somewhat larger in size and more people were living there. Therefore, in the municipality with high CSDI there may be other supermarkets as well and consumers may buy less from one supermarket. Another explanation would be, that people in municipalities with low CSDI may work more at home and therefore consume and buy more food. However, to understand these unexpected results would need more studies. The municipality based CSDI showed to be a useful tool to monitor crop diversity and facilitates the comparison between data from different sources.

It was observed that the economy and the number of people living in the municipality are connected to high CDSI. In municipality with higher income, farmers may have more possibilities to sell various crops and raw materials. It is also possible, that the municipalities differ in the spirit of enterprise, and this may affect for both farmers and consumers attitudes. However, the economy may not explain everything, and other drivers exist as well.

5. Acknowledgements.

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