Land Consolidation and Agricultural Traffic
– Instrument for Calculating the Traffic Volume

Suvi PANSCHIN and Arvo VITIKAINEN, Finland

SUMMARY

The study outlined the volume of agricultural traffic and the possibilities of reducing the traffic by land consolidation. Further, the study investigated the total load caused to the village road network by agricultural traffic and the possibilities of analysing the future changes.

The initial material for the study was obtained from the Finnish Land Parcel Identification System, i.e. the FLPIS, maintained by the Ministry of Agriculture and Forestry. The FLPIS contains the location information of all farmsteads and field parcels of the farms receiving acreage-based support, and, among other information, the field parcel identifiers, surface areas and outer boundaries and information of the owners and tenants. The data of the study area in the FLPIS was downloaded into the JAKO land data bank system of the National Land Survey of Finland and the lengths of travel to the field parcels and the volume of agricultural traffic on the road network were counted by the route calculating instrument contained in the system. The road network of the area was obtained from the Land Information System maintained by the National Land Survey of Finland and the Smallworld Network Follower application was used as the calculating instrument.

The study shows that by land consolidation the agricultural traffic of 129 farms on the through-passing highway could be reduced by ca. 45% from the present 57 000 km/year, i.e. to some 26 000 km/year. According to the estimate of the National Land Survey and the compensations in the expense data bank this would bring about 25 000 euros of annual savings to the farmers, which, when capitalised (30 years, 5 % rate of interest), means total savings of ca. 390 000 euros. The reduction of slow agricultural traffic on the highway also has a significant benefit to traffic safety.

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1 INTRODUCTION

A revolutionary structural change took place in the 20th century in the Finnish rural area and agricultural industry. In the 1940's the share of the rural population was still about a half of the whole population but had decreased to some 10 % by the turn of the century. At the same time the number of farms decreased from more than 300 000 in the late 1950's to ca. 100 000 in 1995. In 1995 to 2008 the number of farms still decreased by ca. 35 000 so that in 2008 there were only about 60 000 farms in Finland. (TIKE 2009).

After Finland joined the European Union in 1995 the focal strategy of the agriculture has been to adapt to the new situation by growing the farm size either by buying or leasing fields from the ones withdrawing from production. Growing the farm size aims to lowering the unit costs of production and assuring adequate income for the farming family.

In 1995 to 2008 the average size of farms has in fact grown from 22 field hectares to about 35. The share of leased fields in the same period has increased from ca. 22 % to 54 %. (TIKE 2009).

The rapid structural change in agriculture, which is still going on, indicates that together with the decrease in the number of farms and increase in the farm size the internal structure of the farms has undergone remarkable changes. According to various studies the increase in farm size nearly exclusively seems to take place by the increase in field parcel number and very little by the increase of parcel size. For instance, according to studies concerning Western Finland and Ostrobothnia about a half of the field parcels are less than 2 hectares and about a third of the arable area consists of parcels of less than 2 hectares. (Myyrä 2000; Ylikangas 1999).

The development can be explained by competition for additional land. The farmers who continue production are usually interested in increasing the size of their enterprise by purchasing more land. In that case the purchased or leased parcels are rather seldom obtained by the ones whom they fit the best, or even if they did, the road and drainage networks following the old property division will remain to fragment the area.

The purchased and especially leased additional parcels are usually further from the farmstead than the fields already used. The increase in cultivation distances adds the volume of agricultural traffic and causes extra costs due to the increased logistics expenses and work time when moving from one parcel to another.

Along with the fragmentation of property division the impractical crosswise traffic from the

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homestead to parcels of one's own or leased closer to other homesteads will increase. This is seen by crosswise traffic directions compared to other farms and the locations of their parcels. Picture 1 shows the problems of crosswise traffic.

The increase of agricultural and crosswise traffic on the road network is also seen by the traffic flow, especially in the peak seasons, spring and autumn. On the highway network this is a problem of traffic safety. When the volume of slow agricultural traffic increases the average speed of the traffic slows down and overtakings substantially increase.

The study outlines the volume of agricultural and crosswise traffic and the potentials for decreasing this traffic on the highway network. Also the total volume of agricultural traffic and its changes due to the changes in the production structure of the village were studied. The research area was the coverage area of highway 18 between Laihia and Ylistaro (Picture 1) and the village of Sääksjärvi in the municipality of Mäntsälä (Picture 5).
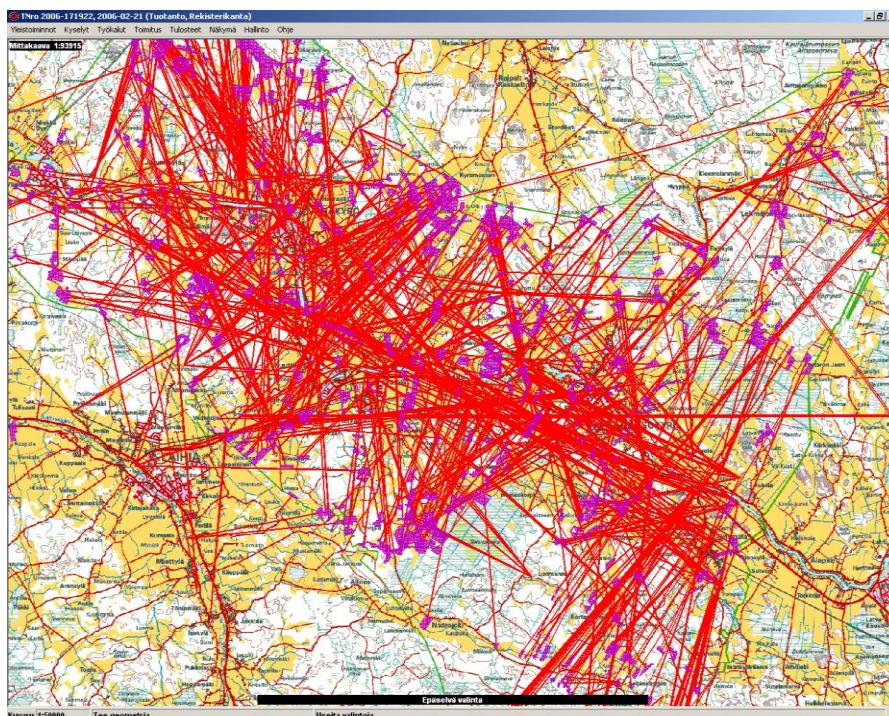
Picture 1. Field parcels located farther than 6 kilometres from the homestead; at least 1 km drive on highway 18. (NLS 2006).

2. METHOD OF ANALYSIS FOR AGRICULTURAL TRAFFIC

2.1 Material and instruments used

In Finland the field parcel subsidies by EU are controlled by the Ministry of Agriculture and Forestry using the IACS (Integrated Administration and Control System) covering all farms receiving acreage-based support. The field parcel register, i.e. the FLPIS (Finnish Land Parcel Identification System) is a part of the IACS. The FLPIS contains the location information of

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all farmsteads and field parcels of the farms receiving acreage-based support, and, among other information, the field parcel identifiers, surface areas and outer boundaries and information of the owners and tenants. (www.nls.fi / 2009a)

The data in the Finnish Land Parcel Identification System can be loaded into the JAKO land data bank system of the National Land Survey of Finland, and the lengths of travel to the field parcels and the volume of agricultural traffic on the road network were counted by the route calculating instrument contained in the system. The route calculating in the JAKO land data bank system is carried out by using the Land Information System maintained by the National Land Survey of Finland and the Smallworld Network Follower application contained in the system as the instrument. The Land Information System contains data of the whole of Finland. Its most important target groups are the road network, buildings and constructions, place-names, land use and altitudes. The accuracy of the location data in the system corresponds to the scale of 1:5 000 to 1:10 000. The road network data includes all trafficable roads. The roads are rated in the Land Information System as motorable roads of different sizes 1a to IIIb, access roads, ferryboat, ferry, old trail, winter road, pedestrian and bicycle way, and trail. The road network is continuously updated in the data bank. (www.nls.fi / 2009b).

For analysing the crosswise traffic the volume of agricultural traffic was counted on the highway 18 between Laihia and Ylistaro. The road distance studied was 29 kilometres and its average daily traffic is 4 800 to 6 600 vehicles/day. Field parcels requiring traffic on highway 18 at least for one kilometre and located at the minimum distance of six kilometres from the farmstead were chosen from the register and included in the study (Picture 1).

129 farms were analysed. The overall area of the studied field parcels was 1 450 hectares and the fields were totally in 545 parcels (average size of the parcel 2,7 hectares). The analysis of the data was made on the grounds of the possession, so that both owned (936 hectares) and leased (514 hectares) field parcels of the farms were included. 77 % of the total agricultural traffic on the road section was considered in the study, but only some 40 % of the field parcels using traffic on highway 18. The average length of travel from the farmstead to the field parcels was 11,2 kilometres, 5,1 kilometres of which on highway 18.

2.2 Agricultural traffic count

When calculating the lengths of travel to the farms one has to specify the ”farmstead” point and calculate the ”access” points to the field parcels. Length of travel to each pair of ”farmstead” – ”access” can be calculated either by searching the shortest or fastest route on the road network in the Land Information System. (NLS 2006).

The route calculation avails itself of all passages in the Land Information System, and therefore the shortest route may result in pedestrian or bicycle ways. Due to this the fastest route was decided to be used in the analysis. The data bank includes default values for travel speeds of each road rate (Table 1) and these speeds were used for the calculation.

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Table 1. Travel speeds for different road rates used for calculating agricultural traffic. (NLS 2006).

Road rate	Sped (km/h)
Motorable road Ia	40,00
Motorable road Ib	40,00
Motorable road IIa	40,00
Motorable road IIb	21,00
Motorable road IIIa	21,00
Motorable road IIIb	18,00
Access road	12,50
Old trail	8,00
Pedestrian/bicycle way	8,00
Trail	8,00
Other	0

The volume of agricultural traffic on the road network is also affected by the production lines of the farms. When calculating the total use of highway 18 for agricultural traffic the travels were described emphasising the production lines of the farms in the area (dairy cattle 11 %, pig breeding 8 %, grain growing 72 % and fallow 9 %). The number of annual travels required by different production lines was obtained from the data bank for valuation and compensations of the National Land Survey of Finland (www.nls.fi / 2009c). The number of travels for grain growing was 8,5 per field parcel, and for dairy cattle and pig breeding 10,8 per field parcel. Travels to fallows were estimated to be once a year.

The number of travels in the calculation is obtained by the formula (Halonen 2007):

$$k = \sum_{i=1}^{n} t_i * p_i \qquad (1)$$

k = average annual number of travels in the area (number/field parcel)
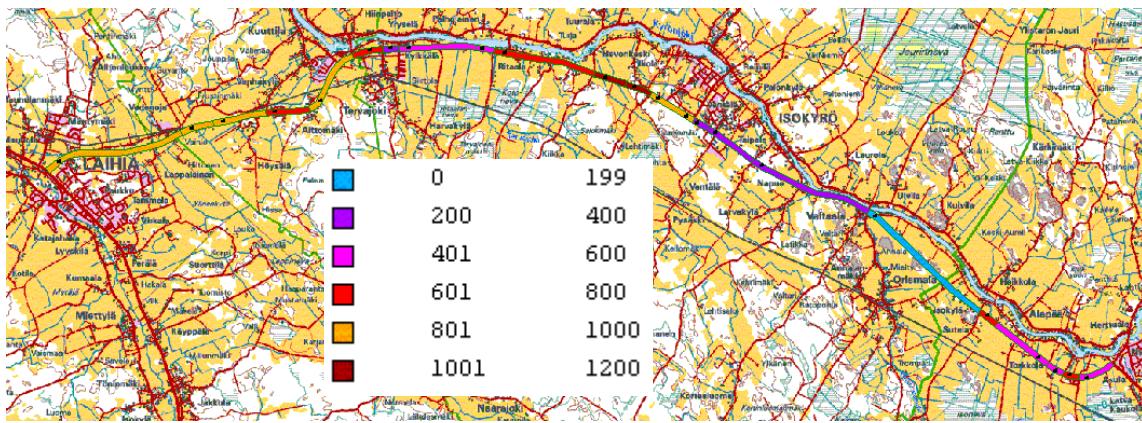i = production line (1-n)
t = share of the production line of the agriculture in the area (%)
p = production line specified number of travels per year (number/field parcel)

The volume of agricultural traffic in the area by the formula (1) was 8 travels/parcel/year, on the average (k = 0,72*8,5 + 0,08*10,8 + 0,11*10,8 + 0,09*1 = 8,262).

The total volume of agricultural traffic (129 farms) on the studied road section on highway 18 was 35 300 km/year to own field parcels and 21 700 km/year to leased parcels, i.e. 57 000 km/year (440 km/farm/year) in total.

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Picture 2. The present agricultural traffic on highway 18, travels/year

3 MINIMISATION OF AGRICULTURAL TRAFFIC ON THE MAIN ROAD NETWORK

For minimising the volume of agricultural traffic the study outlined such an optimal model of locating the parcels, in which the agricultural traffic from the homestead to the field parcels is at the minimum. Production sectors were first formed in the study area for calculating the optimal parcel locations. A production sector was formed of an area, which was convergent so that it always consisted of field parcels in the range of a road intersecting from the main road (Picture 3). Thus, 13 production sectors were formed in the study area, the average size being 112 hectares (range of variation 40 to 225 hectares). There were 10 farms in the range of one production sector, on the average (range of variation 4 to 17 farms). '
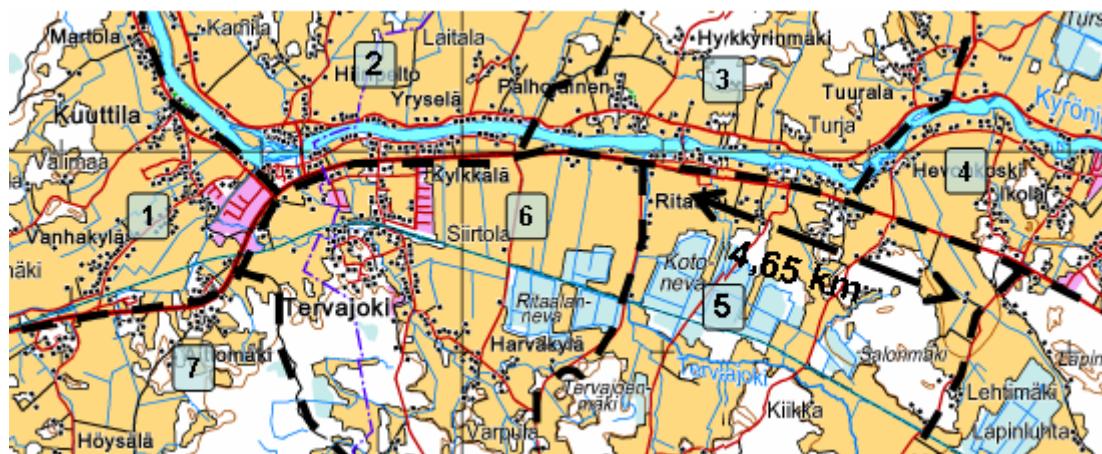
Picture 3. An example of the formation of production sectors on highway 18.

After forming the sectors the field parcels of the farms located in the sector were placed in the same sector where the farmstead was located. If the arable area in the production sector was not sufficiently large for locating the field parcels of all farms in the sector where the farmstead was, the rest of the field parcels of the farms in question were located in such a

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sector with additional field, which was traffic-wise closest to the farmstead.

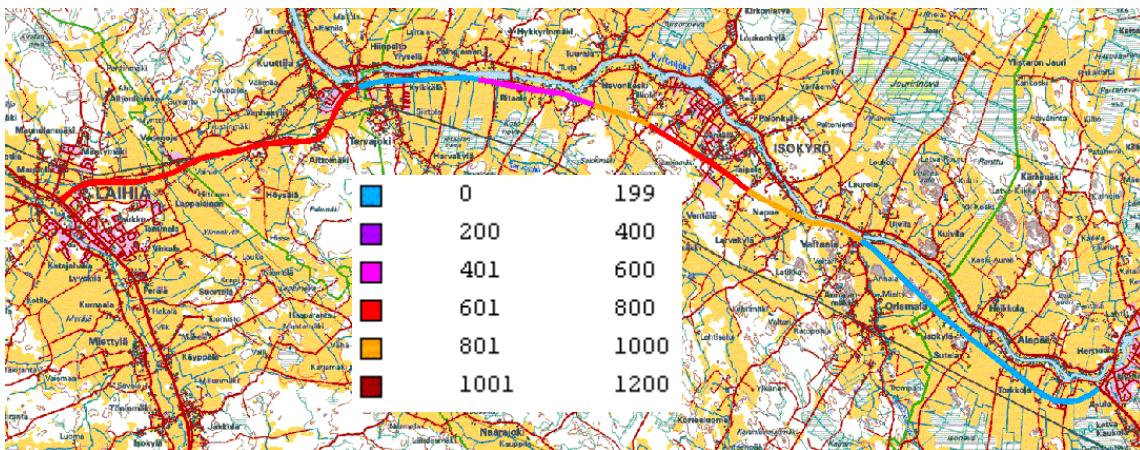**Table 2.** Division of arable area into production sectors.

Sector No.	The length of the sector on the highway, km	Farms in the sector, gty	Fields (hectares) of the farms in the sector	Arable area of the sector, hectares
1	2,24	8	45,47	132,26
2	5,00	4	75,35	72,59
3	7,92	6	89,48	109,64
4	2,76	17	210,02	83,34
5	4,41	7	81,83	116,66
6	3,23	7	79,84	161,89
7	4,68	14	131,44	115,51
8	2,70	9	39,47	95,89
9	6,77	4	117,20	60,88
10	5,03	15	225,21	128,52
11	5,01	16	187,04	170,02
12	4,40	13	123,90	132,04
13	5,21	6	44,99	72,00

The agricultural traffic on the main road was then calculated in a new situation. Both owned and leased fields were considered. The outcome of the analysis was that if it was possible to arrange the field parcels in the area absolutely optimally, the volume of agricultural traffic on highway 18 could be reduced with 45 % from the present, i.e. some 26 000 km/year (Table 3 and Picture 4).

Table 3. Potentials for reducing agricultural traffic on highway 18.

	Kilometres/year at present	Kilometres/year in optimum	Reduction (km)	Reduction (%)
To leased parcels	21 680	12 256	9 424	43 %
To owned parcels	35 248	18 832	16 416	47 %
Total	56 928	31 088	25 840	45 %

One-way travel per parcel on the highway shortened from 5,0 kilometres to 2,1 kilometres in the optimal case. If the tractor speed on the highway is 30 km/h, time saving caused by this shortening travel is a year will be some 7 hours/farmer. According to the data bank of valuation and compensations maintained by the National Land Survey of Finland (www.nls.fi / 2009c) this will cause annual savings of appr. 25 000 euros to the farmers, which when capitalised (30 years, 5 % interest) means the total savings of 390 000 euros. The reduction of agricultural traffic by 26 000 kilometres is also an important benefit. (Halonen 2007). Of course it have to consider that in this study the reduction of agricultural traffic after land consolidation calculated under the hypothesis of a full exchangeability of the plots but in reality it can be a lot of restrictions.

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Picture 4 Agricultural traffic on highway 18 in optimal situation, travels/year.

4 DESCRIPTION OF THE FUTURE CHANGES IN THE AGRICULTURAL TRAFFIC VOLUME ON THE VILLAGE ROAD NETWORK
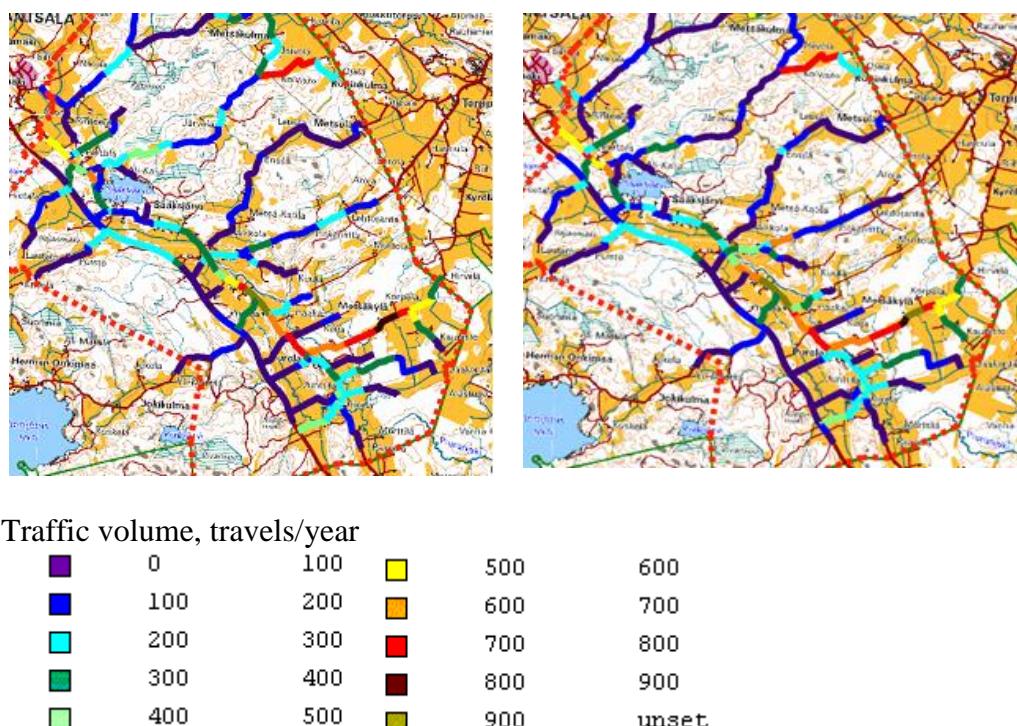
By means of the route calculation instrument contained in the Finnish Land Parcel Identification System and the JAKO System one can also consider how much the agricultural traffic volume will change in the future on the village (or other area) road network, e.g. when the number of farms decreases or land consolidations change the property division. In that case the present volume of agricultural traffic on the road network will be calculated as described above.

After this it is possible, by interviews, age of the farmer, etc., to farm-specifically evaluate which farms will end their production in 5 to 10 years or how the property division will otherwise change. Then the fields in the studied area will be allocated to the farms continuing production in the readjustment plan (Picture 5).
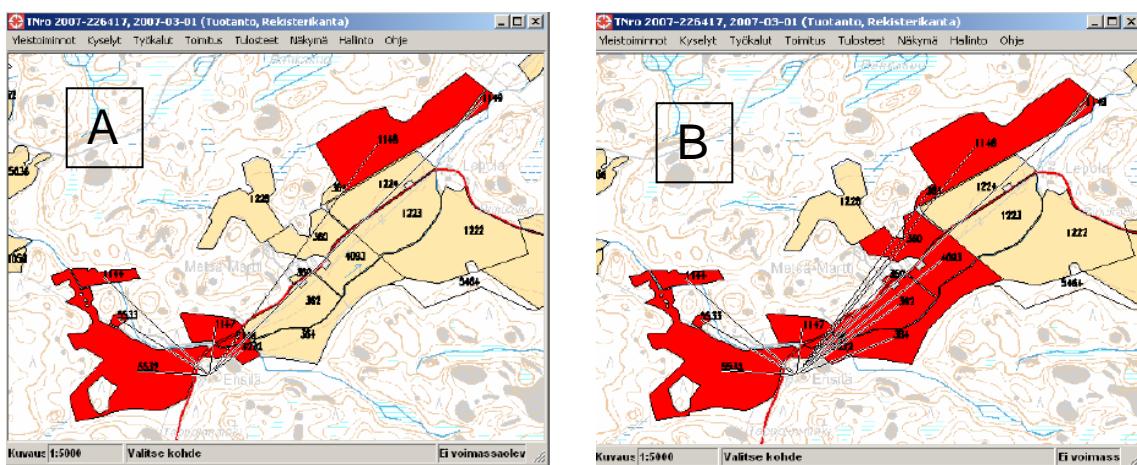
Picture 5. Field parcels of a farm today, 6 pcs. (A) and after 5 years, 14 pcs. (B).

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Considering the other factors affecting the agricultural traffic in the future, such as changes in the productions lines and road network structure, the impacts of the changes on the traffic volumes in different parts of the village road network can be calculated. Picture 6 presents the results of the calculation in the village of Sääksjärvi in the municipality of Mäntsälä. The calculation was made from the hypothesis that 15 of the 79 farms in the village will end their production within five years and all the fields of those withdrawing will be used by the ones continuing production. As seen in Picture 5 the changes in the production structure will also cause changes in the agricultural traffic on the village road network, albeit the changes in this case were not very big.

Traffic volume, travels/year

■	0	100	■	500	600
■	100	200	■	600	700
■	200	300	■	700	800
■	300	400	■	800	900
■	400	500	■	900	unset

Picture 6. Change in the agricultural traffic volume on the village road network (municipality of Mäntsälä, village of Sääksjärvi).

5 CONCLUSIONS

The purpose of this study was to create a calculation method for calculating the agricultural traffic volume on the road network or on a part of it and consider the possibilities of reducing the agricultural traffic on the main roads by means of land consolidation. The Finnish Land Parcel Identification System used in the control of EU farming subsidy, road network contained in the Land Information System maintained by the National Land Survey of Finland, and the route calculation instrument within the JAKO System of the National Land Survey of Finland were availed in the calculation.

The study shows that by changing the location of the field parcels the maximum of 45 %, i.e.

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nearly 26 000 kilometres, of annual agricultural traffic on the main roads could be reduced. According to the cost information contained in the data bank of valuation and compensations (www.nls.fi / 2009c) this will annually benefit the farmers with 25 000 euros in savings, which, when capitalised (30 years, 5 % rate of interest), means total savings of ca. 390 000 euros. Further, the reduction of agricultural traffic on the main road network would also improve traffic safety.

Readjustment of fragmented field parcels for optimising the traffic volume is, on the other hand, a challenging assignment where the readjustments can probably be realised only by land consolidation or project land consolidation. These measures could then be integrated with readjustment of leased parcels and land bank for providing additional land for the farms continuing production.

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BIOGRAPHICAL NOTES

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