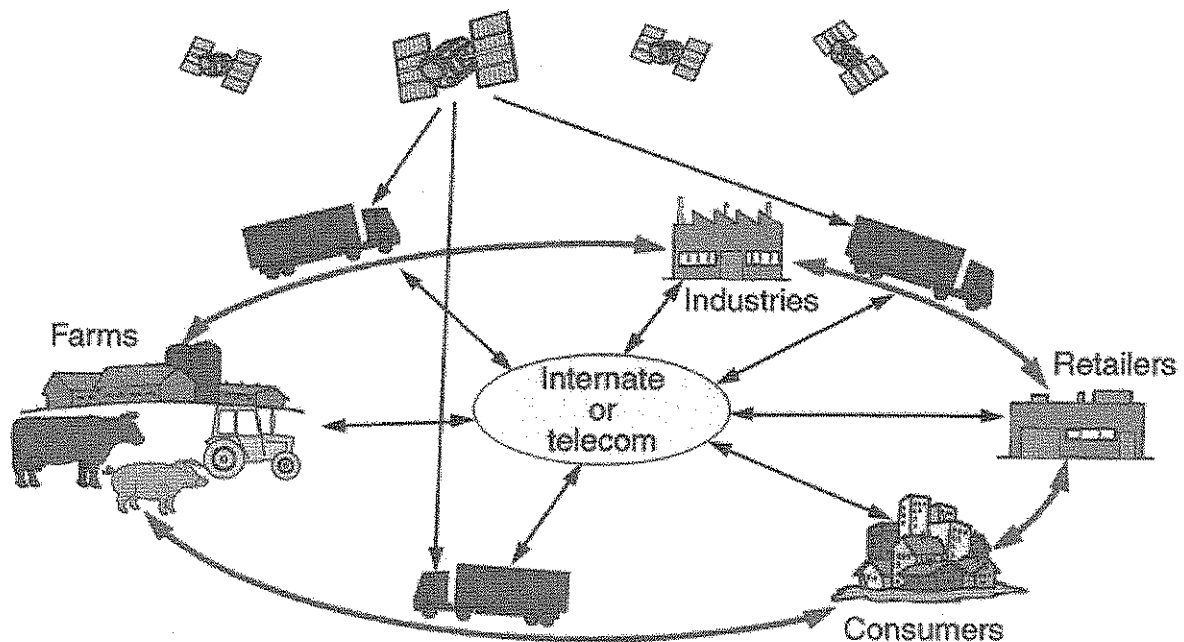




AGRICULTURAL GOODS TRANSPORT AND ENVIRONMENT

Visions, strategies and the role of SLU in the development of environmentally sustainable transport

Girma Gebresenbet



Institutionen för lantbruksteknik

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Contents	Page
Abstract	3
1. Introduction	3
2. Transport and environment	5
2.1. Causes and effects of transport growth	5
2.2. The concept of JIT and environment	8
2.3. Emissions and environment	8
3. Global and national attention on environment	10
3.1. Concept of sustainability	11
3.2. Swedish government's proposals	12
4. Agricultural transport in Sweden	13
4.1. Components of agricultural transport	13
4.2. Trends in agricultural production and transport	14
4.3. Research in agricultural transport	24
5. Visions and strategies to develop environmentally sustainable goods transport	25
5.1. General concept	25
5.2. Strategies to reach the goal of visions	26
5.2.1. Integration of IT with logistics	27
5.2.2. Coordination of transport, localization and the concept of JIT	30
5.2.3. Avoidance of transport required activities	32
5.2.4. Alternative fuel system	33
5.2.5. Animal transport	33
5.2.6. Use of vehicles for various goods delivery	34
6. Role of SLU in agricultural transport	34
7. Concluding remarks	36
Acknowledgement	38
References	38

Abstract

Transport plays a controversial role and highly related to almost all sectors of human activities. It plays an important role in stimulating economy and promoting the well being and quality of human life. However, its negative impact on the environment in the form of pollution is increasing at a high rate, and thus becoming a serious threat to plant, animal and human life.

In the recent decades, goods transport has been intensified and its contribution to the environmental deterioration is steadily increasing. Transport of agricultural produce, means of production, food and wood is a significant component of goods transport as a whole in Sweden, and the trend of intensification is analogous with other sectors.

The paper addresses the transport-induced environmental constraints with especial emphasis on goods transport in agricultural sector. Brief analysis is made on the causes and effects of goods transport intensification. Global and national awareness on the amelioration of the most pervasive environmental problems such as pollution, global warming and ozone depletion are presented.

A brief account is given on goods flow within farms, to and from farms and the tendencies in production, holdings, and transport demand in each sub-sector is discussed. The paper presents also the general visions and strategies to reach the goal of the development of environmentally sustainable goods transport. It emphasized the role of Information Technology to attenuate the intensity of transport and its consequence on environment.

Finally, the role of Swedish University of Agricultural Sciences and its sectoral responsibility in agricultural transport is highlighted and some plausible proposals are forwarded to facilitate research and education to promote the environmentally sustainable goods transport in the sector.

1. Introduction

Goods transport to and from agricultural and forestry sector is a significant component of goods transport as a whole. In Sweden, about 100 million tons of goods were transported by lorries in 1996 in the agricultural sector which is about 32% (Fig. 1) of the total goods in the country (SCB, 1998). Out of the given figure about 60 million tons are wood and cork while

the remaining 40 million tons are agriculture produce, means of production and food. The transport work performed was about 13 000 million tonkm which is about 40% of the total goods transport work by lorries in all sectors in the same year.

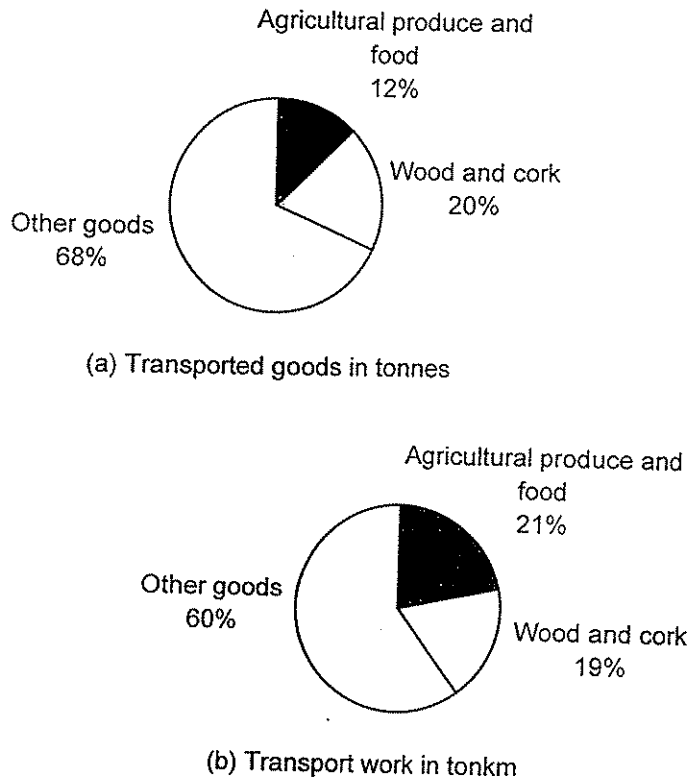


Figure 1. Transported goods and transport work distribution in Sweden (SCB, 1997)

In general, there is a sustained trend to concentrate production and storage in fewer but larger manufacturing and stockholders sites, trend toward globalization and flexible production technologies, changes in pattern of peoples settlement, localisation of supply and production and these have increased the demand for transport. In connection to the expansion of EU membership and the emergence of Single European Market (SEM), material flow is increasing rapidly, particularly within and through Sweden. Companies usually regarded transport as relatively cheap in comparison with other logistics costs, and thus transport continues increasing at a high rate. Such scenario turned great attention in the requirement of development of effective logistics system.

In the agricultural sector, the number of producers, i.e., farmers, dairy industries and abattoirs are decreasing through centralising (8 abattoirs were closed in the last 25 years). As a consequence the transport work has been increased significantly.

The intensity of goods transport contributes to the environmental pollution caused by air emissions generated from the vehicles. For example, about 20% of the global warming is attributed to the emissions from lorries engaged in goods transport. According to the directives of UN, EU and Swedish government such emissions should drastically be decreased by the year 2020.

In the agricultural sector, there is no sufficient information on the material flow to and from the farms and neither between farms. Hitherto, little attention has been paid to the on-farm and off-farm transport of especially primary food products, fodder, fertilisers, both live and slaughter animals, etc, and its impact on the environment. This may necessitates to conduct a comprehensive research to study the system in detail to provide better information on goods flow and its effects on environment which may allow to develop an environmentally acceptable, economically effective sustainable transport-logistics system in the agricultural sector in the future.

Though transport related research activities have been carried out at SLU, transport has never been SLU's key subject. However, the subject is gradually gaining popularity at the university in the recent years and drew attention of researchers.

For this particular work, the Research and Information Centre of SLU (SLU-Kontakt) and the Engineering departments of SLU took initiative to review relevant works at the university and formulate strategies for the foreseeable future perspective.

The general objective of this paper is to develop the concept of Agricultural transport which may fit in the frame work of sustainable development. Nowadays, it is the desire of the society to develop resource effective and environmentally sustainable logistics system should be developed to guarantee the move towards sustainable society.

The specific objective of the current work is to briefly describe the transport induced environmental constraints within agricultural sector, the status of research and development in the sector, highlight the role of Swedish University of Agricultural Sciences in agricultural transport, and develop recommendations in research and education.

2. Transport and environment

2.1. Causes and effects of transport growth

To analyze the causes and effects of goods transport, the problem analysis method may be utilized. According to the method, it is important to determine the core problem, the causes and effects or symptoms of the core problem. After determining the core problem, causes and effects, appropriate interventions will be developed to tackle the causes not the effects or symptoms. In the road goods transport and environment system, it may be assumed that intensification of goods transport is the main core problem. As illustrated in Figure 2, the main causes are increased transport demand and cheap fossil fuel. An increased transport

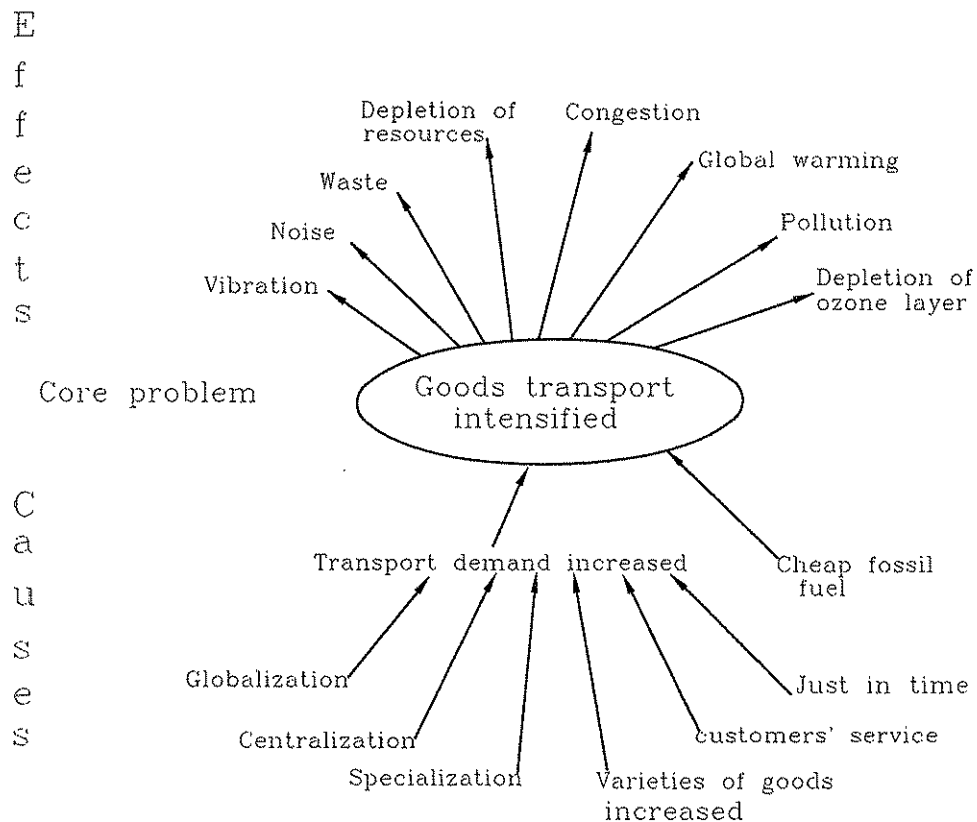


Figure 2. Causes and effects of goods transport

demand is caused by various factors such as:

- globalization,
- centralization,
- specialization of production,
- increased customers' service,
- increased varieties of goods, and
- flexible delivery system (the concept of JIT).

Further detailed breakdown can be made to determine the lower level causes for the above factors mentioned. Analogously, the same can be done for the effects. Those shown in Figure 2 are the immediate effects (global warming, depletion of ozone layer, pollution, congestion, depletion of resources, waste, noise, vibration, etc).

The vast majority of road transport is strongly related to consumers freedom and competition of international and national markets in Europe (Whitelegg, 1991). The tendency towards globalisation of companies is a very strong, and it may be possible to forecast that within the coming 10 to 20 years the national companies will be limited producing specific local demands. From Figure 3 it can be observed that the transported goods in Sweden per year

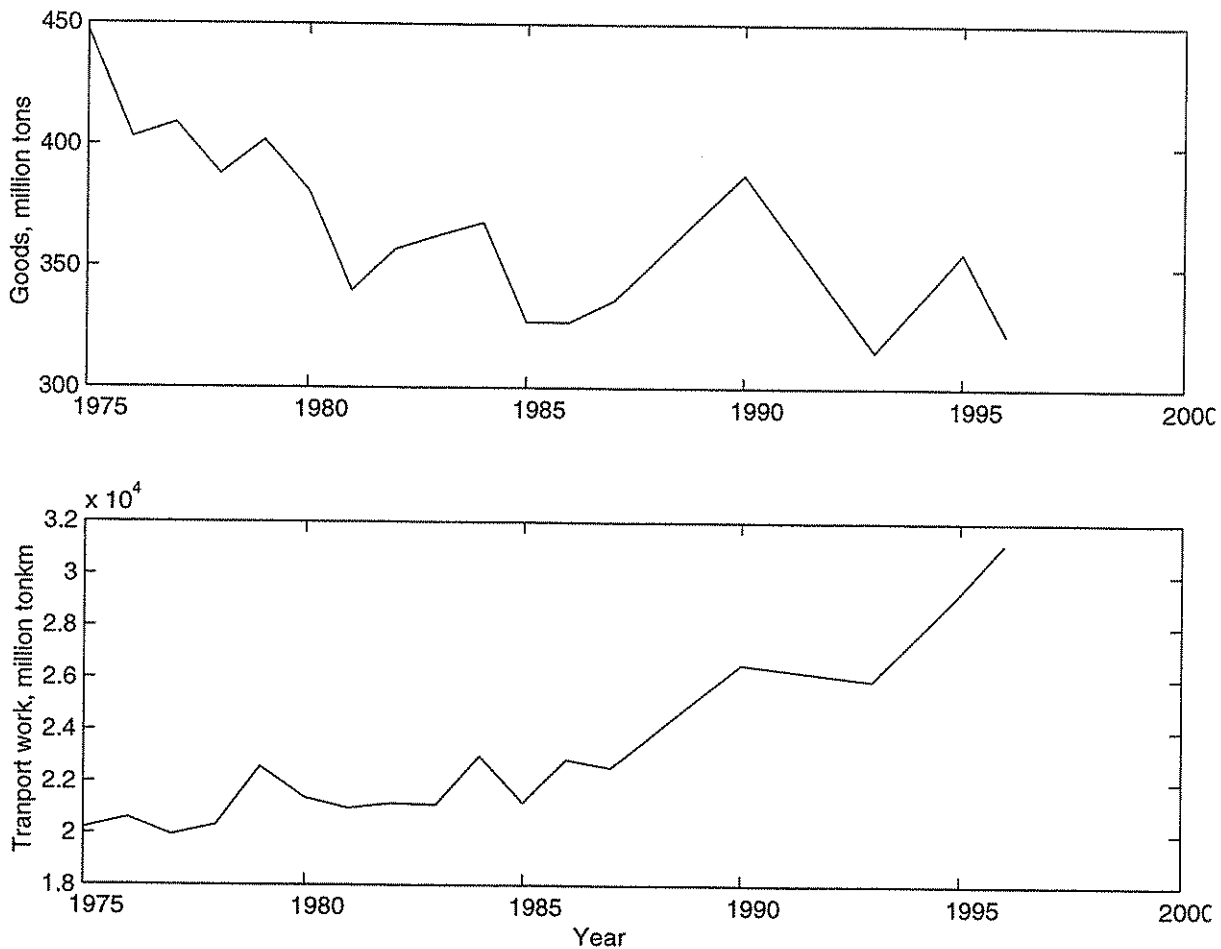


Figure 3. Tendency in transported amount of goods and performed transport work between 1975 to 1996 in Sweden. The amount of goods in terms of weight is decreasing while transport work increases attributed to an increase of distance

decreases gradually while the transport work increases in the last 20 years, indicating the effect of centralization. This tendency creates substantial challenges for logistics to solve the environmental problem.

McKinnon and Woodburn (1996) have conducted a survey to determine the main factors which may cause an increase of goods transport demand over five years in UK. The authors reported that total volume of sale, the nature of the product and logistical factors influence the road freight demand. They divide further the logistical factors into five categories:

- a) structure of logistical system (number of locations, capacity of producer and warehouses),
- b) pattern of sourcing and distribution,
- c) scheduling of product flow (for example sourcing of component on a just in time basis),

- d) management of transport resources (for example choice of transport modes, planning of loads and transport route depending on the traffic levels), and
- e) tightening of customer service requirement.

2.2. The concept of Just-in-time (JIT) and environment

The concept of JIT is originated in Japan and refers to frequent supply in a small volume to attenuate the storage cost and transport is regarded as cheap in comparison to stock-holding. The principle of JIT is based on 'no activity should take place in a system until there is a demand for it and thus no component ordered until there is a downstream requirement (Christopher, 1993). Implications of JIT, in the European context, are stated as follows (Browne, 1994):

- ' a) A closer relationship between supplier and manufacturer*
- b) A closer relationship between manufacturer and transport company
(reduced or zero inventory means there is no margin for late or erratic delivery of raw materials or components)*
- c) More frequent delivery, but of smaller amounts*
- d) Intensive flows of information between supplier, manufacturer and transport operator.'*

Application of JIT definitely minimize storage cost for the retailers by delivering the just required amount several times a day using smaller vehicles instead of delivering by larger lorries once or twice a week. However, this certainly leads to environmental degradation in the form of increased pollution generated from the vehicle and creates congestion in the road network. Figure 4 illustrates fuel consumption of vehicles with different load carrying capacity (Cooper, et al, 1993). From the Figure it may be observed that, seven vehicles with the load carrying capacity of 3.5 tonne can deliver totally 24.5 tonne and the fuel they consume for the length of haul of 100 km is 140 litres. However, a vehicle with carrying capacity of 25 tonne can deliver, almost equivalent to what can be delivered by seven vehicles, and consumes only 49 litres, which is almost three times less than what the other seven smaller vehicles consume.

2.3. Emissions and environment

Transport activities are highly related to almost all sectors of human activities. It plays important role in stimulating economy, promote well being and quality of human life. However, its negative impact on the environment in the form of pollution and the environmental degradation is increasing at a high rate becoming a serious threat to plant, animal and human life.

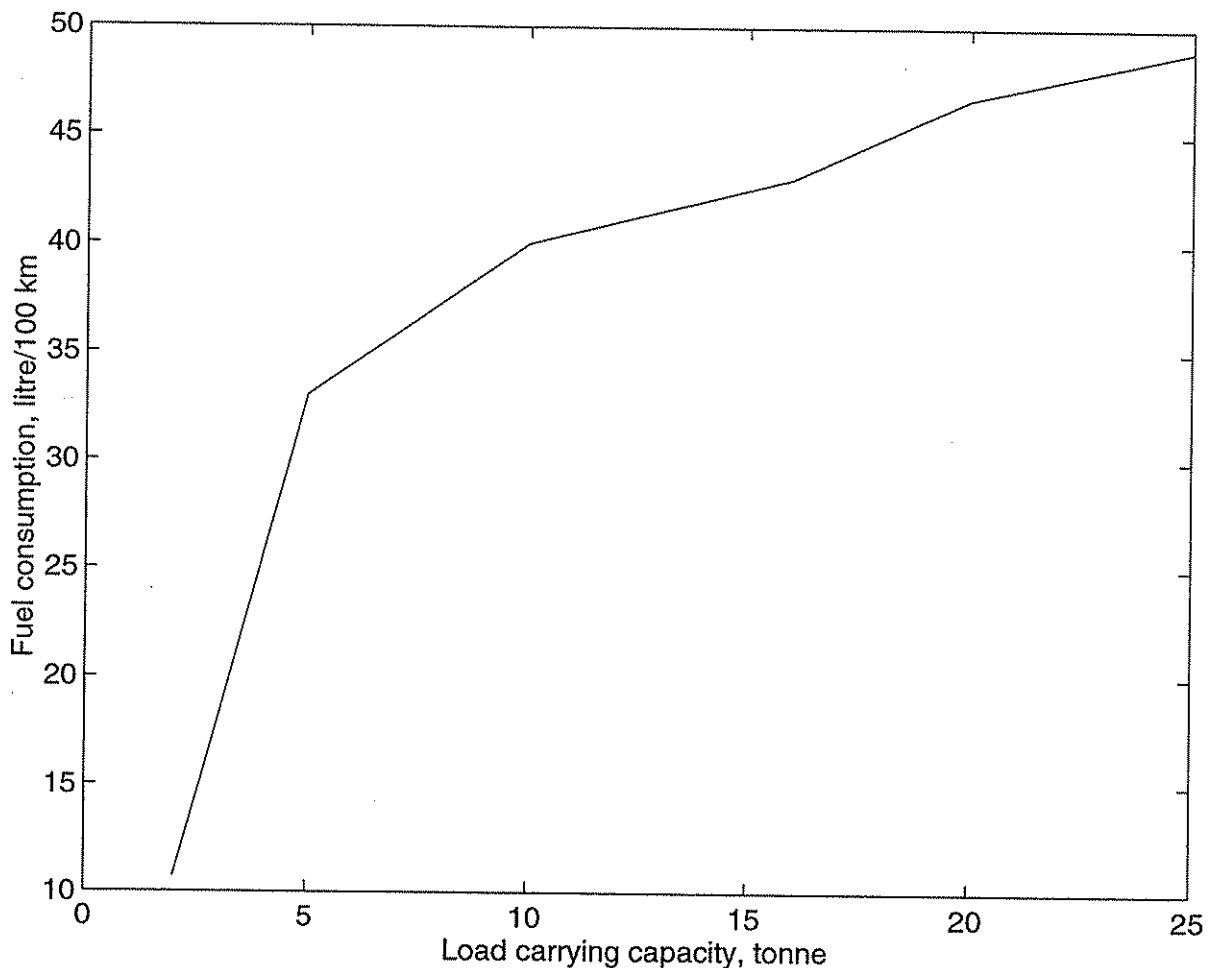


Figure 4. Fuel consumption of vehicles for different carrying capacity (Cooper et al, 1993)

An increase of emissions of greenhouse gases such as carbon dioxide, carbon monoxide, methane and nitrogen oxides, which have global warming potential and result in irreversible climate change, at the global level, created widespread concern (EU, 1995). About 20% of these emissions are nowadays emanated from road transport (Royal Commission, 1995). In the 80s, road haulage accounted for about 87% of the goods flow within EU member countries (CBI, 1992), and this figure increases indicating that road haulage is the most predominant method of goods transport.

The potential impact of emissions from road goods transport on environment has received an increasing attention in the recent decades. Emissions such as CO₂, hydro carbon and NO_x (nitric oxide NO and nitrogen dioxide NO₂) play an important role in the atmospheric ozone chemistry (the production and depletion of green house gas ozone O₃). Especially NO_x concentration results in ozone production below approximately 13 km and ozone destruction above this altitude in the atmosphere (Fortuin et al, 1994). The nitrogen oxides NO and NO₂

play a dual role in tropospheric chemistry: they are a major controlling factor for the concentration of the hydroxyl radical, OH, and they are the necessary ingredient in the tropospheric formation of ozone, O₃.

NO_x is emanated mainly from (Zimmermann, 1994):

- fossil fuel combustion mostly in the industrialized regions (49.3%),
- bio-mass burning in the tropics (12.3%),
- exhalation from soil (24.6%),
- air traffic (1.5%), and
- lightning (12.3%) mostly in the tropics.

An increase in atmospheric concentration of man-made gases such as CFC (chlorofluorocarbon) and HCFC (hydrochlorofluorocarbon) cause the depletion of stratospheric ozone layer is among the adverse environmental effect of road transport. CFC and HCFC depletes ozone layer which prevents harmful ultraviolet radiation from the sun which mainly causes skin cancer. Mason (1993) emphasised that the effect of CFC and HCFC is most serious in the Antarctica where ozone-hole forms and expands every year. Lorries use CFC in refrigeration and air conditioning and are the potential end use of ozone depletes. Mason (1993) reported that 'mobile air conditioners represent about 21% of the residual demand for CFC.

The air pollution-induced cancer cases are escalating in the recent decades. According to the OECD report (Mason, 1993) about 58% of the cancer incidents in USA is caused by emissions from vehicles and 42% from stationary sources and therefore emissions from vehicle obtained central attention.

An integrated and coordinated measures should be taken by all sectors to meet these environmental challenges to attenuate the negative impact of transport on environment and health before it is too late. Here it is worth to stress that three equally important core values, i.e., **environment, safety and economy** to secure the well-being and quality of life when dealing with transport. Thus, it is important to work on the system and promote an efficient road transport to cope with environmental and business demands.

3. Global and national attentions on environment

Nowadays, the potential impact of emissions from road goods transport up on the atmosphere is leading to an increase of environmental concern at an exponential rate (Penman, 1994). Thus, the public awareness on environment has forced both governments and companies not to be negligent towards environment. Emission control policies have been adopted and being implemented to limit the adverse of environmental impact of economic activities, and to protect human and ecological health in general.

Environmental protection is the long term and survival question for nature, individual, society, enterprises, and industries. Every human activities should be adapted to the conditions which the nature tolerates and should also fit in the natural recycling process.

In relation to human and environment co-existence there may be two possible options, i.e., either surrender by destroying our environment or utilize the natural resource within the natural norm of ecosystem. The environmental issue has not been appeared on the international agenda until the 1970s. The UN Stockholm conference which was held in 1972 on the human environment initiated the work on environmental awareness.

The global concern of depletion of ozone layer, global warming and the question of sustainability, i.e., exploitation of the resource to sustain the current life without causing environmentally and ecologically disastrous consequences to compromise the life of coming generation (WCED, 1987) is today's global concern.

3.1. The concept of sustainability

The concept of sustainable development was emanated from the document developed by three international agencies: World Conservation Union, United Nation Environmental Programme (UNEP), and the World Wildlife Fund (WWF) in 1980 (Dieren, 1995). Later in 1983 the World Commission on Environment and Development (WCED) was established by UN General Assembly "to undertake a global enquiry on the prospect of combining social and economic development with environmental protection". It was anticipated that the Commission work out proposals for a long-term environmental strategies which may stimulate a sustainable development in the foreseeable future. The Commission has compiled important document (WCED, 1987) where the concept of sustainable development was formulated and legal principles for environmental protection and sustainable development. The Commission define sustainable development as follows:

"sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

It should be emphasized that the concept of needs is the key issue, that to reach the needs of, particularly the poorest part of the present world by eradicating poverty, and to reach the needs of future generation by preserving natural resource and protecting environment.

Following the Commission's work series of international conferences on environmental issues have been held. The UN Conferences of Rio de Janeiro in 1992 and Kyoto (Japan) in 1997 on environment and the development of Agenda 21 where emphasis on sustainable development in developing countries are given are among the out comes of the Commission's efforts.

To date, many nations are adopting vehicle emission control policies. At the International Climate Conference held in 1997, Kyoto, Japan, the industrial countries agreed to decrease emissions of green house gases by 5.2% between the year 2000 and 2012 in comparison to the emission level at 1990. EU parliament has taken a decision to make a substantial reduction of CO₂ emissions by the year 2020. Germany has proposed to reduce CO₂ emissions from road transport by 40%, The Netherlands by 10-20% between 1993 to 2005 (Mason, 1993). Japan's strategy is to increase fuel efficiency by 8.5% between the same years as above, and UK's intervention to reduce CO₂ emission is by raising road fuel tax by 30% so that the emission will be decreased by 2 million tonne by the year 2000.

3.2. Swedish government's adoption of proposal on environment and agriculture

In its proposal regarding environmental politics, the Swedish government has stated that (Riksdagen, 1990):

"the objective of the environmental policy is to protect human health, preserve the biological multitudinous, careful and long term utilization of natural resource, and protect nature and cultural landscape".

It has also made several specific proposals in relation to the above objective. It emphasized that the sustainable agricultural and forestry production should fulfil the demand for quality and at same time be environmental friendly.

The green house effect on global warming is a very serious international concern. The main gases which contribute to the global warming are CO₂, CO, O₃, NO_x, methane and CFC. The Swedish government has taken a decision that:

- a) pollution from CO₂ at the year 2000 should not exceed the level at 1990, and thereafter decreases successively,
- b) totally terminate the use of CFC,
- c) sulphur emissions decreases by 80% until the year 2000 from the level 1980,
- d) emissions of fluid organic matter (where 40% emanated from transport sector) should be reduced by 50% in general and the part emitted from transport should be reduced by 70% until the year 2000 from the level of 1980.

The proposals emphasised that to reach the above objectives, a global policy on the preservation of nature and sustainable utilization of natural resource should be worked out in all sectors including agriculture.

4. Agricultural goods transport in Sweden

As mentioned earlier, agricultural and forestry goods transports are significant components of goods transport as a whole in Sweden. As illustrated in Table 1, the amount of goods is about 103 038 million tonnes and 12511 tonkm which comprise about 32% and 40% of the total goods and transport work in the country respectively (SCB, 1997). However, it is important to note that on-farm transport activities performed by mainly tractors and the machinery transported to the sector are not included in the given figures, though tractor-based transport activities are substantial within the sector.

Table 1. Goods transported by lorries under 1996 (SCB, 1997)

Goods type	Goods amount, 1000 tons	Transport work, million tonkm
Agricultural produce, means of production and food	39 419	6 651
Wood and cork	63 619	5 860
Other goods	218 652	18 674
Total	321 690	31 185

4.1. Components of agricultural goods transport

Goods flow to, from and within agricultural sector could be classified into two main categories: on-farm and off-farm transport. Further classification may be made as shown in Figure 5. The material flow within the agricultural sector, to and from the sector is illustrated in Figure 6. The figure depicts further, flow of food products from industries to consumers through wholesalers and retailers. It is important to identify the intensity of transportation between various components to work out appropriate solutions.

On-farm transport

- a) transport of means of production (seeds, fertilizers, etc) from homestead or storage to field
- b) transport of agricultural produce from fields to homesteads or storage,
- c) transport activities in the field (ploughing, harrowing, sowing, cultivation, spraying and harvesting)

Off-farm transport**a) transport from farms to:**

- (i) industries (abattoirs, dairies, fodder industries, mills),
- (ii) retailers, wholesales and depots, farmers cooperatives
- (iii) incineration plants landfill (waste)
- (iv) consumers
- (v) export

b) transport to farms from:

- (i) industries (fertilizer, fodder, pesticides, machinery, seeds)
- (ii) cooperatives (partially what the industries may supply),
- (iii) retailers and wholesalers (food and commodities which the industries may supply)

c) transport activities between farms:

- (i) animals, and
- (ii) fodder

4.2. Trends in agricultural produce and transport

In the agricultural sector, the number of people which actively engaged with agriculture is decreasing rapidly and the number of farms declines gradually as shown in Figure 7 and Table 2, and only 3% of the economically active part of population is engaged with agriculture.

However the production, specially meat production still increases at a slow rate. To date, in Sweden the number of large scale farms comprises about 61% (crop production 16%, animal husbandry 38%, and integrated animal and crop production 7%), and while small scale farms (farms which require less than 400 standard man-hour labour per year) is 39%, and produce only about 4% of the total production.

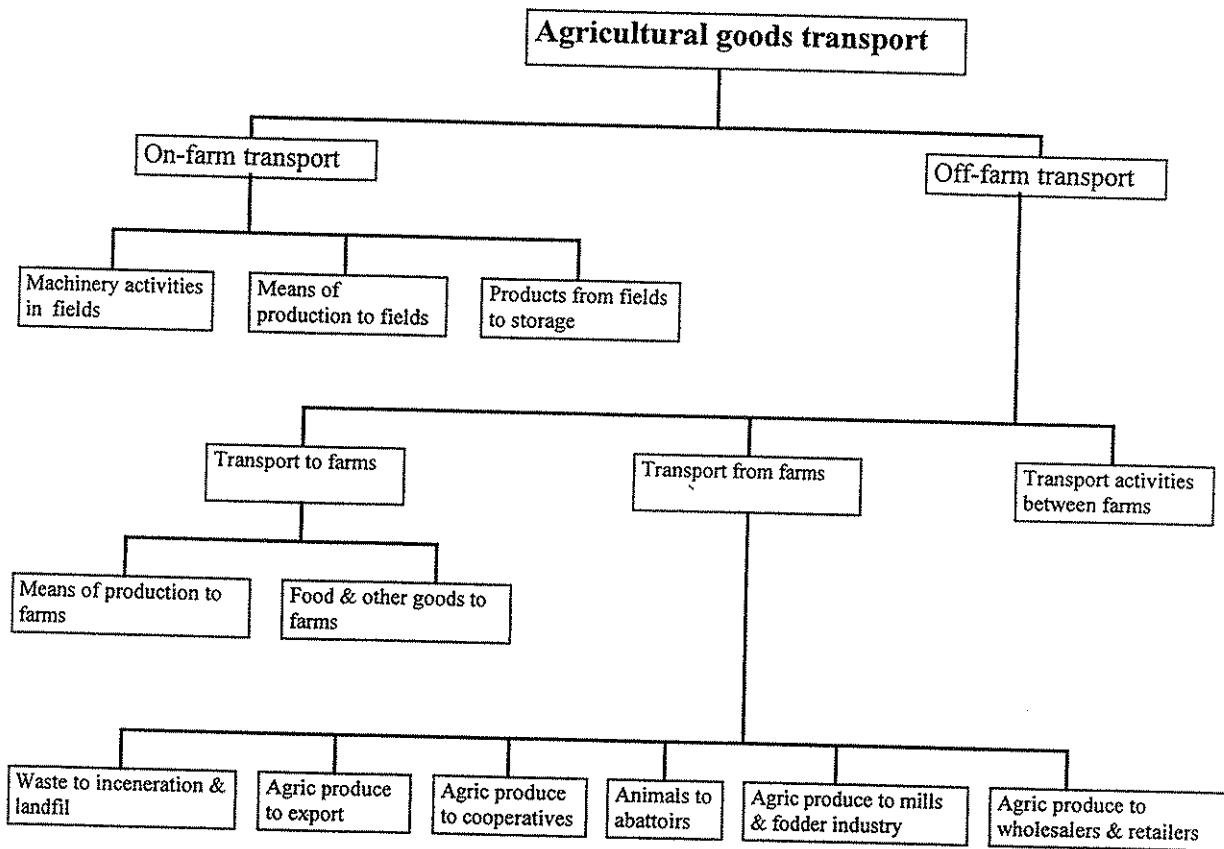


Figure 5. Components of agricultural transport

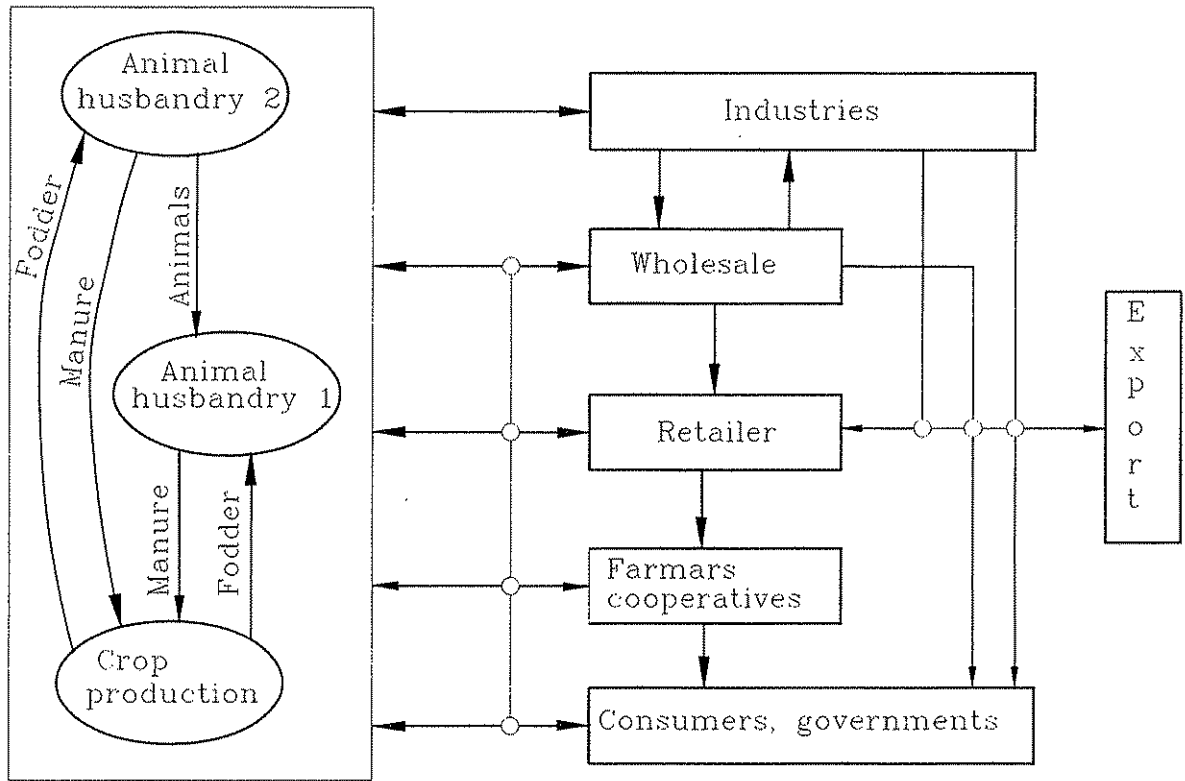


Figure. 6. Goods flows to, from and within agricultural sector

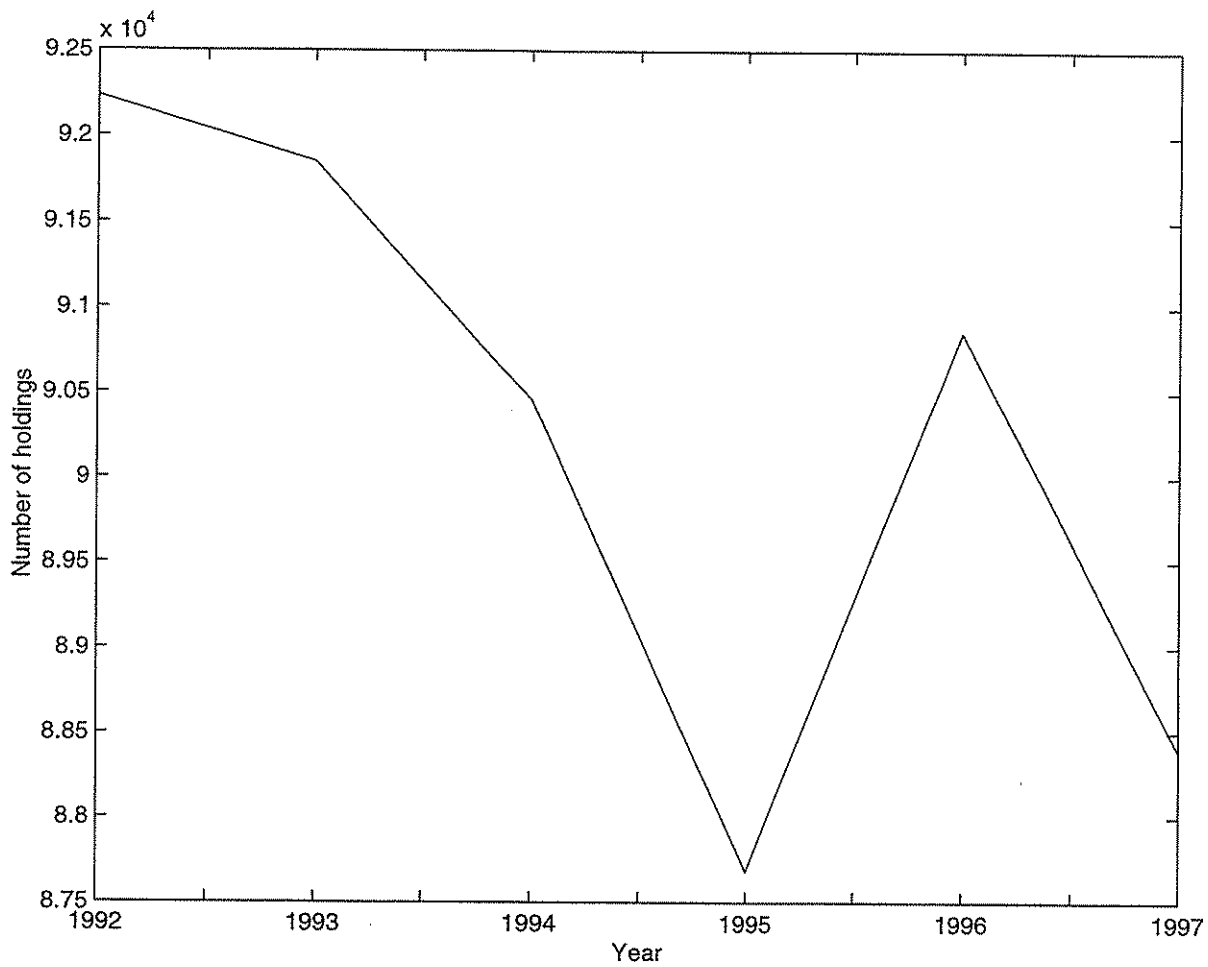


Figure 7. The number of holdings in agriculture between 1992 to 1997 (SCB, 1998)

Table 2. Number of holdings of various produce (SCB, 1998)

Year	Number of holding		
	Potatoes	Ley and green fodder	Oil crops
1992	16 805	69 457	5 524
1993	15 977	69 055	7 248
1994	14 466	68 748	5 038
1995	13 371	65 684	5 316
1996	13 009	64 659	2 444
1997	11 699	61 905	2 601

Animal husbandry plays economically important role for the Swedish farmers. About 50% of the farmers' income comes from animal husbandry (milk 31%, pig meat 14%, and other animals' meat 15%).

The number of milk suppliers and dairies successively decreased by about 25% and 15% respectively as illustrated in Figure 8. About 99.7% of the milk delivers to 8 large scale dairies (Fig. 9) such as Arla, Gefleortens, Milko, Norrmejerier, Falköping mejeri, Gäsene mejeri, NNP, and Skåne mejerier, and the remaining 0.3% to the other 44 small scale dairies. After the EU membership, the maximum milk production is limited to 3300 million kg per year, and therefore the variation of production level is insignificant since then.

Analogously, the number of abattoirs is declining in the recent decades, and at present there are five (Fig.10) large scale abattoirs (SkaneK, Scan KLS, Scan Farmek, Scan Norrland and Norrmejerier). Centralization in the abattoir branch is still in progress, as a consequence intensive animal transport can be anticipated. Long range transport of animals induces stress on animals and this compromises animal welfare and meat quality, and also contributes to the environmental deterioration in the form of air pollutant generated from the vehicles.

With the exception of cereals and milk (Fig. 11), the production volume and transported agricultural produce is increased slowly (Fig. 12), particularly meat (beef, pork and fowl) and eggs. An increase of volume of goods and centralization leads to a rapid growth of the total transport work (Table 3).

Figure 13 reports the development of transport work of agricultural produce and from 1985 to 1995. Between the years 1986 to 1990 the transport work increased at about 200 tonkm per year. However, between 1991 to 1994 it rather decreased, and thereafter the increasing tendency continues.

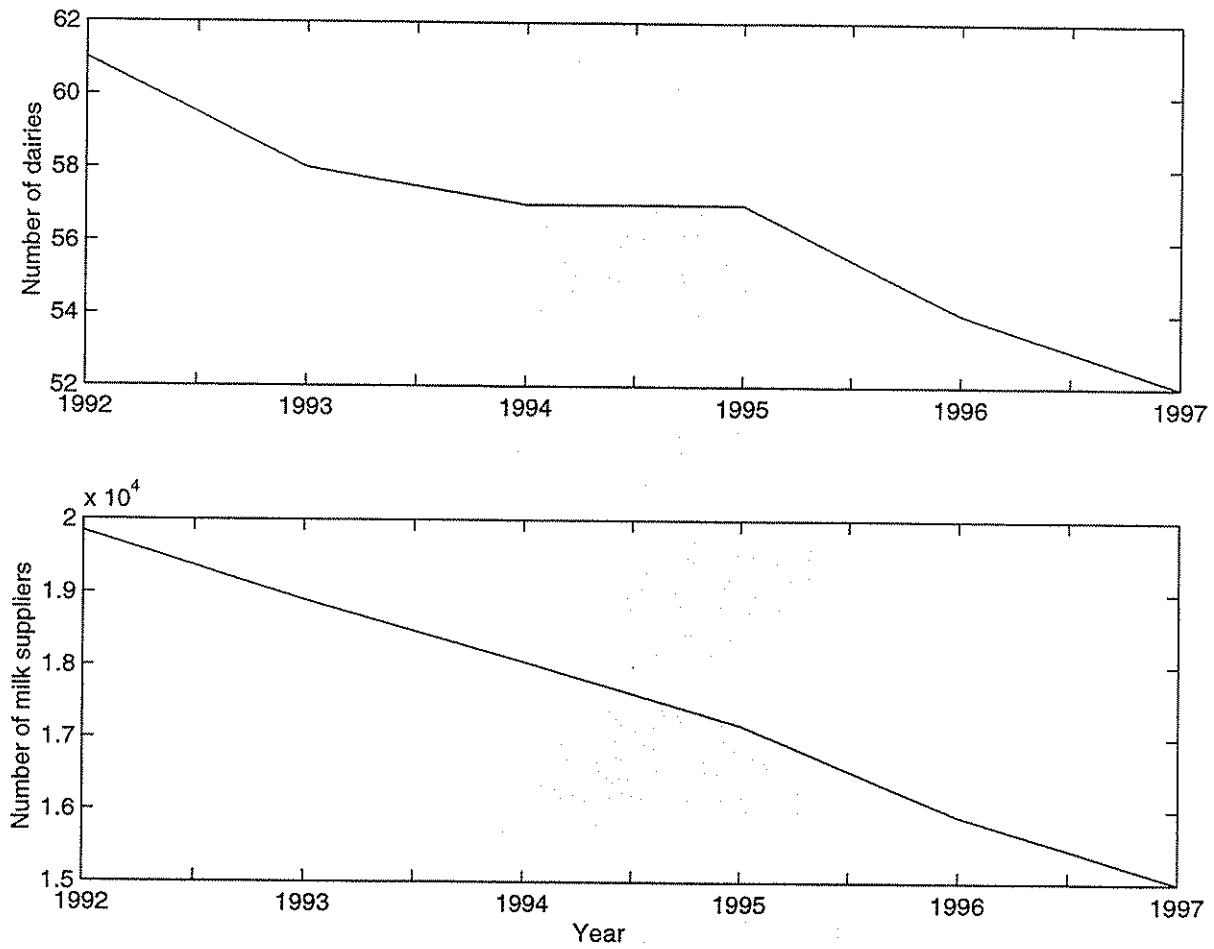


Figure 8. Number of dairies and milk suppliers between 1992 to 1997 (SCB, 1998)

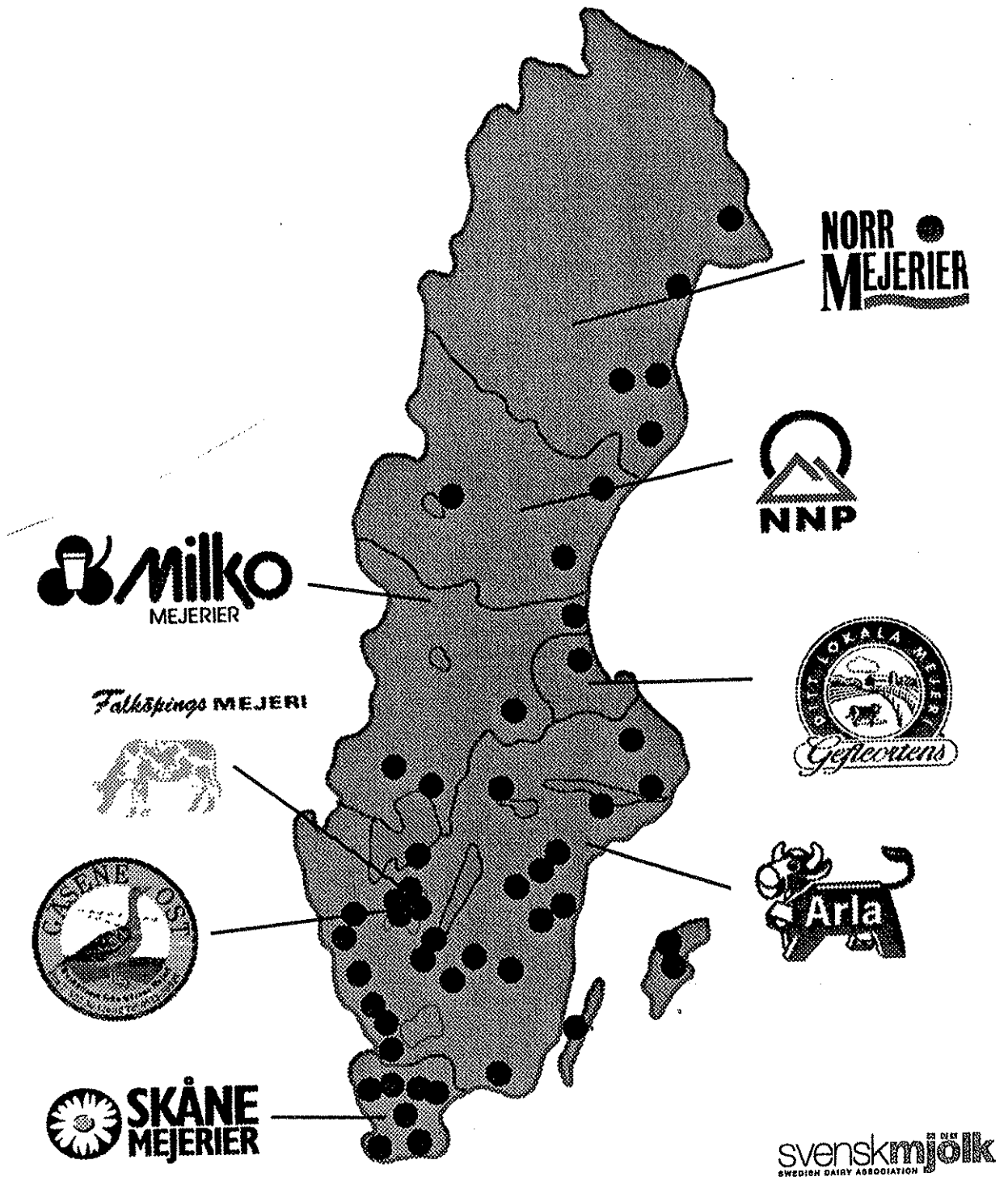


Figure 9. Distribution of 8 dairies in Sweden

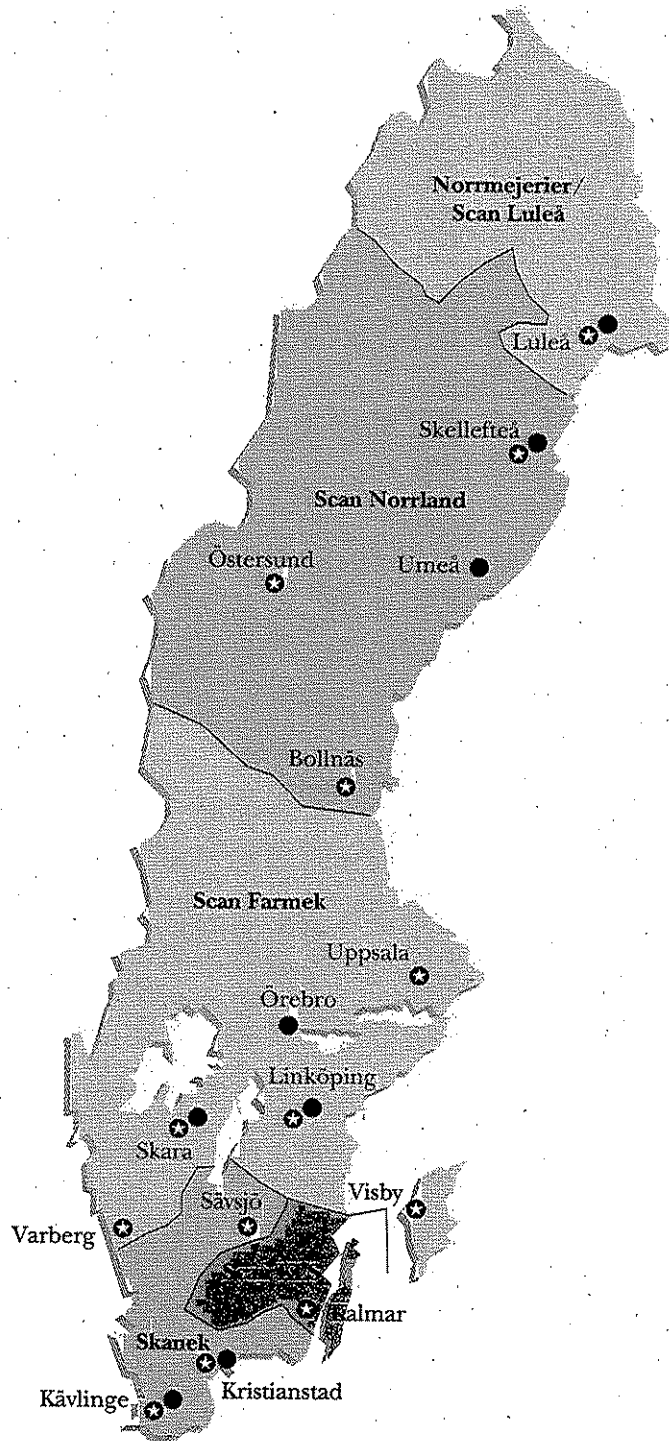


Figure 10. Distribution of the 5 biggest abattoirs in Sweden

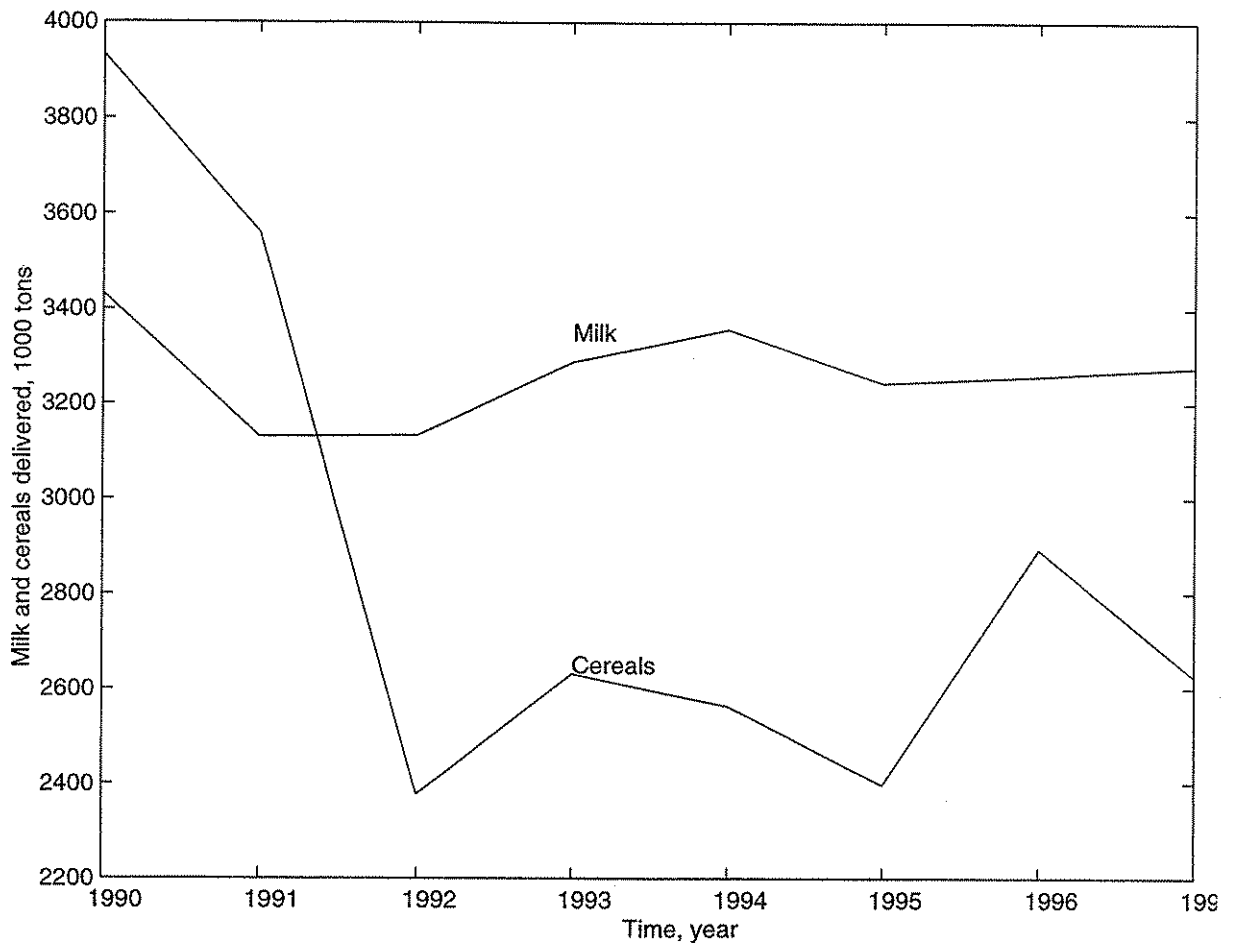


Figure 11. Amount of cereals and milk delivered by farmers in 1000 tons

Table 3. Agricultural produce and food products transported by lorries and railway between 1985 to 1995 (SCB, 1998)

Year	transport work by lorries, million tonkm	transport work by railway, million tonkm	mean haulage by lorries, km	mean load on lorries, tonne
1985	3 953	681	118	11.5
1986	3 783	735	130	12.2
1987	4 017	695	117	12.1
1990	4 695	629	136	13.6
1993	4 585	580	138	14.9
1995	4 684	483	135	15.2

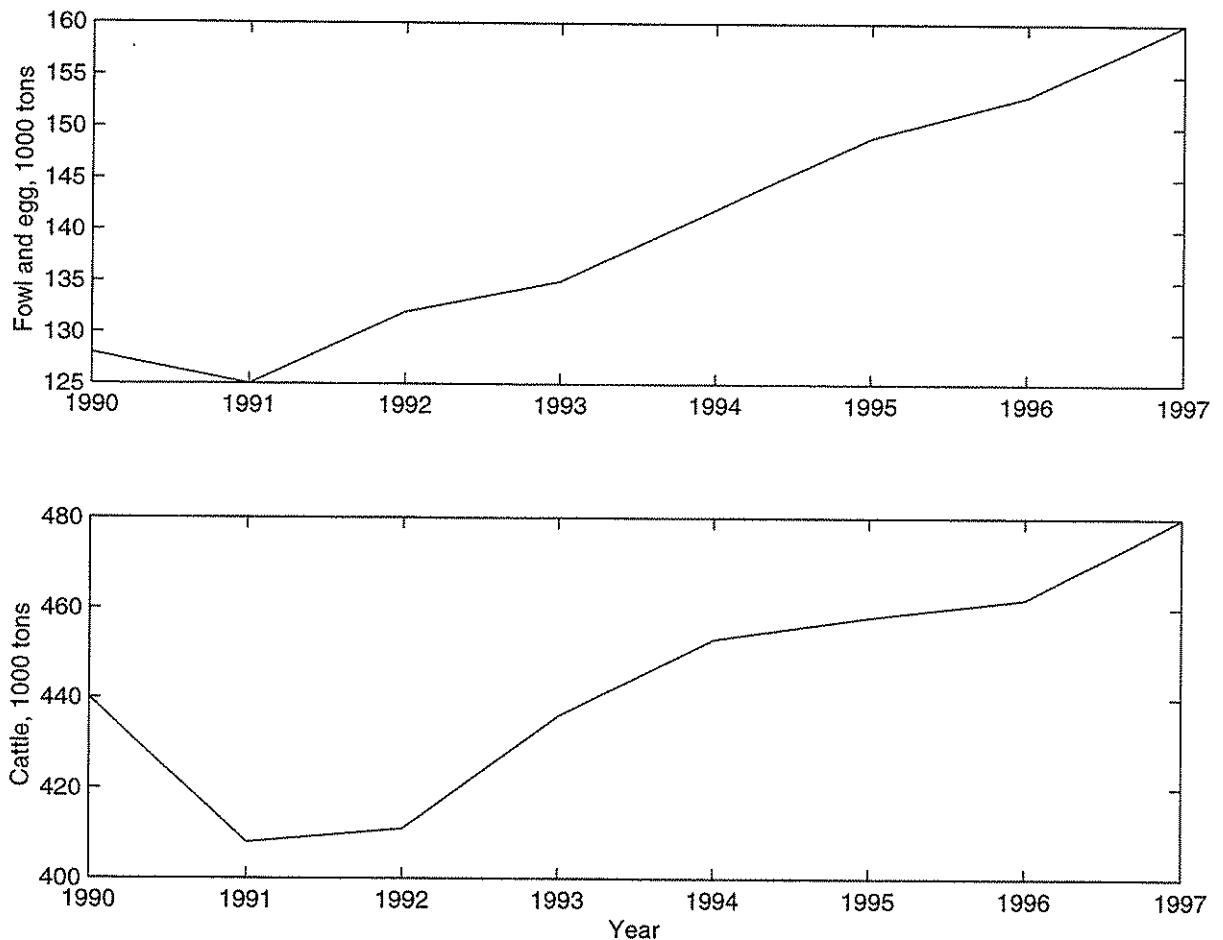


Figure 12. Cattle in the form of meat, fowl and egg delivered by farmers in 1000 tons

4.3. Research in agricultural transport

Though agricultural goods transport is considerable, as mentioned earlier, research and development made on the subject in Sweden is limited. In forestry, important works on wood transport-logistics were conducted by 'SkogForsk' and some are in progress. At the end of 1970s and at the beginning of 1980s valuable works were made (Ottosson et al, 1976, 1982) on material flows (agricultural produce and means of production) within agricultural sector. Later, the simulation model, MODTRANS, was developed by Gebresenbet and Oostra (1996) to describe the goods flow in the sector and to study the environmental impacts.

In relation to research in animal handling and meat quality, some considerations were made on animal transport in the 1980s and 90s (Olsson, 1986, Carlsson, 1985, Wiklund, 1996). Gebresenbet and Eriksson (1998) reported the study performed recently on slaughter animal transport in relation to environment, animal welfare and meat quality. The study identified stress inducing factors on animals during handling and transport.

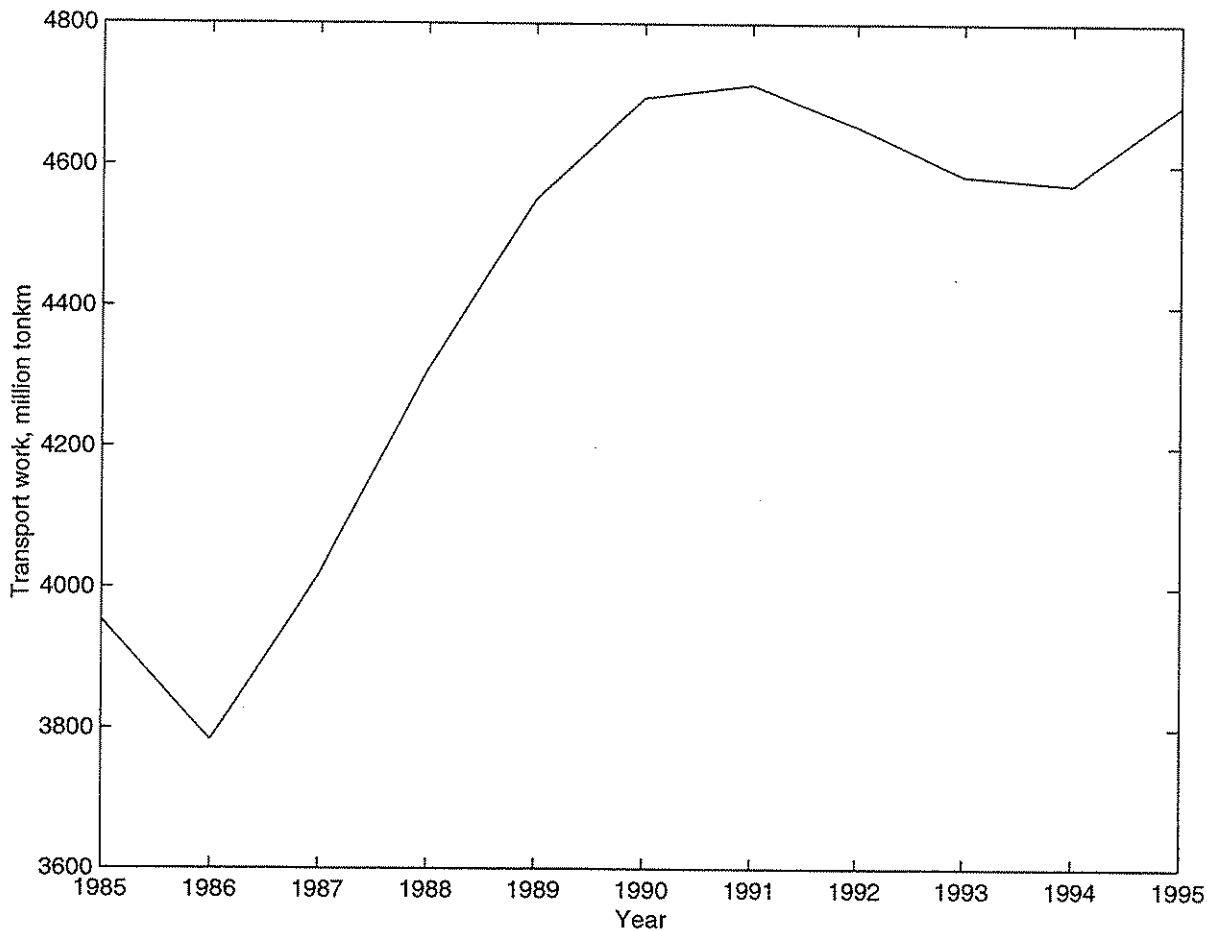


Figure 13. Transport work (agricultural produce and food) between 1985 to 1995

Lundin (1996) assessed the transported goods volume of food and transport work during the period between 1987 and 1993 in Sweden. The author reported that the transport work within this time range increased by 10% and the transport distance increased by 15%, where as no increase of transported food volume has been observed. The tendency shows that the goods volume rather decreases.

5. Visions and strategies to promote environmentally sustainable transport

5.1. General concept

A vision is an imaginary picture of a foreseeable future which formed from historical development of the past, the current conditions and future wishes. In the case of transport and environment, the historical development refers to the extensive and intensive exploitation of natural resource, economical development, gradual degradation of environment and tendency of serious threat to coming generation. The recent tendencies and forecasts suggest that the demand for transport will continue to increase.

An increase of freedom of individuals in social and economic terms is the outstanding feature of the current tendency which may contribute to the fast growing rate of transport. These conditions force the present generation to re-design a path of development which leads to a clean environment and effective economy. Based on the visions formulated by national and international (mainly industrial nations) authorities and agencies, we may state that our over all vision regarding goods transport may be to:

develop environmentally sustainable goods transport system within
20 to 25 years, and emission generated from road goods transport
shall be more than halved by the year 2020.

In this regard, it may be worth to mention that the Swedish Environmental Protection Agency (1994) emphasized in its long-range goal formulations that 'transport activities shall be made compatible with what man and nature can tolerate.' However, The 'zero-vision' may well required for environment as formulated for safety to go beyond 'toleration'. Safety and environment together with culture and economy make the core value for the co-existence of human and nature, and thus the future development should be environmentally, socially, and economically sustainable.

5.2. Strategies to reach the goal of the visions

A vision includes strategies to reach the goal. In this aspect, the following measures may be considered.

- a) Effective utilization of vehicles (for instance through promoting coordinated goods transport, able to transport various types of goods on the same vehicle, etc)
- b) Improve vehicles technology,
- c) Improve fuel's efficiency,
- d) Search for alternative fuel system,
- e) Promote IT-supported logistics system,
- f) Improve driving performance (develop eco-driving performance)
- g) Localisation of production and distribution system,
- h) Integrated production system
- i) Avoidance of transport demanding activities (location production, integrated production, mobile abattoir, 'group-shopping', etc).

5.2.1. Integration of Information Technology with logistics

The maximum possible advantages of information technology could be the key means to be considered to reach the demands of clean environment, consumers' service and economic activities. Figure 14 illustrates the future IT supported goods transport from and to farms. The geographical positions of vehicles are determined using satellite steered Global Position System (GPS), and the communication and data transfer between farms, industries, wholesalers, retailers and driver is performed using either telecom or internet.

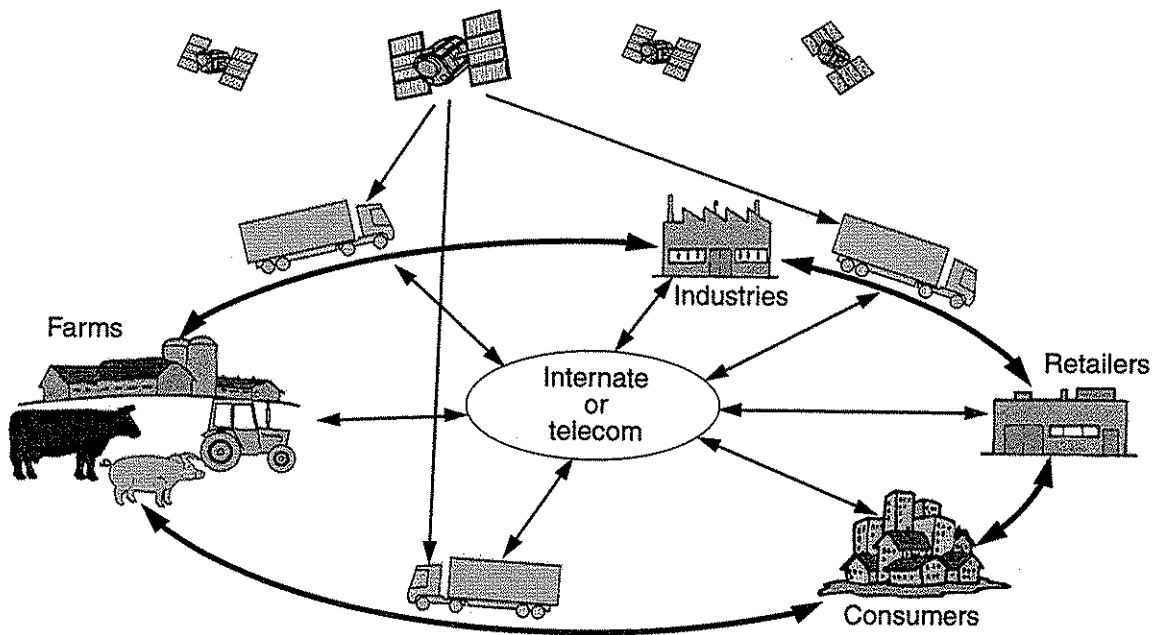


Figure 14. IT supported goods transport between various sectors including agriculture. The thin arrows designate information flow including GPS signals, data transfer through internate and the thick curved arrows represent physical material flows between different sectors. The vehicles are equipped with IT system

It may be emphasized that information technology is one of the key resources to achieve the objective of reducing transport work. To date, we are in the epoch of transformation from industrial to information society. The recent spectacular development of computer hardware and software made the Information Technology a key component in the logistics planning in all production and distribution sectors (Cooper et al., 1993) with the main objectives of improving stock control and service and to reduce operational cost. The introduction of:

- electronic point of sale (EPOS), a computerized system of recording sales at retail check-outs, which simplified a physical counting of commodities
- just-in-time (JIT) delivery concepts,
- electronic data interchange (EDI) which replaces orders by telephone

calls and paperwork,
 - universal product coding (UPC)

successively revolutionized the logistics system. The integral information chain between producers, distributors and retailers could speed up and smooths the logistical flows IT integrates Walker (1994). Applications of IT have the potential to play an important role in logistics. The importance of information component of logistics is growing and it is considered as a key ingredient of logistics and which may produce sustainable advantages in the logistics performances (Cooper, et al, 1993).

Walker (1994) summarized the description given by Massachusetts Institute of Technology on the development of Information Technology and gave a five-stage process by which companies could exploit the benefits of IT. The described stages are:

1. **Localized exploitation of IT**, which involves installation of a vehicle routing and warehouse control computer system to promote a single logistics business constraints.
2. **Internal integration of IT**, where a wider company database is developed to enable a multi-user within the same company to integrate the functions of buying, production and distribution systems of the company.
3. **Process redesign**, which requires a transparent information links between manufacturer and retailer, and which enables the manufacturer to trigger the orders without the involvement of the retailer and the manufacturer is pain through EPOS.
4. **Network redesign**, this refers to a transfer of logistics network, i.e., a shift from stock orders in full truck loads of palletized products to ship products in smaller volumes, and this reduces the retailer's stock-holding and increase transport.
5. **Scope re-definition**, this is a transfer of a retailing company from physical retailing operation to information network. Walker (1994) gives the Japanese food retailers as a good example which successfully benefited IT in the scope re-definition.

Currently, the above IT development stages number one through four are in practice in small scale many sectors in Sweden. However, in agriculture sector it is on its very initial stage.

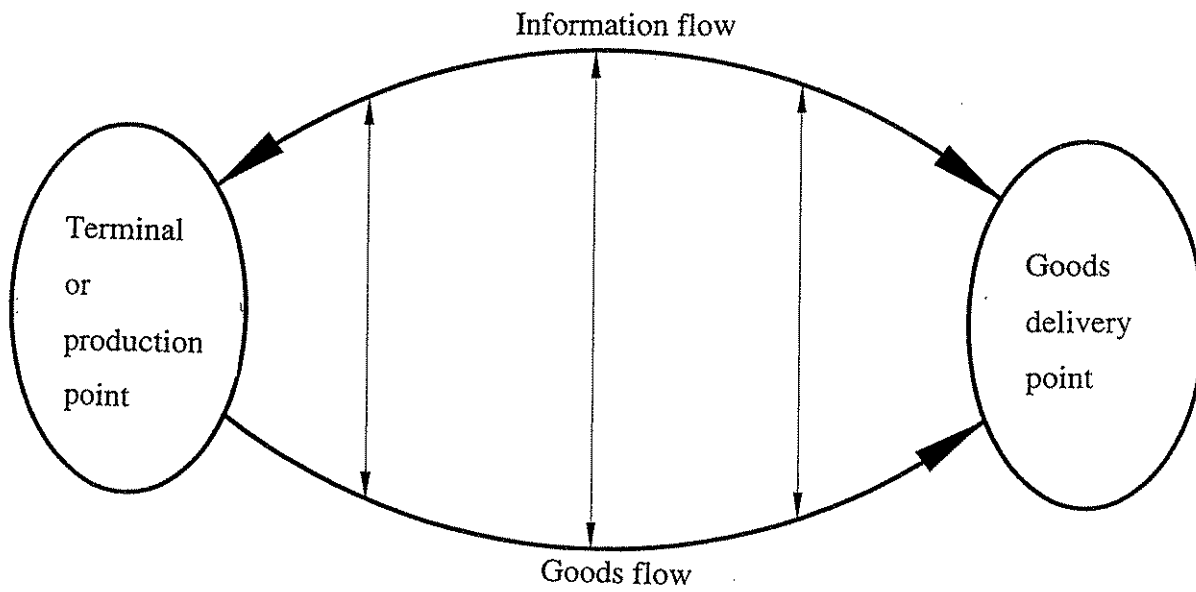


Figure 15. Goods and information flows

Information flow is the key component in the goods transport system. Figure 15 shows a simplified model where transport is a function of goods and information flows. The main arrow depicts transport of goods from production to delivery points and information flow in both directions. The perpendicular arrows between the two flows describe activities such as planning, steering and follow-up (Tarkowski et al, 1995).

The components of rapid and reliable information system may make collection and delivery operations effective. This may be effectuated using:

- a) satellite steered communication,
- b) route planning and route information,
- c) computerized freight tracking system to 'monitor various shipments at various points in the door-to-door transport operation' and coordination,
- d) promoting shopping and collection through internet.

The utilization of components (a) through (c) are particularly in progress at Engineering department of SLU in the Animal Transport and Coordinated food distribution. The use of Geographical Information System, GIS and GPS simplifies questions related to geographical location of producers, retailers, consumers and service centres.

Informations regarding which vehicle carry which load at a given moment is important for coordinating and control system. Informations which may be able to identify vehicles, their position and time continuously are necessary in order to use the best possible optimized network.

To utilize the maximum possible advantages of IT, the freight carriers should be equipped with IT facilities and have interface with the IT system of the producers and retailers or consumers. Figure 14 illustrates IT supported goods flow from and to farms. The positions of the vehicles are determined using satellite steered Global Position System, GPS, and communication and data transfer between farmers, industries, wholesalers and drivers is facilitated using either telecom or internet.

5.2.2. Coordination of transport, localization and the concept of JIT

Localisation of agricultural production and processing is vital for both sustainable environment and effective economy. The key factor in this aspect is distance between production, storage and processing plant's locations, labour availability and cost. The other favourable condition is the possible common location for food processing industries. For example, effective transport co-ordination can be feasible if agriculture and food industries such as Dairies, abattoirs, mills, and fodder companies situated in the same site.

The new approach in restructuring and rationalizing of distribution or collection requires suitable site of common depots for several companies in order to reach the demand for new environmental friendly goods transport network. Waston-Gandy (1994) and Lundin (1996) discussed the theoretical development made by Alfred Weber in 1909 and later works on selection of local site for cost savings and business opportunities. Waston-Gandy (1994) gave several factors which may determine the depots location and some of those relevant factors for the current work are as follows:

- availability of labour,
- traffic congestion,
- local communication especially for employees,
- availability facilities for vehicles' service,

The depots serve as common stock and centrally used by multi-companies and more use of third party which provide with effective logistics supported by advanced information technology. The depots may have two parts, goods and vehicles depots. The third party take care of both goods management at the depots and distribution.

Figure 16 illustrates the trade-off between warehousing and transport (Cooper et al, 1993). This diagram is usually used to determine the optimum number of warehouse and to show the combined effect of transport and warehouse operating cost. As it can be observed from the figure, an increase in the number of depots or warehouses increases warehouse operating costs, but decreases transport at the same rate as shown in Figure 16. The main beneficiary in the method is the environment.

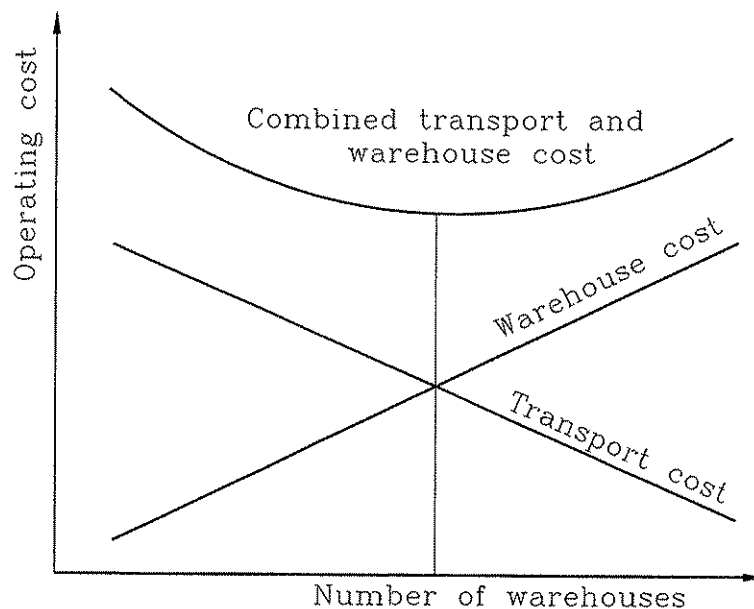


Figure 16. Transport and warehouse cost (Cooper et al, 1993)

In the case of agricultural sector, primary products will be collected from farms to a regional depots. Agricultural inputs from industries, such as commercial fertilizers, fodder, machinery, seeds, pesticides, etc, are also transported from the other end to the depots (Fig 17). Goods to be transported to the farms or to industries and other destinations can be coordinated from the depots. This enables coordination of both collection and distribution. A vehicle which distributes goods should be able to collect goods. In that way, vehicles may be used effectively.

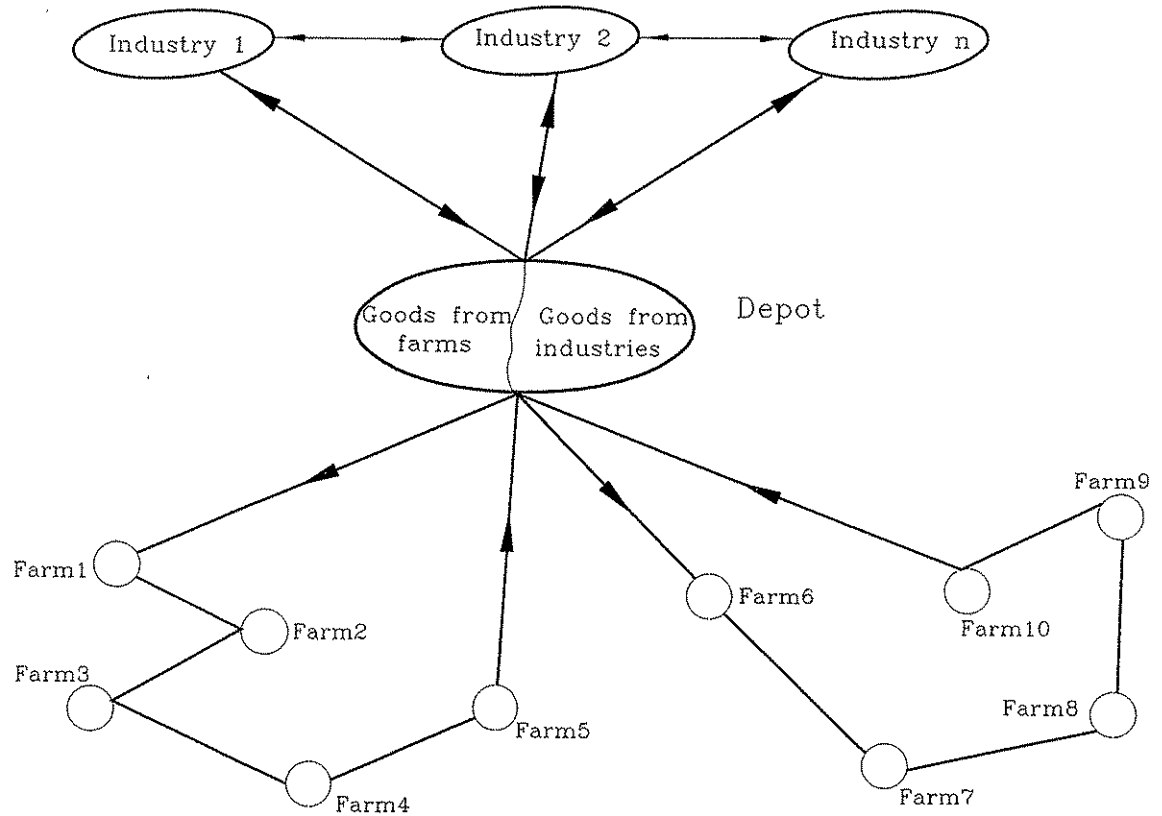


Figure 17. Distribution and collection network in agricultural sector

5.2.3. Avoidance of transport requirement activities

a) Promotion of local production and consume locally produced food

It is a common understanding that local production and consumption of locally produced food retards the ever growing transport activities. The pressure from consumers is a very important means to promote local production by pressing and also encouraging both wholesales and retailers of food to buy and sell locally produced and processed foods. This may stimulate local producers and significantly reduce transport work.

b) Integrated production

Todate, transport between farms is very significant. Transport of fodder from crop production sector to animal husbandry, transport of millions of small pigs and calves between farms are the main components. Farmers who produce small pigs and calves could be able to maintain them up to the phase of slaughtering. To realize that, farmers may require to organize cooperative for fattening of pigs.

Therefore, the integration of crop production and animal husbandry could be another approach of reducing transport. This particularly influences transport of fodder, encourages the use of natural fertilizer rather than commercial fertilizer which otherwise require substantial transport.

5.2.4. Alternative fuel systems

As mentioned earlier, transport is a major consumer of energy (about 31% in OECD countries and up to 45% in developing countries) and the energy demand for transport continues (Whitelegg, 1992). There may exist two ways of approach to tackle this tendency, i.e., by increasing the fuel efficiency and by searching for alternative fuel systems. Electric/battery, ethanol and methanol based alternative fuels have been considered in the recent years as alternative fuels to ameliorate the transport associated environmental constraints. The use of ethanol and methanol is progressing in many countries, especially in USA in California, to maintain the required environmental quality.

Promotion of bio-fuel system, specially conversion of agricultural products to a source of fuel system for transport, revolutionize in an increase of fuel efficiency will be the future challenge of researchers and vehicle producers to reach the environmental goals.

5.2.5. Animal transport

a) Develop a sustainable handling and transport routine under the current production (farms-abattoir system). The main principles to reduce transport work are:

- i) avoiding transport required activities,
- ii) dynamic optimization of transport using network database and satellite communication,
- iii) improve handling procedures, and
- iv) improve driving performances.

b) Develop mobile abattoir or semi-mobile abattoir

Developing mobile slaughter and nearing slaughter to the point of production has enormous advantages. It:

- avoids stressing animals,
- provides service to farmers in remote regions (far away from the large abattoirs),
- provides service for local butchers,
- minimizes the need for the transport of live animals,
- reduces transport time for the animals,
- decreases stress on animals (special animals which may not be

- easily handled in the conventional method),
- integrates collection and distribution in the sense that meat of slaughter animals can be distributed to the food shops situated in the same area.

5.2.6. Use of a vehicle for various goods delivery on the same trip

As mentioned else where in the text, current vehicles are specialized to transport certain goods, i.e., specific vehicle for specific goods with specific environment (temperature and humidity) in the vehicle. The average load carrying capacity utilization level of such vehicles is less than 50%.

The objective of increasing the utilization level of vehicle's load carrying capacity may be fulfilled if only various types of goods could be loaded on the same vehicle during the same trip or delivery. Such flexible loading necessitates a technological development of compartments of the vehicle to sustain the quality of goods, in this case food, by maintaining the climatic environment each goods may require.

6. Role of SLU in agricultural transport and environment research

In its future programme, *focus on natural resource (1996)*, SLU has vividly stated that preservation of natural resource, development of sustainable agricultural production system with steadily improved quality of primary food products and protection of the environment are among SLU's main foremost research priorities in all the three faculties (Agriculture, Forestry and Veterinary science).

As mentioned earlier, material flow within the sector is a significant part of (32% of the total goods in weight and 40% of the total transport work performed by goods transporters) goods flow in the country as a whole. Even materials such as fodder, grains, etc from farms to farmers cooperatives and to other farms is performed using tractors which comprises a significant part of the total goods transport from farms to various destinations.

As stated earlier, transport plays an important and controversial role. On one hand, it stimulates economy and promote the societal well being, and on the other hand it substantially contributes to the environmental degradation through generation of emissions from vehicles. It should be noted that flow of goods may not be hampered, but at the same time it may not impose negative impact on environment. This is not a simple challenge for SLU to reach the societal demand of

- improving and maintain quality of agricultural produce, and at the time working towards the requirement for clean environment, and working towards preservation of natural resource.

Development of competence and knowledge on material flow from points of production, i.e., from farms, to consumers through processing plants and retailers, and partially back to farms (Fig 13) lies within the frame work of the above mentioned SLU's strategic programme.

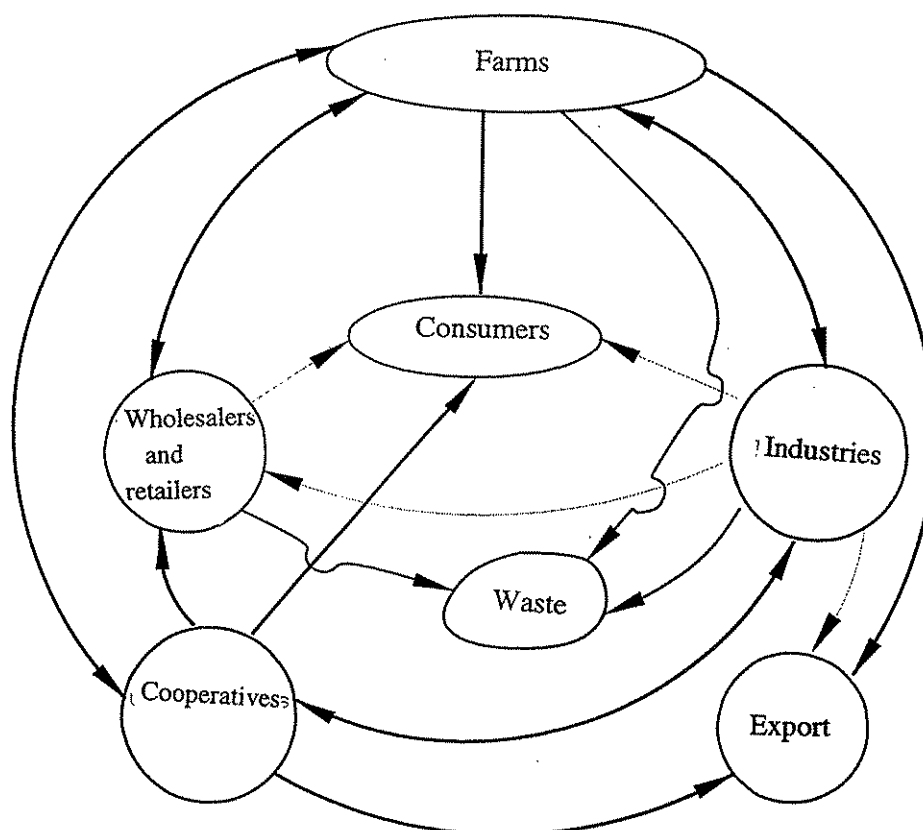


Figure 18. A simplified sketch of material flow from and to farms. The thick lines indicate material flows of SLU's area of responsibility

It is important to note that several universities and research institutions are working with goods transport between industries and consumers, while goods (mainly agricultural produce) transport from farms to industries, consumers, wholesalers and retailers, and the other way round (Fig 18) is the sectoral responsibility of SLU. **It is therefore SLU's sectoral responsibility to develop competence and knowledge which allow to develop effective, efficient and sustainable agricultural logistics system which may fulfil the requirements mentioned above.**

However, hitherto, transport has never been SLU's centre of attention. Many of the research and education subjects, available at the traditional universities where basic theories are the core of both teaching and research, are also available at SLU in a specific and applied form.

For example, Agricultural Economy, Agricultural Engineering, etc. Analogically **Agricultural Transport** could have been among the key programme within SLU which may be married with many of the other subjects in the University.

Noting that the specific vision and sector responsibility of Swedish University of Agricultural Sciences, SLU, is to develop competence and knowledge to reach the requirements of improved quality of agricultural produce, clean environment and conserved natural resource, it can be stated that agricultural transport and environment is in line with these strategies, and therefore the theme Agricultural Transport could be considered as an integrated part of SLU's research and educational programme to develop competence and knowledge in agricultural and forestry transport.

To realize this it may be required to organize a special competence centre. A co-ordinating working group which includes all the three faculties may be set up to:

- work out detailed programme on research and education for the theme,
- facilitate coordination among transport related research and educational activities at SLU,
- initiate strategic and specific projects,
- establish and strengthen collaboration with national and international research and education institutions in the subject area,
- establish network with producers, wholesalers, retailers, large scale consumers, transport companies and governmental authorities.

It is assumed that the anticipated possible solutions and recommendations formulated by the centre may lead to the formulation and implementation of new policies to meet the demands for resource effective, environmentally sustainable agricultural logistics system.

Within the framework of global agenda for environment, the Swedish government set its visionary plan stating that the environmental constraints associated with transport will be solved within 25 years. To achieve this, research institutions are putting their effort to develop an intelligent transport system (ITS). Thus, collaboration of SLU with the involved institutions is important and necessary. More over collaboration with national and international research institutions, production and transport companies is essential to strength competence, exchange experiences and to guarantee the implementation and materialization of research results and the system developed.

7. Concluding remarks

It is a global and international commitment to promote sustainability in terms of environment, social, culture and economy. Based on the visions formulated by national and international agencies, the following transport-environmental visions may be stated:

- a) environmentally sustainable goods transport system

shall be developed within 20 - 25 years,

- b) emissions generated from road goods transport will be more than halved by the year 2020 from the present level

To reach the above goals the following strategies may be promoted:

- a) Effective utilization of vehicles (for example through promoting coordinated goods transport, able to transport various types of goods on the same vehicle, etc)
- b) Improve vehicles technology,
- c) Improve fuel's efficiency,
- d) Search for alternative fuel system,
- e) Promote IT-supported logistics,
- f) Improve driving performance (develop eco-driving performance)
- g) Localisation of production and distribution system,
- h) Integrated production system
- i) Avoidance of transport demanding activities (location production, integrated production, mobile abattoir, 'group-shopping', etc).

In general it may be noted that environmental constraints related to transport can be tackled through developing information technology supported effective logistics system

Agricultural goods transport is found to be a considerable part of goods transport in Sweden as a whole. As in other sectors, the process of centralization is in progress in the agricultural sector leading to substantial transport demand in the foreseeable future. However, hitherto, little attention has been paid to the agricultural goods transport activities.

Noting that agricultural transport and environment is in line with SLU's sector responsibility, SLU may consider the subject as one of its main themes to develop competence and knowledge in agricultural and forestry transport. To realize this a competence centre may be organized to:

- a) coordinate the on-going transport related research activities within SLU,
- b) work out detailed programme on research and education for the theme
- c) promote collaboration with primary producers, industries, wholesalers, transport companies, international and national research institutions.

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