Baltic Sea
ENVIRONMENT
PROGRAMME

European Bank
for Reconstruction and Development

BALTIC SEA ENVIRONMENT PROGRAMME

TOPICAL AREA STUDY
FOR AGRICULTURAL RUNOFF

FINAL SYNTHESIS REPORT

APRIL 1992

Norwegian Institute for Water Research NIVA

NIVA - REPORT

Norwegian Institute for Water Research NIVA

Report No.:	Sub-No.:
O-91163	
Serial No.:	Limited distrib.:
2751	

Main Office	Regional Office, Sørlandet	Regional Office, Østlandet	Regional Office, Vestlandet	Akvaplan-NIVA A/S
P.O. Box 69, Korsvoll	Televeien 1	Rute 866	Breiviken 5	Søndre Tollbugate 3
N-0808 Oslo 8	N-4890 Grimstad	N-2312 Ottestad	N-5035 Bergen - Sandviken	N-9000 Tromsø
Norway	Norway	Norway	Norway	Norway
Phone (47 2) 23 52 80	Phone (47 41) 43 033	Phone (47 65) 76 752	Phone (47 5) 95 17 00	Phone (47 83) 85 280
Telefax (47 2) 95 21 89	Telefax (47 41) 44 513	Telefax (47 65) 78 402	Telefax (47 5) 25 78 90	Telefax (47 83) 80 509

Report Title:

TOPICAL AREA STUDY FOR AGRICULTURAL RUNOFF

Final Synthesis Report

Date:	Printed:
11. June	NIVA 1992

Topic group: Agricult./Water Manag.

Author(s):

Dag Berge — Norwegian Inst. Water Research
Hans Olav Ibrekk — "
Nils Vagstad — *Centre Soil and Env. Research*

Geographical area: Eastern Baltic Region

Pages:	Edition:
75	275

Contractor: European Bank for Reconstruction and Development (EBRD)

Contractors ref. (or NTNF-No.):

Abstract:

The study comprises an evaluation of the agricultural water pollution in the countries bordering the Eastern Baltic Sea, i.e. St. Petersburg Region, Estonia, Latvia, Lithuania, Kaliningrad Region, Vistula River Basin, Odra River Basin, and the North German Coast. The loading of the nutrients Phoshporus and Nitrogen is estimated both to local waterbodies within the different regions, as well as to the Baltic Sea. Totally, it is estimated that 171,000 tonnes of nitrogen and 11,500 tonnes of phosphorus enter the Baltic Sea from these areas. Most of the pollution originates from point sources and insufficient handling of manure within the animal husbandry. Implementation of the proposed action plan will reduce the nitrogen loading by approximately 25% and the phosphorus loading from agriculture by about 70%. The action plan is estimated to cost about 37 billion ECU.

4 keywords, Norwegian

1. Østersjøens østkyst
2. Landbruksforurensninger
3. Fosfor og nitrogen belastning
4. Tiltaksplan

4 keywords, English

1. Eastern Baltic Region
2. Pollution from agriculture
3. Phosphorus and nitrogen loading
4. Action Plan

Project leader

Dag Berge

For the Administration

Haakon Thaulow

ISBN 82-577-2129-8

Norwegian Institute for Water Research

Oslo

O-91163

TOPICAL AREA STUDY

FOR

AGRICULTURAL RUNOFF

Final Synthesis Report

Oslo, Norway 11. june 1992

Project leader: Dag Berge

Co-workers: Hans Olav Ibrekk
Hans Holtan
Gjertrud Holtan
Nils Vagstad, Centre Soil and Env. Res.

PREFACE

Norwegian Institute for Water Research (NIVA) in co-operation with Centre for Soil and Environmental Research (Jordforsk) have been contracted by the European Bank for Reconstruction and Development (EBRD) to prepare a topical area study for agricultural runoff in the Baltic Sea region. The study area comprises the drainage basins of seven prefeasibility study areas in the former U.S.S.R., Baltic Republics, Poland and Germany.

This Synthesis Report is a presentation of the findings and the conclusions of the Pre-feasibility study. The presentation is according to the general table of contents for the final Synthesis Report. However, due to the scope of the work some adjustments to the proposed outline have been made.

The result of the study is presented in two reports:

- *The present Synthesis Report*
- *A Technical Report that provides detailed information concerning technical, economic, financial and institutional issues.*

The report is mainly based on agricultural data collected by the consultants for the seven study areas. However, to get reliable statistics from the area proved to be a difficult task. This is partly due to the large structural changes in the agriculture following the recent political changes.

In addition to the difficulties regarding collection of data, the likelyhood of structural changes in the large scale state farming due to recent political changes makes it difficult to point out the most cost-effective actions.

The study team responsible for the preparation of this report consists of Research Director Dag Berge, Research Manager Hans Olav Ibrekk, Senior Scientist Hans Holtan and Scientist Gertrud Holtan, Norwegian Institute for Water research (NIVA), and Head of Department Nils Vagstad, Centre for Soil and Environmental Research (Jordforsk).

Oslo, April 1992

Dag Berge

EXECUTIVE SUMMARY

OBJECTIVES AND SCOPE OF WORK

The Topical Area Study for Agricultural Runoff, which is part of the Baltic Sea Environment Programme, was initiated by the European Bank for Reconstruction and Development (EBRD) with the objectives:

Estimate the pollution load from agricultural runoff both to local waters and to the Baltic Sea.

Propose a Priority Action Programme of abatement measures against agricultural pollution.

Assess the environmental benefits of this action plan both with regard to local waters and for the Baltic Sea.

Estimate the costs confined with this action plan.

Evaluate accompanying measures, like environmental legislation, human and institutional strengthening, etc.

The study area comprises the St. Petersburg Region, Estonia, Latvia, Lithuania, the Kaliningrad Region, Vistula River Basin, Odra River Basin, and The North German Coast. The data should be provided by the consutants responsible for the prefeasibilty studies within each region.

AGRICULTURE STATUS AND TRENDS

In the St. Petersburg Region, Estonia, Latvia, Lithuania, and the Kaliningrad Region, the agriculture is characterized by the predominant former USSR agricultural policy with very large state owned farms of an average size of more than 5000 ha. Animal husbandry dominates and provides for about 70% of the economic output from agriculture. The animal husbandry is characterized by large specialized units comprising cattle farms, poultry farms and piggeries.

Manure storage capacity is in general insufficient. Storage capacity for manure is about 3 months. Indoor leakage proof storages of "Western standard" do almost not exist. Handling of urine is normally dealt with by mixing urine with other waste waters and thus urine will enter the sewers from the farm complexes. The waste water is either discharged directly into a recipient or at best via a biological treatment plant removing organic material but not nutrients. For some cattle and poultry farms manure is mixed with peat and composted. The solid manure is for the most applied on agricultural land.

The most severe problem with manure storage and handling is manure from the piggeries. The manure handling technology is based on hydraulic systems both with regard to cleaning and transportation.

Table S1. Essential agricultural statistical data from the different Prefeasibility Regions.

	Agricult. area (ha) x1000	Animal Units (AU) x1000	Animal Density AU per ha	Mineral Fertilizer (total consume)		Manure Fertilizer (total production)		Mineral Fertilizer Application rate		Manure Fertilizer Application rate		Total fertilizer (mineral + manure)	
				Tons N	Tons P	Tons N	Tons P	kgN/ha	kgP/ha	kgN/ha	kgP/ha	kgN/ha	kgP/ha
St. Petersburg Reg.	555	610	1.1	49500	6050	30500	6100	90	35	55	11	145	46
Estonia	1362	675	0.5	110000	27000	34000	6800	80	20	25	5	105	25
Latvia	2570	2000	0.8	177000	51000	100000	20000	69	20	40	8	110	28
Lithuania	3425	2454	0.72	398700	115000	122700	24540	116.4	33.6	35.8	7.2	152.2	40.8
Kaliningrad Region	789.1	418	0.53	37700	10872	20900	4180	47.8	13.8	26.5	5.3	74.3	19.1
Vistula	12495	9200	0.74	810000	220000	460000	92000	75	20	37	7.4	112	27
Odra	7080	5000	0.7	531000	141600	250000	50000	75	20	35	7	110	27
Former DDR	1190.6	1187	1	166690	33338	71220	11870	140	28	60	10	200	38
Sleswig Holstein	1074.6	1491	1.38	124654	20417	89460	14910	116	19	83	14	199	33

In Poland is most of the farms privately owned. The private farms are of an average size of only 5 ha. There are also several large state owned farms in Poland with huge livestock numbers causing the same environmental problems as in the previous described area. Both on private farms and state farms is manure storage capacity insufficient. With regard to fertilizer consumption is the Polish agriculture characterized as medium intensive.

In Germany there is a highly intensive agriculture both with regard to plant cultivation and animal husbandry. In the former DDR there are large livestock farms as in the former Soviet areas with huge pollution problems arising from bad manure handling and storage.

The intensity of the agriculture within the different region is given in Table S1. It should be noted that large changes are at the moment taking place concerning the ownership of many farms, consumption of mineral fertilizers, etc., in large parts of the area in study. The statistics are mostly from the period just before this changing started, 1988/89/90.

NUTRIENT LOAD FROM AGRICULTURE

Nutrient load to local waters, lakes and rivers

The nutrient loading to local water recipient from different agricultural sources within the different prefeasibility regions is given in Table S2 to S10.

Table S2 Estimated nutrient load from agriculture to local water recipients in the Kaliningrad Region.

Pollution categories	Nitrogen (tonnes N/year)	Phosphorus (tonnes P/year)
Average runoff from agricultural fields	15000	160
Extra loss from heavily manured fields	1900	50
Direct discharge of farm waste (slurry)	7200	1430
Leakage from manure storages	3140	420
Leakage from fertilizer storage	700	120
Silage effluent leakage	400	50
Total nutrient load from agriculture	28340	2230

Table S3 Estimated nutrient load from agriculture to local water recipients in The St. Petersburg Region.

Pollution categories	Nitrogen (tonnes N/year)	Phosphorus (tonnes P/year)
Average runoff from agricultural fields	13700	170
Extra loss from heavily manured fields	2700	75
Direct discharge of farm waste (slurry)	4500	900
Leakage from manure storages	4500	600
Leakage from fertilizer storage	600	140
Silage effluent leakage	300	60
Total nutrient load from agriculture	26300	1950

Table S4 Estimated nutrient load from agriculture to local water recipients in Estonia.

Pollution categories	Nitrogen (tonnes N/year)	Phosphorus (tonnes P/year)
Average runoff from agricultural fields	27400	280
Extra loss from heavily manured fields	3500	90
Direct discharge of farm waste (slurry)	5100	1020
Leakage from manure storages	5000	650
Leakage from fertilizer storage	1300	200
Silage effluent leakage	500	65
Total nutrient load from agriculture	42800	2305

Table S5 Estimated nutrient load from agriculture to local water recipients in Latvia.

Pollution categories	Nitrogen (tonnes N/year)	Phosphorus (tonnes P/year)
Average runoff from agricultural fields	59110	650
Extra loss from heavily manured fields	7500	200
Direct discharge of farm waste (slurry)	10000	2000
Leakage from manure storages	15000	2000
Leakage from fertilizer storage	1700	300
Silage effluent leakage	1500	200
Total nutrient load from agriculture	94810	5350

Table S6 Estimated nutrient load from agriculture to local water recipients in Lithuania.

Pollution categories	Nitrogen (tonnes N/year)	Phosphorus (tonnes P/year)
Average runoff from agricultural fields	85600	1030
Extra loss from heavily manured fields	9200	250
Direct discharge of farm waste (slurry)	9800	1900
Leakage from manure storages	18000	2400
Leakage from fertilizer storage	3500	600
Silage effluent leakage	1800	240
Total nutrient load from agriculture	127900	6420

Table S7 Estimated nutrient load from agriculture to local water recipients in the Polish part of Vistula Catchment and the Baltic Coast of Poland.

Pollution categories	Nitrogen (tonnes N/year)	Phosphorus (tonnes P/year)
Average runoff from agricultural fields	280000	2500
Extra loss from heavily manured fields	13000	360
Direct discharge of farm waste (slurry)	9200	1800
Leakage from manure storages	32000	3700
Leakage from fertilizer storage	3000	480
Silage effluent leakage	3400	460
Total nutrient load from agriculture	340600	9300

Table S8 Estimated nutrient load from agriculture to local water recipients in the Oder River Basin.

Pollution categories	Nitrogen (tonnes N/year)	Phosphorus (tonnes P/year)
Average runoff from agricultural fields	162000	1540
Extra loss from heavily manured fields	7500	200
Direct discharge of farm waste (slurry)	5000	1000
Leakage from manure storages	17000	2000
Leakage from fertilizer storage	1900	300
Silage effluent leakage	1800	250
Total nutrient load from agriculture	195200	5290

It has not been data available to perform these calculations for the North German Coast.

Nurient load from agriculture reaching the Baltic Sea

From runoff:
Corrected for assumed retention in primary and secondary recipients, the nutrient load from agricultural runoff that reach the Baltic Sea from the differnt regions are estimated as follows.

Table S9 Estimated nutrient loading to the Baltic Sea arising from agriculture runoff in the Prefeasibility Regions.

Prefeasibility Region	Nitrogen (tonnes N/year)	Phosphorus (tonnes P/year)
St. Petersburg Region	5260	680
Estonia	8560	810
Latvia	18960	1870
Lithuania	25580	2250
The Kaliningrad Region	5670	780
The Vistula River Basin	68120	3260
The Oder River Basin	39040	1850
The North German Coast		
Total from agriculture	171190	11500

From ammonia deposition

Table S10 Total annual ammonia deposition onto the Baltic Sea surface arising from the prefeasibilty region, tentatively after the table 1 in NILU synthesis report (Pacyna 1992).

Contributor (Prefeasibility region)	Ammonia deposition (tonnes per year) Based on 1985 data
St. Petersburg Region, Estonia, Latvia, Lithuania, Kaliningrad Region	20000
Vistula River Basin and Oder River Basin	16500
Schwerin and Neu Brandenburg (DDR)	4500
Schleswig-Holstein	3000
Total N-load from ammonia deposition	44000

Total nutrient load from agriculture within the prefesibilty regions to the Baltic Sea is estimated to 11000 tonnes of Phosphorus and 208000 tonnes nitrogen.

PRIORITY ACTION PROGRAMME

One important long term measure should be to split the large farms into smaller units which are much more easy to run after environmentally sound principles. However, this will take at least one generation to perform. In the mean time the short term measures that should be implemented are as follows:

Animal husbandry

It is quite obvious that the largest pollution sources from agriculture is confined within the animal husbandry. The following measures must be implemented.

1) Increase the storage capacity of manure to approximately 8 months, which is necessary to avoid spreading of manure outside the growing season.

2) Ensuring sufficient technical standard of the manure storage facilities. They should be roofed over and with no leakages both to ground- and surface waters.

3) Stop the direct discharge of liquidized manure/ farm wastes.

4) Stop dumping of manure on small areas.

5) Avoid outdoor storages of manure, particularly the lagoon solution.

6) Ensuring sufficient capacity and standard of silage storages.

7) Ensure safe storages for mineral fertilizers and other agrochemicals.

8) Reduce the volume of water in piggeries to what is necessary to make the manure pumpable.

10) Change from high spreading equipment to low spreading equipment in manure application (reduce ammonia volatilization).

11) Incorporate manure into soil without delay after application by plowing or harrowing (reduce ammonia volatilization).

Runoff from agricultural fields

It does not seem to be much nutrient reduction to achieve from measures against this kind of diffuce pollution sources other than:

Reduce autumn tillage as much as possible, especially on erosion exposed fields, which, however, are few.

Increase the use of catch crops.

It is, however, likely that the effect of these measures will be counteracted by increased tile drainage, and other means of effectivization in the agriculture in the future.

ACCOMPANYING MEASURES

To assure an environmentally sound agriculture in the future the accompanying measures that should be developed are:

Institutional strengthening.

Develop Advisory service, e.g. to help farmers setting up fertilizing plans, etc.

Increase both the capacity and quality of agricultural education.

Develop and adopt environmental legislation and standards.

Develop effective Pollution control services and /authorities, including use of fines.

Bring environmental aspects into agricultural policy.

Active use of subsidies to achieve extensivation where it is needed.

Use of taxation to achieve sound use of agrochemicals/ better utilization of manure.

Development of agro-related infrastructure, to secure the farmers with necessary supplies and secure storage, distribution and sales of the agricultural products.

BENEFITS FROM THE PRIORITY ACTION PROGRAMME

The actions will improve the water quality both in local waters (lakes and rivers, ground waters) and in the Baltic Sea. The improvement is quantified by the estimated loading reductions:

Load reductions to local waters:

Table S11 Reductions in nutrient load (annual) from agriculture to the local surface water recipients as a result of the Priority Action Plan.

Prefeasibility Region	N-reductions (tonnes N/year)	(%)	P-reductions (tonnes P/year)	(%)
St. Petersburg Region	11400	43	1616	83
Estonia	13990	32	1843	79
Latvia	32300	34	4260	79
Lithuania	38420	30	4911	76
The Kaliningrad Region	12076	43	1875	80
The Vistula River Basin	54840	16	6168	66
The Oder River Basin	30070	15	3405	64
The North German Coast				
Total from agriculture	193096		24078	

Load reductions to the Baltic Sea

Adjusting the local pollution load reductions for retention in primary and secondary recipients the corresponding total load reductions to the Baltic Sea from agricultural runoff are estimated to:

39000 tons of nitrogen per year (23% reduction of present runoff load)
8400 tons of phosphorus per year (73% reduction of present runoff load)

These figures apply to agricultural runoff. In addition comes ammonia deposition directly onto the Baltic Sea surface. According to the NILU study "Topical area study for atmospheric deposition of pollutants" it is possible to reduce the loading from ammonia deposition by 60% via measures within the agricultural sector. How much of the total ammonia deposition onto the Baltic Sea arises in the Prefeasibility regions is uncertain. We have tentatively estimatet this to 44,000 tonnes N per year, of which 26000 tonnes can be removed by the measures in the priority action plan.

The total N load from agriculture of approximately 208 000 tonnes (runoff + deposition) can then be reduced by 65,000 tonnes N which equals a 31% reduction.

CAPITAL AND RECURRENT COSTS CONFINED WITH THE ACTION PLAN

The total investment costs confined with the priority action plan in the agricultural sector in the different prefeasibility study areas are given below. The cost estimate is based on the Norwegian price level in 1991.

Table S12 Total investment costs confined with the Priority Action Plan in the agricultural sector in the different prefeasibility study areas.

Prefeasibility region	Investment Costs (mill. ECU)
St. Petersburg Region	1056
Estonia	1168
Latvia	3434
Lithuania	4211
Kaliningrad Region	731
Vistula River Basin	15728
Odra River Basin	8552
Former DDR	2039

Summarizing it gives total investment need of 37 billion ECU if the former DDR is included and about 35 billion ECU if DDR is omitted. The cost estimate is based on the Norwegian price level in 1991.

The capital costs (pro annum) confined with these investments will depend on the conditions, rate of interest, and so on offered by the banks and financial institutions involved.

Recurrent cost, comprising operating and maintenance costs, are very low as the investments include mainly simple buildings and/or traditional farm machineries. There are no treatment plants which needs special trained or educated personnel, nor any expensive process chemicals. There will not be any increased demand for energy for heating.

The only recurrent costs will comprise normal maintenance of buildings and tractors, increased diesel consumption in manure spreading, and some electricity to run the manure pumps. These costs are at maximum 4% of the investment, i.e. about 1.5 billion ECU per year.

The real lifetime of the buildings, manure storages, silage storages, pipeline systems are estimated to about 50 years, while the tractors and spreading equipment, pumps, etc. have a maximum lifetime of 15-20 years.

TABLE OF CONTENTS

EXECUTIVE SUMMARY 3
LIST OF TABLES 15
LIST OF FIGURES 16
1. BACKGROUND 17
1.1 Introduction 17
1.2 Objectives and scope of work 17
2 BRIEF DESCRIPTION OF THE STUDY AREA 18
2.1 Geographical area 18
2.2 Agricultural Status And Trends 18
2.1 Review of Existing Data on On Agricultural Practices 18
2.1.1 St. Petersburg Region, Estonia, Latvia, Lithuania, and the Kaliningrad Region 18
2.1.2 Poland 19
2.1.3 The North German Coast. 20
2.3 Agricultural statistics 21
2.3.1 Compiled basic agricultural statistics from the prefeasibilty regions 21
3. NUTRIENT LOAD FROM AGRICULTURE 23
3.1 Introduction 23
3.2 Load to local waters 23
3.2.1 Introduction 23
3.2.2 Comparison of the intensity of agriculture within the different Prefeasibility Regions - nutrient runoff coefficients 23
3.2.3 The Kaliningrad region 25
3.2.3.1 Agriculture profile 25
3.2.3.2 Nutrient pollution load to local water bodies from agriculture in the Kaliningrad region 26
3.2.4 Karelia 26
3.2.5 The St. Petersburg Region 27
3.2.5.1 Agriculture profile 27
3.2.5.2 Nutrient pollution load to local water bodies from agriculture in The St. Petersburg Region 28
3.2.6 Estonia 28
3.2.6.1 Agriculture profile 28
3.2.6.2 Nutrient pollution load to local water bodies from agriculture in Estonia 29
3.2.7 Latvia 29
3.2.7.1 Agriculture profile 29
3.2.7.2 Nutrient pollution load to local water bodies from agriculture in Latvia 30
3.2.8 Lithuania 31
3.2.8.1 Agriculture profile 31
3.2.8.2 Nutrient pollution load to local water bodies from agriculture in Lithuania 32
3.2.9 Vistula Catchment and Baltic Coast of Poland 32
3.2.9.1 Agriculture profile 32
3.2.9.2 Nutrient pollution load to local water bodies from agriculture in Vistula Catchment and The Baltic Coast of Poland. 33
3.2.10 Oder/Odra River Basin 33
3.2.10.1 Agriculture profile 33
3.2.10.2 Nutrient pollution load to local water bodies from agriculture in Oder River Basin. 34
3.3 Nutrient Load from Agricultural Areas reaching the Baltic Sea 35
3.3.1 The problem of estimation of retention 35
3.3.2 Nutrient load to the Baltic Sea arising from agricultural runoff 36

3.3.3 Ammonia deposition direct onto the Baltic Sea surface ... 36
4 EFFECTS OF AGRICULTURAL POLLUTION ON THE LOCAL ENVIRONMENT AND ON THE BALTIC SEA ... 39
4.1 Pollution effects on Baltic environment ... 39
4.2 Effects of agricultural pollution on the local environment ... 40
5 EVALUATION OF PROPOSED ACTIONS ... 42
5.1 Introduction ... 42
5.2 Brief Description of Different Measures ... 42
5.2.1 Milk producing farms ... 42
5.2.2 Meat production in poultries and piggeries ... 43
5.2.3 Farms with only plant production ... 44
5.3 Proposed interventions and alternatives ... 45
5.4 Accompanying Measures ... 45
5.4.1 Institutional and human resource requirements ... 45
5.4.2 Environmental Legislation and Standards ... 46
5.4.3 Factors influencing the future development of agriculture ... 47
5.4.3.1 Agricultural policy ... 47
5.4.3.2 Legal and institutional arrangements ... 48
5.4.3.3 Efficient and Rational Allocation of Water: Quality and Quantity ... 49
5.4.3.4 Capacity building ... 49
5.4.3.5 Factors influencing the future development of agriculture ... 50
5.4.3.5.1 Economic development ... 50
5.4.3.5.2 Land reforms ... 50
5.4.3.5.3 International markets ... 50
5.4.3.5.4 National price control; subsidies ... 51
5.4.3.5.5 Pricing of fertilizers ... 51
5.4.3.5.6 Level of self-sufficiency ... 52
5.4.3.5.7 Development of infrastructure ... 52
6 PROPOSED ENVIRONMENTAL PRIORITY ACTION PROGRAMME ... 53
6.1 Introduction ... 53
6.2 Average runoff from agricultural fields ... 53
6.3 Animal husbandry farms ... 54
6.3.1 Long term measure - split the large animal farms into smaller units ... 54
6.3.2 Short term measures - priority action plan ... 55
7 PROJECTED ENVIRONMENTAL BENEFITS FROM THE PRIORITY ACTION PLAN ... 57
7.1 Local environmental benefits ... 57
7.1.1 Water quality improvement in lakes and rivers ... 57
7.1.2 Reduced pollution loading to lakes, rivers and ground waters ... 57
7.2 Baltic Sea environmental benefits ... 58
7.2.1 Water quality improvement ... 58
7.2.2 Reduced pollution load to the Baltic Sea ... 58
8. CAPITAL AND RECURRENT COSTS FOR IMPLEMENTATION OF THE PRIORITY ACTION PROGRAMME ... 60
8.1 Introduction ... 60
8.2 Necessary investments on a typical Russian animal husbandry farm. ... 60
8.2.1 Investments in Manure Storages - Technical and Cost Estimates ... 60
8.2.2 Investments in spreading equipment - Technical and cost estimates ... 61
8.2.3 Investments in Fodder Silage Storages - Technical and Cost Estimates ... 62
8.2.4 Total Investment - Large animal husbandry farms ... 62
8.3 Necessary environmental investments in animal husbandry in each Prefeasibilty Region ... 63
8.4 Investments in safe storages for mineral fertilizers and other agrochemicals ... 65
8.5 Total investment needed in the agricultural sector to reach the goal in the Priority Action Plan ... 66
9 APPENDIXES ... 68
9.1 Appendix A: List of prepares ... 69
9.2 Appendix B. List of Persons Contacted ... 69
9.3 Appendix C. List of References ... 70

9.4 Appendix D. List of Sources of Data 72
9.4.1 Original request for data 73
9.4.2 Data received 74
9.5 Appendix E. Review of Cost Estimation Procedures and Assumptions 75

LIST OF TABLES

Table 2.1 Essential agricultural statistics describing the intensity of the agriculture within the different pre-feasibility regions.

Table 3.1 The average nutrient runoff coefficients for agricultural areas chosen for the different prefeasibility regions.

Table 3.2 Estimated nutrient load from agriculture to local water recipients in the Kaliningrad Region.

Table 3.3 Estimated nutrient load from agriculture to local water recipients in The St. Petersburg Region.

Table 3.4 Estimated nutrient load from agriculture to local water recipients in Estonia.

Table 3.5 Estimated nutrient load from agriculture to local water recipients in Latvia.

Table 3.6 Estimated nutrient load from agriculture to local water recipients in Lithuania.

Table 3.7 Estimated nutrient load from agriculture to local water recipients in the Polish part of Vistula Catchment and the Baltic Coast of Poland.

Table 3.8 Estimated nutrient load from agriculture to local water recipients in the Oder River Basin.

Table 3.9 Estimated nutrient loading to the Baltic Sea arising from agriculture runoff in the Prefeasibility Regions.

Table 3.10 Tentative estimate of the ammonia deposition onto the Baltic Sea surface arising from agricultural sources within the different prefeasibility areas. The estimate is based on the per AU yield calculated from Polish agriculture. (most likely an underestimate, see also Table 4.11.)

Table 3.11 Total annual ammonia deposition onto the Baltic Sea surface arising from the prefeasibilty region, tentatively after the table 1 in NILU synthesis report (Pacyna 1992).

Table 7.1 Reductions in nutrient load (annual) from agriculture to the local surface water recipients as a result of the Priority Action Plan.

Table 8.1 Necessary investments in manure storages on a typical Russian state and collective farm of 5000 ha and 3000 animal units.

Table 8.2 Necessary investments on a typical Russian State- and Collective animal husbandry farm (5000 ha, 3000 AU).

Table 8.3 Total investment need in animal husbandry farms to make them comply with the HELCOM recommendations.(mill ECU).

Table 8.4 Estimated costs for fertilizers and agrochemicals storages.

Table 8.5 Total investment costs confined with the Priority Action Plan in the agricultural sector in the different prefeasibility study areas.

LIST OF FIGURES

Figure 2.1 Development in the consumption of commercial fertilizers in the Polish agriculture (Glowny urzad statystyczny, Warsawa 1990).

Figure 3.1 Data describing the intensity of the agriculture in the region in study: Application of mineral fertilizer, manure, and livestock density (Based on statistics from 1988/89 and 90).

1. BACKGROUND

1.1 Introduction

To implement the Baltic Sea Declaration international organizations have launched studies in the Baltic Sea Region. The objectives of the studies are to prepare a priority action programme to prefeasibility level to control and reduce the present pollution of the Baltic Sea from the countries surrounding the Baltic Sea. This includes a target objective of reducing the 1987 emission level by 50% by 1995.

European Bank for Reconstruction and Development (EBRD), Nordic Investment Bank (NIB), European Investment Bank (EIB) and the World Bank (WB) have initiated several studies in different catchment areas in the Eastern-European part of the Baltic Sea region. As part of these studies the consultants should determine the total amount of pollution arising from different sources. One major source of pollution is agriculture. As much of the agricultural pollution is caused by non-point sources the consultants have encountered problems how to calculate the load from agriculture. To provide the consultants with the necessary information on this issue, EBRD has decided to initiate a study of pollution from agriculture in the river basins which drain into the Baltic Sea from Russia, Estonia, Latvia, Lithuania, Poland and the North German Coast.

Discharges of nitrogen and phosphorus from agriculture to the Baltic Sea contribute significantly to the overall nutrient load to the Baltic Sea. The nutrient discharges from agriculture include ammonia volatilization, nitrogen leaching (nitrate and organic nitrogen), phosphorus leaching and erosion, and discharge of farm waste such as effluents from animal houses, manure storages, heavily manured areas(manure dumping areas), and silage heaps.

1.2 Objectives and scope of work

The objectives of the study are:

1) To develop methods which will be used to estimate the total pollution load from agriculture, and

2) to estimate what reductions in pollution from agriculture can be achieved through implementing different measures. The study will focus primarily on inputs of nutrients and organic matter from agricultural activities.

3) evaluating of accompanying measures, i.e. means of implementation of abatement measures.

The result of the study is depending on the availability of data on agriculture.

2 BRIEF DESCRIPTION OF THE STUDY AREA

2.1 Geographical area

The study area for the topical area study for agricultural runoff comprises the drainage basins of the seven pre-feasibility study areas, which are:

1. Gulf of Finland, St. Petersburg Region and Estonia.
2. Gulf of Riga and Daugava River Basin.
3. Lithuanian Coast and Neman River Basin.
4. Kalinigrad Region and Pregel River Basin.
5. Vistula River and Baltic Coast of Poland.
6. Odra/Oder River Basin.
7. North German Coast.

For further information see the next chapter on agricultural status and trends and the general description given in the chapter dealing with nutrient load from agriculture.

2.2 Agricultural Status And Trends

The data we have received/collected from the respective consultants are insufficient compared to data that were requested. Thus it can hardly serve as a basis for any detailed description of the agricultural practices, waste handling, legislation, pollution load estimate, etc., in the different study areas. The description presented below is based on the different National Plans for Reduction of the Load of Pollution to the Baltic Sea, the evaluation of the plans prepared by Torben A. Bonde for the HELCOM commission, supplemented by more detailed data received from the different study groups, and official statistics and literature.

2.1 Review of Existing Data on On Agricultural Practices

The following chapters review the existing data on agricultural practices in the study areas.

2.1.1 St. Petersburg Region, Estonia, Latvia, Lithuania, and the Kaliningrad Region

No national action plans have so far been presented for these regions.

Agriculture in these areas is characterized by the predominant USSR agricultural policy with very large state owned farms of an average size of more than 5000 ha. Animal husbandry dominates and provides for about 70% of the economic output from agriculture.

The animal husbandry is characterized by large specialized units comprising cattle farms, poultry farms and piggeries.

Manure storage capacity is in general insufficient. Cattle and manure handling is based on storage of solid manure. Handling of urine is normally dealt with by mixing urine with other waste waters and thus urine will enter the sewers from the farm complexes. The waste water is either discharged directly into a recipient or at best via a biological treatment plant removing organic material but not nutrients. Storage capacity for manure is about 3 months. For some cattle and poultry farms manure is mixed with peat and composted. The solid manure is for the most applied on agricultural land.

The most severe problem with manure storage and handling is manure from the piggeries. The manure handling technology is based on hydraulic systems both with regard to cleaning and transportation. This system requires approximately 50 litres of water pr. animal per day which transform the pig manure to a liquid manure, comparable to "normal" waste water. The liquid manure is stored in large outdoor lagoons, which leak both to ground and surface waters. The surface water is only protected against leakages from the lagoons by a soil/sand infiltration wall which, however, in most cases cause considerably seepage to recipients. In reported cases infiltration walls have collapsed resulting in mass fish kills in receiving rivers.

The outdoor storing techniques and the lack of storage capacity, give rise not only to leaching, but also to a large loss to the atmosphere as ammonia volatilization.

The agriculture in the area is characterized as medium intensive. If the livestock is divided by the total agricultural area, the livestock density is low (0.8AU per ha compared to 2 in Denmark and 1.3 in Germany). However, the large farms or so called "bio-industries" in the region make it difficult to achieve an environmentally sound agricultural production. Such "bio-industries" make it difficult to utilize the manure effectively as fertilizers as it requires transportation over long distances which is costly (>95% water content).

About half of the agricultural area is comprised of meadows and pastures (bulk fodder production). The other half is in crop rotation with production of grains, potatoes and vegetables.

The nutrient content of manure from one livestock unit in the region is estimated to approximately 50 kg N and 10 kg P. The livestock density is about 0.8 AU per ha arable land which corresponds to about 40 kg N and 8 kg P per ha arable land. The commercial fertilizer consumption is about 70 kg N and 20 kg P per ha and the total use of fertilizers thus adds up to about 110 kgN and 28 kgP per ha.

The percentage of the arable soils which suffer from inadequate draining is high in the region.

2.1.2 Poland

Within the Baltic region the Polish agriculture is of medium intensity. The farms are mostly privately owned with an average size of only 5 ha, but also large farms exists. The overall livestock density is of the same size as in the previous region, 0.7-0.8 AU per ha and the use of commercial fertilizer is about 70-80 kg N and 20 kg P per ha. The development in commercial fertilizer consumption in Polish agriculture is shown in Fig. 4.1. According to one of Europe's largest fertilizer producers, Norsk Hydro, there has been a dramatic drop over the last 2 years. The soils range from light sandy (poor) soils to clayey loams of high agricultural value.

In the animal farms storage capacity is insufficient. Manure handling in large farms is based on hydraulic systems (slurry) with storage in lagoons, as in the former USSR, giving rise to large leakages to surface water recipients, to ground waters as well as large losses to the atmosphere by ammonia volatilization.

Poland has adopted a National plan for reduction of pollution to the Baltic Sea. For agriculture a set of recommendations is given which are very similar to those given by HELCOM. However, it seems to be problems with implementation of the recommendations. Basic statistics about the structure of farming and the farming practises should be developed in Poland.

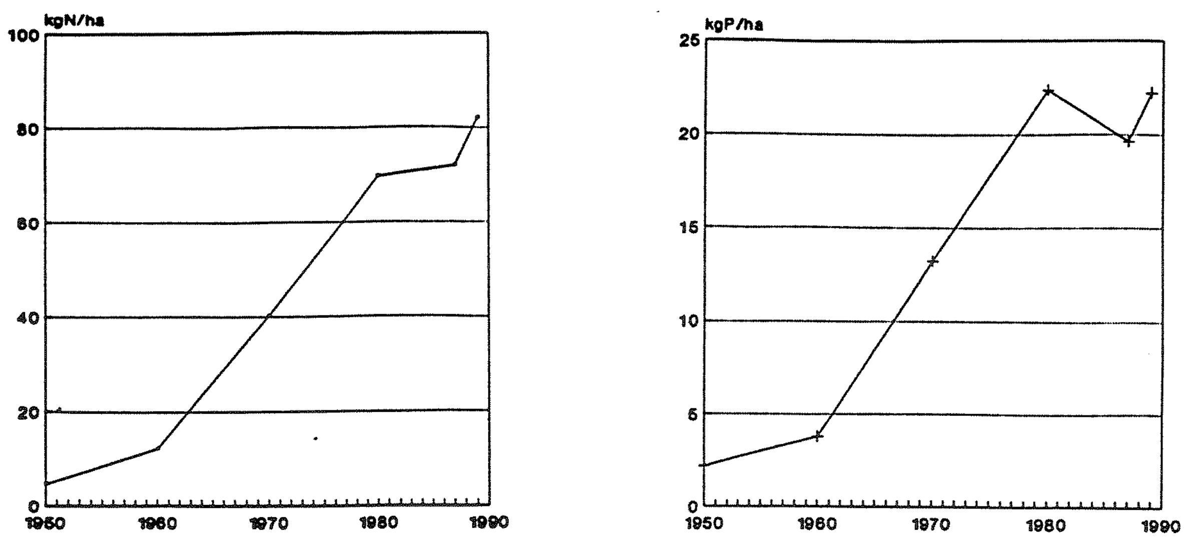

Figure 2.1 Development in the consumption of commercial fertilizers in the Polish agriculture (Glowny urzad statystyczny, Warsawa 1990).

2.1.3 The North German Coast.

Germany has a long tradition of high intensive agriculture. This can be seen from overall numbers of livestock density (approximately 1.3 AU per ha) and a fertilizer consumption of 165 kg N and 56 kg P per ha. The Schleswig-Holstein is further characterized by 90 % of the arable land covered by green fields, mainly winter crops, and high average yields, approaching 10 tons of grain per ha. In Schleswig-Holstein the livestock density is slightly below 1 AU per ha.

70% of the Baltic Sea catchment area of Schleswig-Holstein is tilled land, and another 20% is used as grassland farming.

The Land of Mecklenburg-Western Pommerania and the regions of Oderbruch and Lusatia in Brandenburg and Saxony, respectively, are areas of particularly intensive farming. The main crops are cereals, potatoes, sugar beets and oleaginous fruit.

A seven months storage capacity has been provided between 1974 and 1990 as a result of the governmental programme "The Agricultural Environmental Support Programme". The "Gülleverordnung" (Slurry decree) which took effect from August 1, 1989 regulates the application of animal manures. Among the more important statements in this decree are:

1. Manure from a maximum of 2 AU is to be added per ha.
2. Manure should be applied from February 1. to October 15. (March 1. to Sept. 31., on bare soil.
3. Applied manure should be incorporated not later than 24 hours after application.
4. Poultry manure should be applied based on the P content of the soils.
5. Manure should not be applied on frozen ground, river banks, forests, etc.

A voluntarily extensivation programme is being adopted. Farmers may adopt certain fertilizer and crop rotation schemes and breed livestock at a maximum density of 2 AU per ha. In return they receive subsidizes for such extensivation of the farming practices. Farmers may establish 10 m wide protective zones along watercourses and around lakes and in return receive subsidizes.

The success of this extensivation programme is dependent on the number of farmers joining the programme. So far, less than 10% of the arable land is under extensive farming.

In the new Federal Länder, former DDR, livestocks are concentrated mainly in huge stock raising farms with high output of liquid manure. In those areas, environmentally sound processing of the liquid manure is hampered by insufficient storage capacity and lack of transportation and spreading technologies. The liquid manure is stored in outdoor lagoons, but direct drainage to surface waters takes place. Additional risks are posed by fertilizer and pesticide storage spaces which are insufficiently secured and not roofed over and by trench silos.

2.3 Agricultural statistics

2.3.1 Compiled basic agricultural statistics from the prefeasibilty regions

In Table 2.1 is the most essential agricultural data compiled. The table can be used for comparison of the agricultural intensity in the different areas. See also Fig 3.1.

Table 2.1 Essential agricultural statistical data from the different Prefeasibility Regions.

	Agricult. area (ha) x1000	Animal Units (AU) x1000	Animal Density AU per ha	Mineral Fertilizer (total consume)		Manure Fertilizer (total production)		Mineral Fertilizer Application rate		Manure Fertilizer Application rate		Total fertilizer (mineral + manure)	
				Tons N	Tons P	Tons N	Tons P	kgN/ha	kgP/ha	kgN/ha	kgP/ha	kgN/ha	kgP/ha
St. Petersburg Reg.	555	610	1.1	49500	6050	30500	6100	90	35	55	11	145	46
Estonia	1362	675	0.5	110000	27000	34000	6800	80	20	25	5	105	25
Latvia	2570	2000	0.8	177000	51000	100000	20000	69	20	40	8	110	28
Lithuania	3425	2454	0.72	398700	115000	122700	24540	116.4	33.6	35.8	7.2	152.2	40.8
Kaliningrad Region	789.1	418	0.53	37700	10872	20900	4180	47.8	13.8	26.5	5.3	74.3	19.1
Vistula	12495	9200	0.74	810000	220000	460000	92000	75	20	37	7.4	112	27
Odra	7080	5000	0.7	531000	141600	250000	50000	75	20	35	7	110	27
Former DDR	1190.6	1187	1	166690	33338	71220	11870	140	28	60	10	200	38
Sleswig Holstein	1074.6	1491	1.38	124654	20417	89460	14910	116	19	83	14	199	33

3. NUTRIENT LOAD FROM AGRICULTURE

3.1 Introduction

As part of the study a method how to calculate pollution load from agricultural sources has been developed. This method, which has been used to calculate the pollution loading from agriculture in each study area, is presented in the Technical Report, chapter 3.

In this report the main result is presented. For further information, please see the Technical Report.

3.2 Load to local waters

3.2.1 Introduction

This chapter attempts to quantify the nutrient load to local surface waters from agriculture within the Prefeasibility regions, both with regard to point sources and diffuse runoff from agricultural fields. According to the contract, the calculations should be based on material provided by the lead consultants within each region. Data collection have been very difficult. To supplement the data received national bureaus of statistics in the different countries were contacted. However, the data supplied from these sources are based on national and regional basis and not on catchment borders of the prefeasibilty regions.

Often the received data lacked numeric values. Part of this chapter is therefore based on using best judgement. Descriptions like "a large part of the animal manure slurry being discharged directly into the river, the rest is applied on fields" had to be converted to fixed numeric values. Planimetrations from confusing maps had to be performed to get approximations of agricultural areas where such data are lacking.

3.2.2 Comparison of the intensity of agriculture within the different Prefeasibility Regions - nutrient runoff coefficients

Several factors affect the non-point nutrient loss from agricultural fields. One is the fertilization intensity and livestock density. In Fig. 3.1 the data pertaining to agriculture intensity within the Prefeasibility Regions have been compiled. The Kaliningrad Region being the most extensive followed by the two northernmost Baltic States, the two catchments of Poland, Vistula and Oder. By far the most intensive farming takes place in The North German Coast region, so far illustrated by national statistics from the districts of Schwerin and Neu Brandenburg in the former DDR, and Sleswig Holstein. This is not surprisingly. Surprisingly is, however, the relatively high intensity of the Lithuanian agriculture, and also the agriculture in the St. Petersburg Region.

It should be noted that the data from the latter area are very scarce, making the estimates very uncertain. It should also be noted that the data from the North German Coast will be adjusted to the part of the 3 districts that drain to the Baltic when data are available.

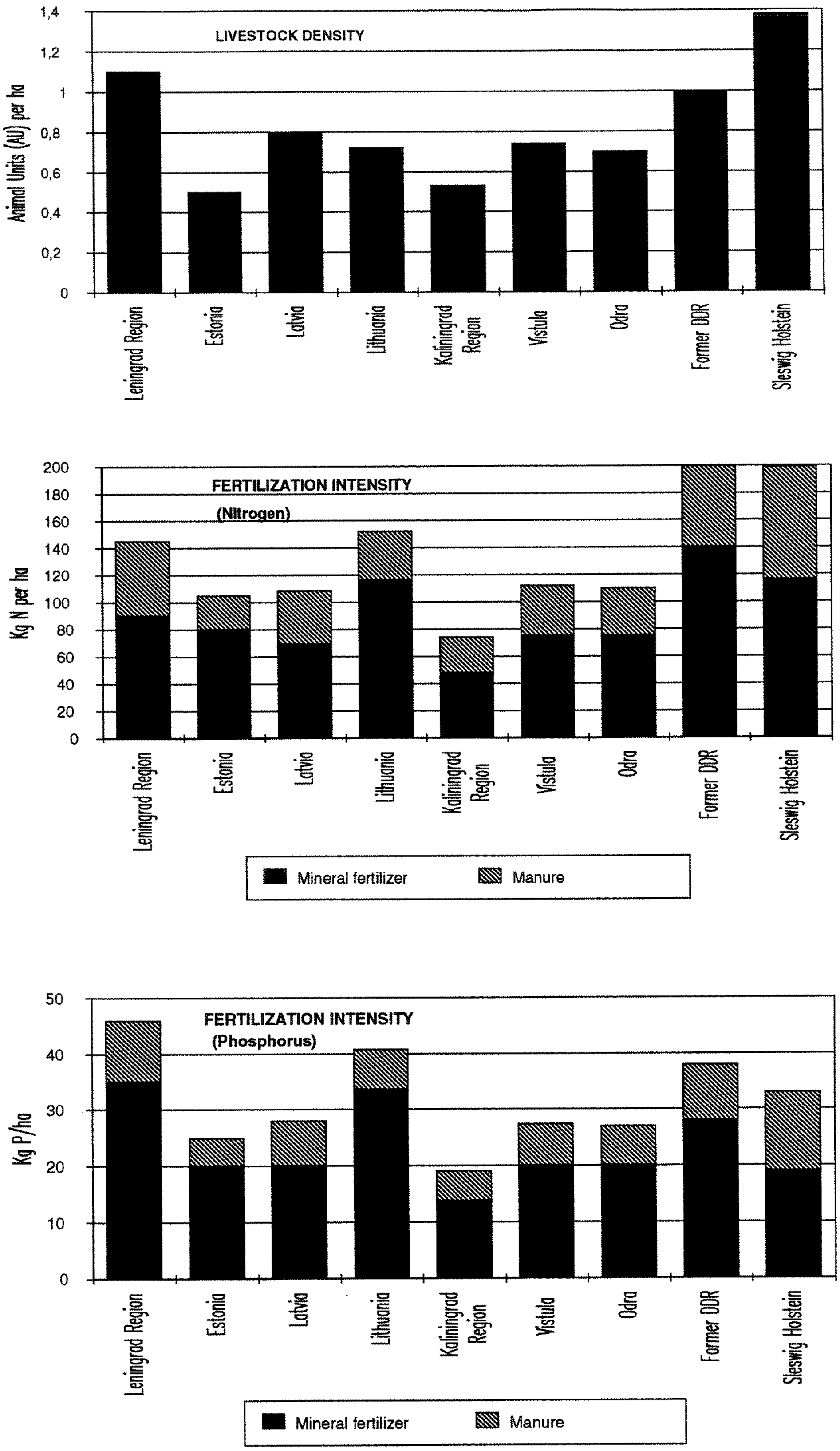

Fig.3.1 Data describing the intensity of the agriculture in the region in study: Application of mineral fertilizer, manure, and livestock density (Based on statistics from 1988/89 and 90).

In addition to fertilization intensity, and mechanical soil handling, some climatological and geographic characters are decisive for the nutrient runoff. These are particularly precipitation and runoff (water) intensity. The precipitation varies between 500 and 750 mm per year and runoff from 200-300 mm. Part of Mid-Poland has runoff as low as 150 mm.

Table 3.1 shows the coefficients used for calculation of nutrient runoff from agricultural fields in the different regions. The coefficients are developed after methods given by Løfgren and Olsson (1990) from Swedish agriculture with similar slopes, precipitation and runoff intensity, and comparable fertilization intensity, supplemented by data from Bonde (1991), Samuelson and Wittgren (1991).

Table 3.1 The average nutrient runoff coefficients for agricultural areas chosen for the different prefeasibility regions.

Region	Nitrogen runoff coefficient Kg N/ha year	Phosphorus runoff coefficient KgP/ha year
St. Petersburg Region	25	0.3
Estonia	20	0.2
Latvia	23	0.25
Lithuania	25	0.3
Kaliningrad Region	19	0.2
Vistula Catchment and Baltic Coast of Poland	23	0.2
Odra River Basin North German Coast	23	0.22

3.2.3 The Kaliningrad region

3.2.3.1 Agriculture profile

When the Kaliningrad Region was annexed by the former Soviet Union, the agriculture was collectivized in the same manner as in most places in the former USSR. This includes three types of production units, the state farms (Sovkhozes), collective farms (Kolkhozes), and the private plots.

The agriculture profile in the Kaliningrad region is clearly dominated by animal husbandry. This applies both to the Kolkhozes and Sovkhozes. The plant cultivation is mainly aimed at fodder production. The total agricultural area of Kaliningrad Region amounts to 789.100 ha including 383.200 ha of arable land, 147.400 ha of hay-making land and 256 600 ha of pasture. The agricultural area constitutes approximately 55% of the total area of the region.

To increase the soil fertility the farms are using mineral and organic fertilizer, along with liming of acidic soils. The nutrient application rate varies depending on the plant production. If the total consumption of fertilizer (37700 ton N and 10872 ton P) is divided on the total agricultural area 789.100 ha it gives an application of 48 kgN/ha and 14 kgP/ha. If we add the total manuring potential estimated to 20900 ton N and 4180 tons P (equals 26.5 kgN/ha and 5.3 kgP/ha) the total fertilizing intensity is 75 kgN/ha and 19 kgP/ha. This is a rather low fertilizing intensity, particularly with respect to nitrogen. In the medium intensive Norwegian agriculture the corresponding figures are 20 kgP/ ha and 110 kgN/ha with respect to mineral fertilizer.

This is extensive compared to Western Europe agriculture. It is also the most extensively fertilizer consumption among the areas comprised by the 7 prefeasibility studies under the Baltic Sea Environment Programme, see Fig 3.1. The extensivity is also reflected in relatively low crop yields, which for summer and winter cereals are reported to be about 30 centners pr. ha, which corresponds to about 3000 kg/ha. In Scandinavia the yearly average varies between 3500 and 6000 kg/ha depending on the weather conditions.

The number of livestock animals amounts to a total of 418000 AU, which gives an overall livestock density of 0.53 AU pr. ha. This is a relatively low value, and clearly the lowest density of livestock animals within the Baltic region, see Fig 3.1.

3.2.3.2 Nutrient pollution load to local water bodies from agriculture in the Kaliningrad region

The total nutrient load from agriculture in the Kaliningrad Region is given in Table 4.2.

Table 3.2 Estimated nutrient load from agriculture to local water recipients in the Kaliningrad Region.

Pollution categories	Nitrogen (tonnes N/year)	Phosphorus (tonnes P/year)
Average runoff from agricultural fields	15000	160
Extra loss from heavily manured fields	1900	50
Direct discharge of farm waste (slurry)	7200	1430
Leakage from manure storages	3140	420
Leakage from fertilizer storage	700	120
Silage effluent leakage	400	50
Total nutrient load from agriculture	28340	2230

3.2.4 Karelia

No reliable statistics concerning the agriculture in Karelia have been received. The Russian Embassy in Oslo and the Norwegian Central Bureau of Statistics have provided some data. Plan Center LTD has inspected the largest animal husbandry farms in the area. The data indicate that the total agricultural area of Karelia is about 200 000 ha, of which 120 000 ha is meadows and pasture.

Most of the farms are small with a diverse production. Data on intensity and operational practices are scarce. The lead consultant (Plan Centre) says:"According to the local authorities, non-point loading of numerous small farms is remarkable and one main factor affecting the water quality of Lake Onega. However there is no numeric data available".

There are a few large state farms producing pigs and poultry. The biggest piggery has a capacity of 20 000 pigs, and the largest chicken farm has a capacity of 320000 birds.

No information about the total animal units are available, nor information on the fertilizer consumption.

The total agricultural area constitutes only 1.3% of the total land area. Compared to other countries within the Baltic Sea Catchment, as e.g. Lithuania and Denmark with 70% and 63% agricultural land respectively, the agricultural activity in Karelia is negligible. A large part of Karelia drains northwards to the White Sea (Arctic Ocean) and the rest to the large lakes of Onega or Ladoga. The agricultural pollution which remains after passing these two lakes is negligible in connection with the pollution of the Baltic Sea.

With this fact in mind, combined with the almost complete lack of numeric data, no estimates of the nutrient runoff from Karelia can be made. However, it should be noted that the storing, handling and disposal of manure at the large animal farms is not environmentally sound, and measures taken against these targets may give considerable local improvements.

3.2.5 The St. Petersburg Region

3.2.5.1 Agriculture profile

As in Karelia no reliable statistics concerning the agriculture in the St. Petersburg region have been received. The Russian Embassy in Oslo and the Norwegian Central Bureau of Statistics have provided some data. Plan Center LTD has inspected the 15 largest animal husbandry farms in the area, but states that the smaller scale agriculture (numerous farms) are not included in their study.

Total arable land in crop rotation is 433 900 ha. It seems like meadows and pastures are not included in this figure. Assuming this area to be about 120 000 ha (as in Karelia), the total agricultural area of the region is 550 000 ha.

The 15 largest state farms have a total of 305 000 AU. How large part of the agriculture in the region these 15 farms constitutes, can only be guessed. However, the average size of the large Soviet state and collective farms is about 5 000 ha. These 15 farms then seem only to comprise 13% of the total agricultural land. An estimate based on doubling the number of animal units, giving 610 000 AU, and applying this to the whole region should be a conservative estimate. This gives a livestock density of 1.1 AU per ha.

This corresponds to a manure production of 30500 tons of N per year and 6100 tons of P. Evenly spread over the agricultural area it corresponds to 55 kgN/ha and 11 kg P/ha.

The average use of mineral fertilizer in the former Soviet agriculture is given to be 90 kgN/ha and 35 kgP/ha (Bonde 1991).

The total fertilization rate (mineral + manure) will then amounts to 145 kgN/ha and 46 kgP/ha. This is a fairly intensive agriculture and a very high fertilization rate, particularly for phosphorus.

3.2.5.2 Nutrient pollution load to local water bodies from agriculture in The St. Petersburg Region.

The total nutrient load from agriculture in The St. Petersburg Region is given in Table 3.3.

Table 3.3 Estimated nutrient load from agriculture to local water recipients in The St. Petersburg Region.

Pollution categories	Nitrogen (tonnes N/year)	Phosphorus (tonnes P/year)
Average runoff from agricultural fields	13700	170
Extra loss from heavily manured fields	2700	75
Direct discharge of farm waste (slurry)	4500	900
Leakage from manure storages	4500	600
Leakage from fertilizer storage	600	140
Silage effluent leakage	300	60
Total nutrient load from agriculture	26300	1950

3.2.6 Estonia

3.2.6.1 Agriculture profile

Agriculture in Estonia as well as in the other Baltic states is focused on livestock production. Pork and poultry production is concentrated to large specialized units. The plant cultivation is mainly aimed at fodder production. The predominant crops are barley, rye, wheat, oats, and perennial grasses. Other typical crops are potatoes and flax.

The arable land makes up 1.362 million ha out of a total land area of 4.530 mill ha. The consumption of mineral fertilizer is about 110 000 tons of nitrogen and 27 000 tons of phosphorus per year. If this amount is evenly distributed over the total agricultural area, it corresponds to 80 kgN/ha and 20 kgP/ha per year.

The animal husbandry is concentrated to a few but large farm units which give rise to large pollution problems from bad manure storage and disposal. This apply particularly to piggeries and to poultry farms. The number of animal units is approximately 675 000 and assuming that one AU produce 50 kg N and 10 kg P per year, this corresponds to 34 000 tons N and 6 800 tons of P. Evenly spread on the agricultural area this manure corresponds to 25 kg N/ha and 5 kgP/ha per year.

Overall average fertilizing intensity in Estonia is according to this 105 kg N/ha and 25 kgP/ha per year. This is a relatively extensive agriculture, and the second most extensive within the Prefeasibility regions, see Fig 3.1..

Most of the soil is sandy loams, the rest varying from sandy soil to light clay.

3.2.6.2 Nutrient pollution load to local water bodies from agriculture in Estonia

The total nutrient load from agriculture in Estonia is given in Table 3.4.

Table 3.4 Estimated nutrient load from agriculture to local water recipients in Estonia.

Pollution categories	Nitrogen (tonnes N/year)	Phosphorus (tonnes P/year)
Average runoff from agricultural fields	27400	280
Extra loss from heavily manured fields	3500	90
Direct discharge of farm waste (slurry)	5100	1020
Leakage from manure storages	5000	650
Leakage from fertilizer storage	1300	200
Silage effluent leakage	500	65
Total nutrient load from agriculture	42800	2305

3.2.7 Latvia

3.2.7.1 Agriculture profile

For Latvia two different statistics which differs somewhat with respect to agricultural area and animal units have been received. Both studies are undertaken by HELCOM. Bonde (1991) gives the agricultural area to 2.57 millions ha and total livestock of 2 millions AU, while Samuelson and Wittgren (1991) give the same parameters to 2 mill ha and 1.255 million AU respectively. It has been impossible to check which of these numbers are appropriate to use. In the remainder of this section the statistics from both of these groups have been used, the latter is part of the Prefeasibility Study of Gulf of Riga and Daugava River (Carl Bro/IVL-group).

The agricultural land in Latvia comprises 2.570 millions hectares out of a total area of 6. 458 mill ha. Of the arable land 1.688 mill ha are within crop rotation while meadows and pasture comprise 15% and 35 %, respectively.

As in the other Baltic States the agriculture profile is clearly being animal husbandry and is the basis for about 70% of the agricultural economic output. This applies both to Sovkhozes and Kolkhozes. The plant cultivation is mainly aimed at fodder production. Of the arable land in crop rotation 42% is used for grain production of which barley comprise 20%. 6% of the area are used for potatoes and 43 % for perennial grass.

The total number of livestock animals is 2 millions animal units (AU). The livestock production is not solely concentrated to large scale farms. In the region there are 230 cattle farms with more than 400 animals per farm, 200 pig farms with more than 1000 pigs per farm and 14 poultry farms with more than 100 000 chickens have an estimated stock of about

100 000 AU out of 2 million AU. The average size of state and collective farms is 3-4000 ha. Small farms have an average size of approximately 20 ha.

No information on the total consumption of mineral fertilizers is available, but Bonde (1991) and Samuelson and Wittgren (1991) indicate an average application rate of 69 and 64 kgN/ha, and 20 and 21 kgP/ha per year respectively. Based on this it can be calculated that the total consumption of commercial fertilizer is about 177 000 tons of N and 51 000 tons of P per year.

Assuming that one animal unit gives 50 kg N and 10 kgP (which is fairly conservative) per year as manure, this corresponds to 100 000 tons of N and 20 000 tons of P. Evenly distributed over the arable land, this gives about 40 kgN and 8 kgP/ha per year.

Total fertilizing intensity is then calculated to 110 kg N/ha and 28 kgP/ha. This is a medium intensive level of fertilization, about the same level as in Norway, and a little higher than in Sweden. It is clearly more intensive than in both the Kaliningrad Region and in Estonia. Fig. 4.1 shows the intensity of the Latvian agriculture relative to the other prefeasibility areas in study.

The soil type in Latvia is mainly sandy loam (50%), the rest of the soil range from sand to clay. The landscape is flat which makes the fields little susceptible to erosion.

The precipitation in Latvia corresponds to a mean value of 750 mm per year.

3.2.7.2 Nutrient pollution load to local water bodies from agriculture in Latvia

The total nutrient load to local water bodies from agriculture in Latvia is given in Table 3.5.

Table 3.5 Estimated nutrient load from agriculture to local water recipients in Latvia.

Pollution categories	Nitrogen (tonnes N/year)	Phosphorus (tonnes P/year)
Average runoff from agricultural fields	59110	650
Extra loss from heavily manured fields	7500	200
Direct discharge of farm waste (slurry)	10000	2000
Leakage from manure storages	15000	2000
Leakage from fertilizer storage	1700	300
Silage effluent leakage	1500	200
Total nutrient load from agriculture	94810	5350

3.2.8 Lithuania

3.2.8.1 Agriculture profile

Agriculture in Lithuania is focused on livestock production as in the other Baltic states. Pork and poultry production are concentrated to large specialized units. In Lithuania there are several pig producing complexes producing more than 5000 tons of living weight annually. By former Soviet standards productivity, fodder conversion rates and sanitary levels are high.

The average size of the state and collective farms is 3-5000 ha. As in Latvia there are also a considerable number of what is called small farms, about 200 ha each.

An important part of the former Soviet food production is the private household plots. In Lithuania, in particular, 30-40 % of the milk and meat were produced in the private sector prior to the recent changes. A large part of all fruit, berries, potatoes and vegetables are produced on private plots. Income from selling these products on the Kolkhoz markets makes a significant contribution to the family economy.

The plant cultivation is mainly aimed at fodder production. Gras production (silage and hay) along with culture pastures make up a great part of the area. The predominant crops are grain, barley, rye, wheat, oats, and perennial grass. Other typical crops are potatoes, flax and sugar beats.

The total agricultural area of Lithuania amounts to 3 425 000 ha of which cereals occupy 903000 ha, meadows and pastures 2222 400 ha, potatoes 112500 ha, and fruit and vegetables 184900 ha.

The total consumption of mineral fertilizers is 398 700 tons of N and 115 000 tons of P. Evenly distributed on the agricultural fields this corresponds to an application intensity of 116 kgN/ha and 33 kgP/ha.

The total number of livestock is estimated to 2 450 000 Animal Units (AU). This produce an amount of manure which corresponds to a nutrient content of 122700 tons of N and 24540 tons of P. Evenly distributed over the entire agricultural area this gives a manuring rate of 36 kg N/ha and 7 kg P/ha.

The total fertilizing intensity will then add up to 152 kgN/ha and 40 kgP/ha.

This is a relative intensive fertilizer application rate also by Western Europe standards and by far the most intensive among the Baltic States. How it compares to the other Prefeasibilty Regions may be seen from Fig. 4.1.

The soil type are mostly sandy loams of high agricultural value, but also sandy soils and clay soils make up some part. The landscape is flat with low slope and thus little vulnerable to erosion.

3.2.8.2 Nutrient pollution load to local water bodies from agriculture in Lithuania

The total nutrient load from agriculture in Lithuania is given in Table 3.6.

Table 3.6 Estimated nutrient load from agriculture to local water recipients in Lithuania.

Pollution categories	Nitrogen (tonnes N/year)	Phosphorus (tonnes P/year)
Average runoff from agricultural fields	85600	1030
Extra loss from heavily manured fields	9200	250
Direct discharge of farm waste (slurry)	9800	1900
Leakage from manure storages	18000	2400
Leakage from fertilizer storage	3500	600
Silage effluent leakage	1800	240
Total nutrient load from agriculture	127900	6420

3.2.9 Vistula Catchment and Baltic Coast of Poland

3.2.9.1 Agriculture profile

In Poland most of the agricultural land is privately owned. In the Polish part of the Vistula catchment basin 88% of the farmland is on private hands while at the coast about 50 % of the farmland is private.

The private farms are very small, on average about 5 ha. Even the state farms are small compared to former Soviet conditions, mostly between 2-3000 ha. The total agricultural area in the Polish part of River Vistula catchment is 12 495 000 ha which is about 66% of the total agricultural area of Poland.

The total number of livestock animal units in Poland is about 14 millions AU. In the Vistula catchment the number is approximately 9.2 million AU. This gives an average livestock density of 0.74 AU per ha. How this compares to the other Prefeasibility Areas are shown in Fig. 4.1.

According to the statistics received from the consultants (SWECO, COWI, VKI) the consumption of mineral fertilizers in the Vistula catchment is given to 810 000 tons of N and 220 000 tons of P. Evenly distributed over the total agricultural area this gives an application rate of 65 kgN/ha and 18 kgP/ha. According to National statistics (Glowny urzad statystyczny, Warsawa 1990) the average consumption in 1990 was 85 kgN/ha and 22 kgP/ha. In the calculations an application rate of mineral fertilizer of 75 kgN/ha and 20 kgP/ha will be used.

Assuming a conservative manure production of 50 kg N and 10 kg P per AU per year, the total manure production in the catchment corresponds to 460 000 tons of N and 92 000 tons of P per year. Evenly distributed over the total agricultural area this gives a manure application rate of 37 kgN and 7.4 kg P per ha and year.

Total average fertilizing intensity is then 112 kgN/ha and 27 kgP/ha. This is a medium intensive agriculture, about the same fertilization level as in Norway. How intensive the fertilization in the Vistula catchment is compared to the other prefeasibility regions is shown in Fig. 4.1.

The soil type is sandy loams, but large parts with sandy soils occur. The precipitation in the area is about 600 mm per year, somewhat less than in the Baltic States. The landscape is flat and should as such be little vulnerable to erosion.

3.2.9.2 Nutrient pollution load to local water bodies from agriculture in Vistula Catchment and The Baltic Coast of Poland.

The total nutrient load to local water bodies from agriculture in the Polish part of Vistula Catchment and The Baltic Coast of Poland is given in Table 3.7.

Table 3.7 Estimated nutrient load from agriculture to local water recipients in the Polish part of Vistula Catchment and the Baltic Coast of Poland.

Pollution categories	Nitrogen (tonnes N/year)	Phosphorus (tonnes P/year)
Average runoff from agricultural fields	280000	2500
Extra loss from heavily manured fields	13000	360
Direct discharge of farm waste (slurry)	9200	1800
Leakage from manure storages	32000	3700
Leakage from fertilizer storage	3000	480
Silage effluent leakage	3400	460
Total nutrient load from agriculture	340600	9300

3.2.10 Oder/Odra River Basin

3.2.10.1 Agriculture profile

The Oder river basin covers an area of 119 000 Km2 of which 89 % is in Polen and 5.5% in Germany, and 5.5% in the Czech and Slovak Federal Republic.

The agricultural area within the Polish part is 6.43 million ha which corresponds to 61% of the total land area. Assuming 40% agriculture in the Czech part and 60% in the German part, this will give an additional agricultural area of 0.65 million ha. The total agricultural area of Oder river basin will then amount to 7.08 millions ha.

The total number of livestock animals in the polish part is estimated to 4.47 million AU on the basis of material collected by BCEOM, SAGE SERVICES and co-workers. This gives a livestock density of 0.7 AU per ha which is slightly less than in the Vistula river basin. If we assume a similar livestock density in the Czechoslovakian part, and 1 AU/ha in the German part which gives 182 000 and 390 000 AU respectively, the total number of livestock animals in Oder River Basin is approximately 5 million Animal Units.

Using conservative values of 50 kgN and 10 kgP production per Au per year, gives a total manure derived quantity of nutrients corresponding to 250 000 tons of N and 50 000 tons of P. If this amount is applied evenly distributed to the total agricultural area, it corresponds to a manure fertilization intensity of 35 kgN/ha and 7 kgP/ha. This is close to the values found in the Vistula Catchment.

According to National statistics (Glowny urzad statystyczny, Warsawa 1990) the average fertilizer consumption in 1989 was 85 kgN/ha and 22 kgP/ha. In the rest of the calculations an application rate of mineral fertilizer of 75 kgN/ha and 20 kgP/ha will be used. This gives a total consume of mineral fertilizer within the catchment area of 530 000 ton N and 142 000 ton P per year.

The total fertilization intensity (mineral + manure) is then estimated to 110 kg N/ha and 27 kg P/ha. How this compares to the other Prefeasibility regions is shown in Fig. 4.1.

The precipitation and area specific water runoff is somewhat greater in this catchment than in the Vistula Region. Runoff is approximately 200-250 mm whereas precipitation varies from 600 to 750 mm per year.

The soil type is sandy loams, suffering from poor drainage. The landscape is flat and should be little susceptible to erosion.

3.2.10.2 Nutrient pollution load to local water bodies from agriculture in Oder River Basin.

The total nutrient load to local water bodies from agriculture in the Oder River Basin is given in Table 3.8.

Table 3.8 Estimated nutrient load from agriculture to local water recipients in the Oder River Basin.

Pollution categories	Nitrogen (tonnes N/year)	Phosphorus (tonnes P/year)
Average runoff from agricultural fields	162000	1540
Extra loss from heavily manured fields	7500	200
Direct discharge of farm waste (slurry)	5000	1000
Leakage from manure storages	17000	2000
Leakage from fertilizer storage	1900	300
Silage effluent leakage	1800	250
Total nutrient load from agriculture	195200	5290

3.3 Nutrient Load from Agricultural Areas reaching the Baltic Sea

3.3.1 The problem of estimation of retention

In the previous sections the nutrient pollution load from agriculture activities to the primary recipient has been calculated. This is normally not the Baltic Sea, but in most cases a channel, a brook or a stream leading to a large river or a lake. On the way towards the coast the nutrients enter into a series of biological, geochemical and physical reactions, which result in significant reductions in the amount of the nutrients that reach the Baltic Sea. The nutrients are either lost to the sediments or to the atmosphere. This loss is called retention.

Both phosphorus and nitrogen are assimilated by river and lake biota. When these organisms die in the autumn, parts of this nutrient uptake is burried in lakes and rivers sediments and retained from reaching the Baltic. This sedimentation applies particularly to phosphorus, but also to nitrogen in a less extent. This retention is mostly a function of water residence time in the actual water body. For example a lake with 10 years water residence time will retain approximately 70% of all the incoming phosphorus.

To be able to calculate the sedimentation loss in a correct and scientific way detailed knowledge about the hydrology and bathyograpy of the water bodies constituting the watercourse is needed.

In addition to sedimentation loss, nitrogen will be lost to the atmosphere as nitrogen gas via the process of denitrification. This process takes place in poorly oxygenated soils and waters if organic matter is available. Heavily polluted (eutrophication) brooks, channels, streames, lakes, rivers and wetlands are the most efficient nitrogen removing water bodies.

For example in the heavily polluted Vistula River, the consultant (SWECO/COWI group) found from river transport studies that as much as 70% of the nitrogen input in the Crakow Region was lost before the river enters the Baltic. The Odra Group (BCEOM and co-workers) indicates a similar loss in Odra.

These large rivers must be regarded as secondary recipients. An even more efficient nitrogen removal may take place within the primary recipients (channels, brooks, streams, lakes, wetlands). The Baltic Sea must be regarded as a tertiary recipients, or perhaps as quaternary as retention also takes place in the sheltered gulfs which are characteristic of several river inlets to the Baltic Sea.

Nutrient retention calculations are kind of inverse compound interest calculation, starting from the top of the watershed and going through the different recipient types all the way down to the Sea. The data needed to perform such calculations of the above mentioned nutrient transport loss are not available. For the denitrification loss the scientific basis in forms of good mathematical models also is lacking.

At this stage the retention of nutrients from the first entrance into surface waters until it reaches the Baltic can only be approximated by qualified assumptions. It is reasonable to assume that there will be a 60% loss in the primary and 50% in the secondary recipients, giving an overall retention of 80% for nitrogen.

For phosphorus a 40% retention in both primary and secondary recipients can be used, giving an overall retention of 65% for phosphorus.

3.3.2 Nutrient load to the Baltic Sea arising from agricultural runoff

Using the retention given above for primary and secondary recipients the load of nutrients to the Baltic Sea arising from agricultural runoff is estimated in Table 3.9. The data that are available from The North German Coast are official statistics from the counties of Schwerin, Neu Brandenburg and Schleswig-Holstein of which considerable parts drains to the North Sea and/or are included in the catchment of Oder. It has therefore not been possible to carry out loading estimates for these areas.

Table 3.9 Estimated nutrient loading to the Baltic Sea arising from agriculture runoff in the Prefeasibility Regions.

Prefeasibility Region	Nitrogen (tonnes N/year)	Phosphorus (tonnes P/year)
St. Petersburg Region	5260	680
Estonia	8560	810
Latvia	18960	1870
Lithuania	25580	2250
The Kaliningrad Region	5670	780
The Vistula River Basin	68120	3260
The Oder River Basin	39040	1850
The North German Coast		
Total from agriculture	171190	11500

3.3.3 Ammonia deposition direct onto the Baltic Sea surface

The loading from nitrogen deposition is a matter included in the NILU prefeasibility study: The Topical Area Study for Atmospheric Deposition of Pollutants (Pacyna 1992). As the ammonia part of it is strongly related to agricultural pollution, we give a brief treatment of the problem also in our report. It should be noted that deposition onto land and inland waters is included in the runoff estimates.

Nitrogen deposition directly onto the Baltic Sea via atmospheric wet and dry fall-out constitutes a significant part of the total nitrogen pollution budget. According to EMEP (cited in the NILU report on atmospheric deposition) the total nitrogen deposition in 1985 was 290 000 tons of N per year. Larsson et al (1985) refers to different calculations ranging from 228,000 to about 400,000 tons N per year with an average of 322 000 tons N per year. The atmospheric fall-out comprised about 26% of their total estimate of nitrogen load (1,200,000 tons N) to the Baltic Sea.

According to EMEP (Iversen et al 1991) about 50% of this deposition are as NOx and the other half as NHx. EMEP addresses the deposition to the Baltic surface to the source countries. Of these source countries, Poland is the only country that almost totally lies within the Baltic Sea catchment area. As the NHx is almost exclusively derived from ammonia volatilization from animal husbandry (Bonde 1991), an indirect method to estimate the contribution from the different prefeasibility areas is to take the Polish contribution as a basis and address their relative shares according to the livestock numbers within the different areas.

The NHx deposition arising from Poland in 1985 was estimated by EMEP to 16,300 tons N per year. The deposition has shown a decreasing trend and in 1990 it was estimated to 11,000 tons. The total number of livestock animals in Poland was in the same period approximately 14 mill. AU. Based on the 1985 data this gives a contribution per AU of 1.16 kg N per AU, while based on the 1990 data it gives 0.75 kg N deposited onto the Baltic surface each year.

Taking this as a basis the following Table 3.10 can be constructed:

Table 3.10 Tentative estimate of the ammonia deposition onto the Baltic Sea surface arising from agricultural sources within the different prefeasibility areas. The estimate is based on the per AU yield calculated from Polish agriculture. (most likely an underestimate, see also Table 4.11.)

Prefeasibility region	Ammonia deposition (tons N per year)	
	Based on 1985 data	Based on 1990 data
St. Petersburg Region	707	458
Estonia	783	506
Latvia	2320	1500
Lithuania	2846	1840
The Kaliningrad Region	485	314
Vistula River Basin	10670	6900
Oder River Basin	5800	3750
Former DDR	1377	890
Schleswig-Holstein	1730	1118
Total N-load from ammonia deposition	26718	17276

This Table is clearly <u>an underestimate</u> which can be seen from the following:

According to Larsson et al (1985) the total ammonia deposition onto the Baltic Sea surface is about 160,000 tons N per year. EMEP (Pacyna 1992) gives ammonia deposition within the range of 107-150,000 tons N per year. If we try to divide these contributions on an area basis on the different contributor country and tentatively addresses the shares to the respective prefeasibilty areas, the following Table 3.11 can be constructed:

Table 3.11 Total annual ammonia deposition onto the Baltic Sea surface arising from the prefeasibilty region, tentatively after the table 1 in NILU synthesis report (Pacyna 1992).

Contributor (Prefeasibility region)	Ammonia deposition (tons per year) Based on 1985 data
St. Petersburg Region, Estonia, Latvia, Lithuania, Kaliningrad Region	20000
Vistula River Basin and Oder River Basin	16500
Schwerin and Neu Brandenburg (DDR)	4500
Schleswig-Holstein	3000
Total N-load from ammonia deposition	44000

The reason for the underestimate in Table 4.10 is that the calculation is based on the unit contribution per AU estimated from Poland. Here there is a domination of small animal farms with dry manure handling and storing and spreading techniques which give little ammonia volatilization as compared to the large scale animal husbandry with liquid manure storing and spreading techniques. This latter techniques are more widespread within the other prefeasibility areas.

If we exclude the areas within the North German Coast where we have not yet been able to perform a good runoff estimate (lack of data), the ammonia deposition from the other Prefeasibility areas is approximately 36,500 tons N per year directly onto the Baltic Sea surface.

Adding ammonia deposition to the total nitrogen load form runoff, Table 4.9, (171190 tons N) gives a total from agriculture of 208,000 tons N per year.

4 EFFECTS OF AGRICULTURAL POLLUTION ON THE LOCAL ENVIRONMENT AND ON THE BALTIC SEA

4.1 Pollution effects on Baltic environment

According to (Larsson et al 1985) the load of to the Baltic Sea has increased about 4x for total nitrogen and nearly 8x for total phosphorus due to mans activity over the last 100 years. Their present loading estimates, which they claim to be very conservative, amount to 77,000 tons P/year and 1,200,000 tons N/year. Putting these loading values into the well established and generally accepted eutrohpication model of Wollenweider (1976), the Baltic Sea being situated in the border area between critical and questionable conditions, while for 100 years ago it was placed well inside the oligotrophic and unpolluted region of the model.

Discharges of phosphorus and nitrogen from agriculture to the Baltic Sea contribute significantly to the overall nutrient load of the Baltic Sea. The nutrient discharges from agriculture include ammonia volatilization, nitrogen leaching, phosphorus leaching and erosion, and discharges of farm waste such as effluents from animal houses, manure storages, and silage heaps.

With respect to nitrogen about 50% of the present supply is derived from atmospheric deposition (40%) and fixation (10%). The atmospheric deposition is made up of dry and wet deposition of about equal amounts of ammonia and nitrate. The ammonia is almost exclusively derived from animal husbandry, indicating that as much as 20% of the total N-load is caused by ammonia volatilization from agriculture.

The agriculture share of the diffuse land based sources varies from about 65% in Denmark to 20-30% in Sweden, suggesting that about 15% of the total load stems from agriculture. The atmospheric and land based contribution from agriculture thus totals up to about 30-35% of the nitrogen load to the Baltic sea. The P load is dominated by land-based sources of which approximately 10% originate from agriculture, according to the report given by Torben A. Bonde (1991) "Analysis of the national reports concerning agriculture".

Applying the percentage of agriculture contribution indicated by Bonde (1991) on the loading numbers from Larsson (op.cit) it appears that the agriculture contribute with approximately 8000 tons of phosphorus and 400 000 tons of nitrogen per year to the pollution of the Baltic Sea. This number is of course very uncertain. Larsson et al (1985) claim that their loading estimate most likely is an underestimate.

The loading numbers from agriculture (runoff + deposition) from this study is 208000 tonnes of N and 11000 tonnes of P from the areas bordering the Eastern and Southern Baltic Coast (Karelia to the Danish Coast). Both methods of estimation must be regarded as uncertain, but they are within the same magnitude.

The use of commercial fertilizer has increased in all the states bordering the Baltic Sea, the curves given for Poland in chapter 2.1.2 is typical for the development. The increase was most dramatic from 1950 until the middle of 1980s, whereafter the consumption levelled off. According to the large fertilizer producer Norsk Hydro, there has been a dramatic reduction in the use of commercial fertilizer in Poland, Former DDR, and the Baltic States the last two years due to rice in prices. No official statistics have been available for these two years.

The input of plant nutrient results in an increased algal growth in the Baltic Sea. To a large extent the algaes sink when they die. Their decomposition consumes oxygen, and the deep waters and sediments are in large areas of the Baltic more or less depleted for oxygen. Several species of bottom dwelling animals die off which again results in less food for the fish and a reduced fishery output. The algal biomass in the surface layers increase the turbidity of the water and gives it an unpleasant look. Along the shoreline the algal growth results in slimy and hairy coatings on stones and other substrates making the beaches little attractive for bathing and recreational use. Blooms of toxic blue-green algaes are also observed.

Another problem confined with severe eutrophication is that the species composition of the phytoplankton changes in a way that very often results in a reduced edibility for the next step in the food web, the zooplankton. A moderate eutrophication can be desirable as it increases the productivity on all steps in the food web, and thus ends up in more fish. A half way inland sea, such as the Baltic Sea, are especially susceptible for damage by eutrophication. The reason why is that most of the freshwaters from the river inputs which form a light brackish layer on top of the normal marine bottom water. This mechanism cuts off the deep waters from oxygen renewal and sulphate reduction will take place in the deep layers causing the toxic gas hydrogen sulphide.

In addition an unknown quantity of pesticides finds its way to the Baltic Sea. Some of these are recalcitrant organic compounds of which the organochlorines are most serious. In the Baltic Sea such compounds are found both in sediments and in biota in critical amounts. Many of the organochlorines are however of industrial origin, as e.g. the PCBs, but pesticides like DDT, DDE, HCH and others are present.

4.2 Effects of agricultural pollution on the local environment

The large amounts of manure produced at the huge state-owned animal farms is not applied in an environmentally sound way. It is often stored in large lagoons, or in many cases discharged directly into the watershed.

In the local environment the discharge of phosphorus and nitrogen has the same eutrophying effect with respect to stimulating algal growth as in the Baltic proper. In the local water bodies the point sources have more dramatic effect than the diffuse runoff. With regard to agriculture, this applies most severely to the manure handling and storage on the large cattle farms and piggeries. Direct effects, like for example fish kills, resulting from discharge of organic oxygen consuming compounds like manure and silage effluents are common.

Manure leakage contains high levels of ammonium. This is converted to free ammonia when it leaks into waters with high pH, as is always confined with eutrophic freshwaters in summertime. Free ammonia is highly toxic to fish and is most likely responsible for several episodes of fish kills.

The storage of manure and the application on a to small area because of transportation costs. results not only in leakage to surface waters, but also to ground waters increasing the nitrate content to above acceptable levels for drinking water. The ammonium oxidation as well as nitrate leaching results in acidification both of the soil and the ground waters. This process mobilizes aluminium into the ground water which also reduces its suitability for potable consume.

With regard to pesticide pollution direct acute toxic effect is much more likely to appear in local water bodies than in the Baltic Sea. In the last years it has been shown almost in every country in Western Europe that small amounts of pesticides enter both ground waters and surface waters. Typical concentrations are in the range 0.1 to 20 pp. It is also shown in bioassays, both lab-scale and model ecosystem scale, that several of these compounds impose stress on the ecosystems. The most pronounced effect seen is changes in community species diversity. The overall ecosystem consequences of such effects are not known.

The pesticides are often very selective in their action, i.e. they are aimed at hitting the target organisms, but not the one they are going to protect. As the same categories of organisms normally are present in lakes and rivers as in the agricultural fields, specific reactions also appear in waters. However, what happens to water organisms on a lower level than fish are normally not observed. A compound such as endosulphane which is acute toxic to fish has received considerable attention all over the world, while another commonly used compound like propikonazole that is even more toxic to the micro algae species Clamydomonas is not of concern for others than experts in toxicology.

Several compounds are also found in ground waters, and having first entered this compartment of the hydrological cycle, the recidence time is long as very little breakdown takes place. There are examples of triazine (attrazine simazine) polluted aquipheres that has kept the same concentration for more than 10 years after application of these compounds has ceased.

The use of pesticides started mainly after World War II. In most modern countries more than 150 compounds are now currently used in agriculture. It is like what they call "A catch 22 game": We are aware of that we are imposing severe pollution to the environment which in many instances also may be dangerous to man in the future, but we do not dare to think about an agriculture without the use of pesticides.

5 EVALUATION OF PROPOSED ACTIONS

5.1 Introduction

When judging appropriate abatement measures focus should be put on the actual problems encountered and the mechanisms and processes behind these. This is a prerequisite for evaluation of cost-effective abatement measures.

The proposed abatement measures should be adjusted to the local farming and cropping system. In addition the basic conditions as climate and soil characteristics have to be taken into account. This is also important in general political decision making regarding the future status of agriculture and what means the authorities can use to ensure the implementation of proposed measures.

5.2 Brief Description of Different Measures

5.2.1 Milk producing farms

The pollution problems are mainly related to storage and application of manure.

Reducing the pollution caused by inadequate or poor standard of the manure storage facilities will be an important and effective way to reduce problems with eutrophication (nutrients) and organic matter in receiving waters. The potential of ammonia losses by volatilization from stored and applied manure, which cause a less effective manure for plant growth, is important to consider. The overall efficiency in agriculture will be increased and at the same time the need for application of commercial fertilizers will be reduced if more effort was put into preserving the N content in manure.

If large amounts of manure are applied on a relatively small area, there is a considerable risk of reaching a level close to P saturation in the soils. If such a level is reached, it will take a very long time to re-establish the natural potential for P retention in the soils. The consequence will be high P concentration in the drainage (runoff) water.

The agricultural pollution problems are severe in most East European countries mainly due to poor management practices. As such the potential effects of abatement measures are expected to be considerable in these countries and less in the Western European countries. In the Baltic Republics (Estonia, Latvia and Lithuania and parts of Russia) a huge potential of reducing agricultural pollution through measures aimed at changing farming practices exists.

However, there is a strong correlation between the agricultural structure and the pollution problems in the described farming systems. This fact should be strongly emphasized when strategies and possible implementation/goals of measures are discussed.

Abatement measures which should be considered:

1. Increase the utilization of manure nutrients (especially N) for plant growth.
   - Reduce out-door storage of manure (i.e. in ponds and lagoons) in order to reduce losses through ammonia volatilization and through direct runoff.
   - Improve the technical standard of in-door storage facilities and thereby reduce direct nutrient leakage.
   - Increase the in-door storage capacity to avoid application of manure in the non-growing season.
   - Avoid application of manure in the non-growing season.
   - Injection rather than surface application of manure
   - Restrict application of manure on bare soil in the autumn.
   - Restrict application of manure on frozen soil.

2. The number of animal units on each farm should be adjusted to a level which not exceed the total requirements of P for the crops grown on the farm.

3. Adjust the use of commercial fertilizers and the application of manure to the real plant nutrient requirements by using chemical soil analyzes.

4. Active use of the agricultural landscape in order to maintain water an soil conservations:

   - Increase the drainage intensity on arable land with high yield potential and with soils which are not natural drained in order to increase the yields and thereby the total efficiency in agriculture. (If not appropriate recommendations for fertilizer use are available the N-runoff might, however, increase in a short time perspective).

   - Avoid drainage of wetland or destruction or riparian vegetation along watercourses. Zones with natural vegetation between the arable land and the receiving waters should be established in order to increase the nutrient retention.

   - Establish meadows and/or pastures on land susceptible to erosion.

   - In a crop rotation system autumn plowing of meadow/pasture should be avoided in order to minimize mineralisation of N during the non-growing season.

5.2.2 Meat production in poultries and piggeries

The environmental problems and most of the abatement measures will be similar to those described above. An important difference between these two agricultural production systems is that the former one includes meadow and pasture as land use. Land use under this farming system is expected to be mainly grain production as monocultures. However, the problems connected to manure will be similar in both systems.

In this farming system the agricultural practice concerning tillage and crop-rotation will have a substantial impact of the nutrient runoff. The balance between the plants actual nutrient requirements and the total application of manure and commercial fertilizers, plays a key role in evaluation of the efficiency of the production.

Basic conditions as climate, soil and topographical properties are of great importance for the total nutrient discharge and expected effects of different measures concerning land use and agricultural practice.

Measures which should be regarded:

1. The same measures as mentioned under "diary farms".

2. In addition:
   - Reduced tillage if climate, soil and topography indicate high risk of soil erosion.
   - Use of catch crops to ensure nutrient uptake after harvesting of the main crop.

5.2.3 Farms with only plant production

Most of the problems are related to land use and agricultural practices and how these factors are adjusted to the basic natural conditions in the area. The variation in nutrient runoff is expected to be large within the study area due to differences in climate, soil properties, land use and in general agricultural practices. Measures should take all these factors into account.

A main problem in grain production is that the soil is left bare, without plant cover, and without any nutrient uptake during a long period of the year. The soil temperature will still be sufficient for mineralisation of N and at the same time the precipitation is rather high. This situation causes a substantial risk for nitrate losses to both surface water and ground water. Growing of vegetables, potatoes etc. will normally leave a great deal of residuals on the surface with high risk of nutrient leaching. Sandy soils are often assumed to be suitable for such crops. These crops require considerable application of nutrients if high yields are to be obtained, some of them also have a rather short growing season. This system of production is therefore highly sensitive to nutrient leaching if not adequate measures are implemented.

Soil erosion might also be a problem in parts of the study area. This will depend on the climatic conditions during the non-growing season, soil and topographical properties. All kinds of measures which aim to protect the soil surface against the eroding forces (rain, water-discharge etc.), are of interest.

The following measures should be considered:

- Adjust the use of fertilizers to the actual requirements for plant production. Develop advisory service systems.
- Use catch crops on fields with annual crops with short growing season.
- Avoid leaving too much fresh (green) plant residues on the soil surface.
- Establish conservation practices on erodible land, reduce tillage, avoid autumn plowing.
- Establish strips of vegetation between cultivated land and the watercourses.

5.3 Proposed interventions and alternatives

Considerable changes in the structure, ownership, farm size and farm running practices are likely to occur in the former USSR and Baltic States in the near future. This expected development will come as a result of the political changes, and thus be relatively independent of the Baltic Sea Environmental Programme. Formerly this huge country had a centrally planned and very specialized agriculture. Some areas, for example Ukraina was producing cereals for bread, whereas the agriculture in the Baltic states and the St. Petersburg Region mainly dealt with animal husbandry for meat and diary production. The supply to the different regions was secured through a well regulated distribution and transportation system. As the country now is being divided into smaller more or less independent (self ruled) republics, where distribution and trade are steered by market mechanisms as prices, supply and demand, etc. it is quite clear that a more diverse agriculture has to be developed to ensure a varied food supply.

This likely development has to be taken into account when proposing actions in this prefeasibility analysis. The agriculture in this area will most likely be more productive in the future. It is not very likely that the use of for example commercial fertilizer will be reduced when there is a need for more food, recognizing that the fertilizer consumption in Western Europe is much greater. In fact the consume of mineral fertilizer is likely to increase rather than to decrease if no regulation is put forward. It will perhaps decrease temporally until the new situation is stabilized due to higher prices as the state subsidizes are taken away.

It is also quite clear that tile drainage of agricultural fields will increase rapidly in the years to come. This will increase the nitrogen runoff, and to some extent also the phosphorus and pesticide runoff.

On the other side, if the large state owned farms will be split-up into smaller farms, it should be possible to change the animal husbandry into an environmental sound activity.

The HELCOM RECOMMENDATIONS seem to be a reasonably and logically correct set of recommendations to achieve an ecologically sound agriculture. But they are no more than ideal statements as long as no fixed regulating numbers are connected to them.

At this stage of the prefeasibility analysis information about the different prefeasibility catchments are insufficient to propose very specific action plans. It is, however, quite clear that the largest environmental improvements will be reached through measures within the animal husbandry branch of agriculture. In the following paragraphs the most promising measures will be described and evaluated.

5.4 Accompanying Measures

5.4.1 Institutional and human resource requirements

Pollution control in agriculture is based mainly on advisory measures and guide-lines. Increased efforts in advising farmers on best management practices are necessary in all study areas. Free cultivation and fertilizer advice should be offered to all farmers. There is also a need to give advice on tillage and use of green fields.

In most countries there is also a need for improving the soil analysis system. Soil analysis can be used to determine the actual need for fertilizers and which type of fertilizers should be applied. Soil analysis laboratories with sufficient equipment have to be set up.

Agricultural advisers should run campaigns informing farmers on fallowing and the use of manure. Agricultural advisers should be trained at universities and farmers should be trained at agricultural vocational.

Human resources development should be an integral part of the proposed action programme for reducing pollution from agriculture. It is considered essential to ensure the participation of all farmers in such a programme. In some of these formerly centralized decision making countries such participation can be difficult to obtain if the programmes are run by the central government.

5.4.2 Environmental Legislation and Standards

Effective environmental legislation and policy addressing pollution from non-point agricultural sources have not been enacted in most countries. Legislation concerning point sources have been enacted in some countries.

Pollution control in agriculture is based mainly on advisory measures and guide-lines, but several countries are working towards providing juridical means for approaching it. However, the revision of the legal basis is considered a difficult and time-consuming task in most countries.

Based on the information available it can be concluded that pollution control in agriculture in most of the study areas is not governed by sufficient environmental legislation. Such legislation should be developed in all countries.

The Water Law in Poland does not take into account the protection of waters against non-point pollution from agriculture. It does, however, provide for creating protective zone for surface waters and intakes.

There is a need for strengthening the legislation covering pollution from agriculture in all study areas. Such regulations should cover, inter alia;

- Spreading of manure or chemical fertilizer.
  - Restrict maximum application of manure and chemical fertilizers.
  - Prohibit application of manure on frozen fields or fields covered with snow.
  - Ploughing in of manure spread on bare soils.
  - Spreading of manure without ploughing should be limited to the growing season.
  - Identify sensitive areas where spreading of manure should be limited.
  - Offer farmers individual plans for use of manure and fertilizer.

- Measures with respect to "farm management".
  - Implement requirements to the capacity of manure storages.

- Silage facilities.
- Implement technical standards of agricultural land that have been levelled.
- Regulations to ensure an increase in "green fields" and plant cover during winter.

  Such regulations are likely to include reduced tillage, use of catch crops, alternative plants on grain areas in sensitive areas and protective vegetation belts
  along rivers and streams.

- Livestock density.
  - Impose restrictions on livestock numbers for farms, i.e. AU (animal units) per ha.

5.4.3 Factors influencing the future development of agriculture

This chapter outlines some factors that will influence the future development of agriculture in the Baltic Sea region. Main emphasis is on agricultural policy and related factors.

The future development of the agricultural sector in Eastern Europe is strongly linked to the overall economic policy in the region. As such it is difficult to predict what will happen. However, in the following sections some factors that might influence the future development are addressed.

5.4.3.1 Agricultural policy

The agriculture in most countries is under continuous development. The concept of sustainable development of agriculture implies:

meeting the basic nutritional requirements of present and future generations;
providing durable employment, sufficient incomes and decent working and living condition in the rural areas;

maintaining productive capacity of the natural resource base, while protecting the environment; and

reducing the vulnerability of the agricultural sector to adverse natural and socioeconomic factors.

Sustainable agriculture minimizes soil loss and maintains productivity through use of organic and inorganic inputs in balance with outputs. It takes into account land capability as a fundamental factors in any agricultural investment decisions. It recognizes that agricultural diversification is a key to the functioning of balanced upland farming systems and that external factors, such as road construction to improve market access may be critical in implementing diversification.

Soil conservation and cultivation practices intended to maintain productivity also minimize environmental damage from loss of vegetative cover, increased runoff, soil erosion and siltation. Judicious use of chemicals, both fertilizers and pesticides, is expedient for economic reasons and will either minimize or prevent eutrophication, contamination, nitrate accumulation, and evolution of pesticide resistance in non-target species which can result from excessive or indiscriminating applications. Following guide-lines for application rates is usually adequate to protect the environment, except where the substance is used inappropriate for toxicological or biological reasons. Recycling of manure and other wastes is common practice and is environmentally protective.

The key strategic principles for holistic and integrated environmentally sound management of water resources in the agricultural context are:

(a) Water should be regarded as a finite resource that has an economic value with significant social implications;

(b) Local communities must participate in all phases of water management;

(c) Water resource management must be developed within a comprehensive set of policies for human health; food production, preservation and distribution; disaster mitigation plans; environmental protection and conservation of the natural resource base;

(d) The need to recognize and actively support the role of farmers, given their role in feeding the globe and protecting its environment.

Water development and management in the agricultural sector will have to be considered in an integrated manner. This integrated approach has to consider sustainable development programmes, including institutional and human resources development, protection of the environment and preservation of feed and food supplies.

The future development of the agricultural sector in the Baltic Sea catchment areas should be based on the idea of sustainable development, which implies that the natural resource base has to be utilized in a way which does not disrupt the ecological balance. Due to intensive agricultural practices the ecological balance in agricultural areas is already disrupted. There is a general trend towards intensification of the agricultural sector in most countries. If the same policy is adopted in the Eastern European countries without taking environmental considerations into account, the environmental impacts of agriculture are likely to increase, i.e. the pollution load from agriculture to the Baltic Sea.

5.4.3.2 Legal and institutional arrangements

The adoption of more efficient water use, protection of water quality from pollution by agricultural chemicals and other contaminating materials, and establishment of clearly defined property rights and obligations require the introduction of appropriate legal instruments at local and national levels. Given the need to address multi-sectoral problems related to water use at the rural level, inter-institutional problems related water use at the rural level, inter-institutional linkages will need to be established. Strengthening the capacity of institutions to administer the legal, economic and monitoring functions is essential.

5.4.3.3 Efficient and Rational Allocation of Water: Quality and Quantity

The combination of increasing demands on finite freshwater resources make them ever scarcer. It calls for a more efficient use of resources, specially in the agricultural sector, and a rational allocation between the various demand sectors. The main strategies should ensure that water users realize the scarcity value of the resource and incentives to promote this must be established. Measures would include demand management in the form of charging systems for efficient and just use of water; cost recovery policies to provide secure sustained efficient operations and maintenance of water supply systems; education and public information programmes; and legal entitlements for access to water resources. Such measures will have to be introduced with due consideration of the cultural, social and ecological values of water. Simultaneously priority should be given to meeting the basic needs of the poor, including drinking water and small scale agriculture. Prerequisites to resolving the competing demands are: comprehensive resource inventory and evaluation of existing land and water needs; the promotion of water storage and saving devices; and sound water use at watershed and village levels.

The quality of freshwater is declining in many parts of the world due to human induced land degradation, salinization, and pollution with chemical compounds and elements. The main strategy to combat this is arresting this problem at its sources, through incentives and regulations for environmentally sound soil and water conservation measures. Close monitoring of all waste disposals and contaminations is required as well as application of appropriate legal and administrative controls and the establishment of requirements for polluters to cover the cost of recovery of the water quality. To prevent losses in quantity and quality of agricultural produce, and protect human health, water quality standards for agricultural, drinking and sanitation uses should be set and appropriate mechanisms put in place for its effective implementation.

5.4.3.4 Capacity building

There is an urgent need for the Baltic Sea nations to build their own long-term capacities for integrated management of agricultural resources that support their communities. The major strategy consists of the creation of policy and legal frameworks, the development and strengthening of institutions, the dissemination of hydrological and other data bases, the promotion of community participation and the training of human resources, all on a continuing basis.

The actions at local, provincial, national and international levels will require an institutional framework, mechanism for coordination within a country and between countries and donor and financing agencies.

There is a need to strengthen national capacities to plan, implement, and monitor integrated water management programmes. The major strategy is to create policy and legal frameworks on a participatory basis, as well as develop and strengthen institutions at all levels. This should be accomplished with emphasis on community participation and human resource development taking into consideration the full involvement of all farmers.

5.4.3.5 Factors influencing the future development of agriculture

The future development of the agricultural sector depends on several factors:

Economic development in the region
Land ownership strategy; land reforms
International market for agricultural products; prices
National price control; subsidizes
Pricing of fertilizers
Level of self-sufficiency
Development of infrastructure

These factors could have significant impact on the future agricultural development. Depending on the general development policy, the environmental impacts can be positive or negative. However, if the agriculture in the former Eastern bloc countries reaches the same level of intensity as the agriculture in Western Europe, the environmental impacts are very likely to increase. Investigations show that the runoff of nutrients and organic matter is higher in Western Europe than in Eastern Europe. A new sound strategy should be developed. This strategy should be based on the principles of sustainable development and the development should be based on a balance between environmental effects and agricultural output.

5.4.3.5.1 Economic development

The general economic development will influence the demand for agricultural products and the ability to pay. The present low income level in Russia is so low that people are substituting some products with others. This affects the demand to a great extent. This substitution effect will require changes in the agricultural production over time. However, there is reason to expect that this change will take some time.

5.4.3.5.2 Land reforms

In most former East-European countries the governments formed collective farms and all land was nationalized, i.e. private ownership was prohibited (Poland is to a certain degree an exception). In Estonia as an example there were 130,000 farms before the nationalization of the land. In several of these newly independent countries there is a move towards giving back the land to the original landowners or their families. This will result in division of most of the large sized farms in the region. This will provide an opportunity to achieve more environmentally sound farming structures. However, this division also may reduce the economic viability of the farms due to the size of the farms.

5.4.3.5.3 International markets

For several agricultural products there are a market surplus. The production of several products in Western Europe, Canada and the USA is higher than the world market demand. One possibility to reduce the shortage of agricultural products is to buy products from the West. However, this requires hard currency, which most of these countries lack. The world market prices will influence the future development of the agricultural sector and as such the economic viability of the farms.

5.4.3.5.4 National price control: subsidies

Government policies are often aimed at keeping consumer prices for agricultural products low. Then to compensate the producers, governments offer subsidies allowing producers to purchase inputs below their real value, provide free services or offer subsidized credits. This creates an artificially bolstered system which may lead to inefficiencies, inequities (favouring the large over the small producers), investment distortions, and the degradation of resources through inappropriate land use. It also tends to favour capital intensive operations.

Most countries subsidize the agriculture sector. The level of subsidizes varies from country to country. As part of the GATT negotiations (Uruguay round) there is a proposal to reduce the level of subsidies. The negotiations have not been completed yet but there is reason to believe that the negotiations will call for substantial reduction in subsidizes.

The level of subsidizes depends on price control mechanisms and the ability to produce the needed products at a reasonable cost. Agriculture in the Eastern European countries as well as in Western Europe is heavily subsidized. Due to the economical problems facing these countries the level of subsidizes is likely to be reduced. This will increase the prices of locally produced agricultural products and as such affect the demand. This will in turn call for changes in the overall agricultural policy.

In most countries the prices of agricultural products are set by the Governments. Privatisation and reduced level of subsidizes will most likely lead to increased prices. Increased prices will generally result in increased supply of products subject to willingness to pay for the products in the market.

The move towards free and unregulated markets already has resulted in outrageous price increases in most countries. The free market concept has increased the availability of products but the prices are higher than people can afford.

5.4.3.5.5 Pricing of fertilizers

In most countries fertilizers are subsidized. Due to the environmental impacts of excess use of fertilizers some countries have taxed the use of fertilizers. This tax is expected to increase in most countries.

Most farms in the former East-European countries have been allocated a certain quota of fertilizers. This quota is based on the agricultural production and availability of fertilizers and not necessarily on the agricultural need for fertilizers. Improved and more efficient use of manure and fertilizers will reduce the pollution caused by excessive use of fertilizers.

In most countries fertilizers have been relatively cheap on state- and collective farms. Due to price increase in for instances Poland, the use of fertilizers has dropped the last few years. The price of fertilizers should reflect the environmental impacts of the use of fertilizers.

The consumption of fertilizers has leveled of in most countries due to price increase. There is a need for more efficient use of manure as fertilizer. This can partly be achieved by increasing the prices of mineral fertilizers.

5.4.3.5.6 Level of self-sufficiency

Most countries adopt a policy of achieving self-sufficiency of agricultural products. Few countries have actually achieved full self-sufficiency for all products. However, the objective is to be able to provide food to the local population in case of emergency. The target level of self-sufficiency has implications on the overall agricultural policy. As the world market for agricultural products is getting more and more open the need for a high level of self-sufficiency has been reduced. Each government set the target objective and as such the agricultural policy has to be consistent with this objective.

Several of the Eastern European Baltic Sea states need to import agricultural products from other countries. This indicates that inadequacies in the production system already has caused low levels of self-sufficiency. To what extent the Governments will adopt a policy which will focus on increased level of self-sufficiency is difficult to predict. The tendency is, however, to increase domestic production and at the same time import needed products from abroad. This requires hard currency and it is therefore likely that the Governments will increase domestic production to reduce the dependency on world market prices and as a consequence less need for hard currency.

5.4.3.5.7 Development of infrastructure

One of the most severe problems currently is the ability to transport the agricultural products effectively from the producers to the consumers. Currently the loss due to lack of storage facilities and transport is expected to be as high as 30% for some agricultural products. In addition agriculture is specialized, i.e. some regions produce grain while others produce vegetables etc. This cause a considerable need for effective means of transportation. Lack of reliable trucks and trains and a poorly developed system of roads and railways aggravates the problems. Improving infrastructure while changing the production structure, i.e more diverse production, is needed to reduce the loss. Development of infrastructure is costly and will necessarily take a long time.

6 PROPOSED ENVIRONMENTAL PRIORITY ACTION PROGRAMME

6.1 Introduction

This chapter concentrates on outlining the most appropriate measures that should be implemented to reduce the water pollution caused by agriculture.

The prerequisites are:

1) Food production is necessary to maintain in the regions and should not be reduced by the actions.

2) The HELCOM recommendations should be fulfilled as far as possible.

6.2 Average runoff from agricultural fields

As described in earlier sections in this chapter there are several measures that can be implemented to reduce the average nutrient leakage from agricultural fields. However, the effects of these will be marginal (except for some extensivation i Germany).

Newer research results (e.g Ruge 1991) clearly demonstrate that the use of catch crops on fields where annual crops are grown can reduce the nitrogen leakage by 25%. The effect will be even greater on over-fertilized fields. This should be regarded as a feasible measure. The costs associated with this measure are small.

Another measure which is effective to reduce both N and P leakages is reduced autumn plowing of fields. Plowing increases the oxygen content of the soil, increasing the conversion of ammonium to nitrate. The latter of these is susceptible to leakage, the former is not. As the fields are very flat, the effect on P-leakage is small. In the spring most fields should be plowed within a limited time (about 5 days) to avoid reduction in crop yields caused by delayed sowing. For large farms plowing will require several tractors which can operate simultaneously. Normally one tractor can manage to plow about 10 ha per day. An average Russian state farm of 5000 ha will need 100 tractors operating at the same time. This may be difficult to achieve. In the grain growing district autumn sowing should be applied as much as possible.

However, the effect of both these two measures will be counterbalanced by the increase of drainage, particularly tile drainage. If the level of drainage is increased without implementing other measures, the nutrient runoff might increase.

As a conclusion, it is not very likely that the average nutrient runoff from the relatively extensively run agricultural fields from Karelia in the north to Poland in the south can be reduced effectively if the food production should be kept at a reasonable level. It seems possible to achieve some reductions in Germany via extensivation.

6.3 Animal husbandry farms

6.3.1 Long term measure - split the large animal farms into smaller units

From the former DDR in the south to Karelia in the north animal husbandry is concentrated to huge state owned farms. The number of large farms relative to smaller private farms varies from country to country. It seems almost impossible to run these large farms environmentally sound, and in particular it is quite impossible to meet HELCOM recommendation A and C which states that nutrients should be brought out when the plants need them.

This can be illustrated by the Novy Svet pig farm in the St. Petersburg Region. This farm produces 250 000 cubic metres liquid manure per year. For an optimal use of the nutrients in this manure the effective spreading are restricted to a few days in spring prior to sowing and a few days in summer after the first harvest. In effect the number of spreading days are restricted to 15 days. To meet HELCOM recommendation A and C this farm must have nearly 200 tractors with the most modern spreading equipment going continuously in these 15 days.

Technical solutions have been tried to treat the manure, but most of them have failed. In the Latvia study Samuelson and Wittgren (1991) indicate a drying method including biogas production, where the biogas should be used to dry the manure. The biogas developed is not enough for drying, and additional energy must be added. The method is currently being adopted in a large scale demonstration project in the Netherlands subsidized by the Government of the Netherlands. The treatment cost is about 10 ECU per cubic meter.

A newer, and perhaps more promising method of water removal, is a multistep membrane filtration with a treatment cost of about 6 ECU per cubic meter. Even this will include a manure treatment cost for this particular farm (Novy Svet) of 1.5 million ECU per year.

Based on the practical problems connected to fulfilling recommendation A and C, combined with the assumption that a private1-2 family farming system will be developed in the future, it seems that for piggeries a number of 2000 heads per farm should be a suitable size. For milking cows this correspond to about 200 cows.

It can also be speculated on what is the most suitable size of arable land that should belong to the "new farms" from an environmentally point of view. Based on the phosphorus content the manure from 1 AU can fertilize 0.6-0.8 ha if it is used optimally. Sweden has adopted the most strict regulation of the animal husbandry within the Baltic Region and prescribe a maximum animal density of 1.6 AU per ha. This will take full effect from 1995. If we take this as a standard, a farm of 200 milking cows will require a spreading area of 125 ha. In practise only half of the farm land in a diverse production can serve as effective spreading area. This should imply that a farm with 200 AU will need about 250 ha to use the manure in an environmentally optimal way.

If we assume that in the long run there will develop a 1-2 family farms (father and son with families) as is most common in the west, and the fields should be plowed in the spring, it follows from what is said in the previous section that the optimal size will be about 100-200 ha.

It is not likely that this will correspond to the optimal size from an economically point of view.

It is obvious that changing the agricultural structure in the former Eastern bloc countries will be a process which will take a long time. It also will be complicated and very expensive. The lack of infrastructure to handle a private farming system including the lack of agronomist experience among the "new farmers", will pose a serious problem that must be regarded. In addition the privatisation and up-splitting will include enormous costs in new buildings.

It will most likely take more than one generation until the agriculture in the former Eastern bloc countries has stabilized in its new form.

6.3.2 Short term measures - priority action plan

In the mean time the following measures have to be taken to reduce pollution from the large scale animal husbandry. These are the measures that can cope with the HELCOM time schedule, e.g. that can be executed within 1995.

1) Increase the storage capacity of manure to approximately 8 months, which is necessary to avoid spreading of manure outside the growing season.

2) Ensuring sufficient technical standard of the manure storage facilities. They should be roofed over and with no leakages both to ground- and surface waters.

3) Stop the direct discharge of liquidized manure/ farm wastes.

4) Stop dumping of manure on small areas.

5) Avoid outdoor storages of manure, particularly the lagoon solution.

6) Ensuring sufficient capacity and standard of silage storages.

7) Ensure safe storages for mineral fertilizers and other agrochemicals.

8) Reduce the volume of water in piggeries to what is necessary to make the manure pumpable.

10) Change from high spreading equipment to low spreading equipment in manure application (reduce ammonia volatilization).

11) Incorporate manure into soil without delay after application by plowing or harrowing (reduce ammonia volatilization).

The received information indicates that the manure and silage storage conditions are very poorly developed. On the state and collective farms nearly all manure storage is outdoor, either as heaps (dry manure) or in lagoons (liquidized manure). This implies a need for considerable investments in constructing new storage facilities if the HELCOM recommendations and the reductions given in chapter 1.1 is to be accomplished within 1995.

The new storage facilities should be located away from the existing farm complexes, more exactly at the spots where the new smaller farms are planned to be situated. In current western farming practises it is at the moment not economically profitable to transport manure more than 4-5 km. This can be used as a guide-line for siting the new storage facilities. In this way several new manure storages will be scattered around on the large farm`s territory serving as starting points for an environmentally sound spreading strategy. Liquidized manure is easily pumped from the animal houses to the manure storages, and dry manure can be transported by some mean of transportation.

As the animal houses need modernization, and the economy and agronomic competence allow it, the animal houses should be moved to the storages and gradually new farm complexes will be built up.

7 PROJECTED ENVIRONMENTAL BENEFITS FROM THE PRIORITY ACTION PLAN

7.1 Local environmental benefits

7.1.1 Water quality improvement in lakes and rivers

The benefits of the actions on local environmental environment are mostly related to water quality improvement:

1. Less eutrophic waters
2. Increased transparency of the water
3. Less algal growth
4. Better oxygen condition
5. Fewer episodes with fish kills
6. Lower frequency of blue-green algal blooms
7. More pleasant looking beaches, shorelines and river banks
8. Improved conditions for bathing and other recreational use
9. Water quality will improve so that it will comply with the requirements for a more diverse use.
10. Safer drinking water quality
11. Improved water quality for irrigation
12. Fewer conflicts with downstream water users
13. Reduced danger of polluting surface water and ground water by recalcitrant organics, and other pesticides.

In the long run the farmers also will have several advantages from the actions, not only through better water supply for farm use, but also through more effective use of nutrients both in commercial fertilizer and in manure, and through a better conservancy of the fertile top-soil layer.

7.1.2 Reduced pollution loading to lakes, rivers and ground waters

Through the actions described in the previous sections the following loading reductions can be achieved:

Average nutrient runoff from agricultural fields	0% reduction
Extra loss from heavily manured fields	90% "
Direct discharges of farm wastes	90% "
Leakages from manure stores	90% "
Leakages from mineral fertilizer storages	100 "
Silage effluent leakages	90% "

The Table 7.1 below shows the expected reductions within the different catchment areas:

Table 7.1 Reductions in nutrient load (annual) from agriculture to the local surface water recipients as a result of the Priority Action Plan.

Prefeasibility Region	N-reductions (tonnes N/year)	(%)	P-reductions (tonnes P/year)	(%)
St. Petersburg Region	11400	43	1616	83
Estonia	13990	32	1843	79
Latvia	32300	34	4260	79
Lithuania	38420	30	4911	76
The Kaliningrad Region	12076	43	1875	80
The Vistula River Basin	54840	16	6168	66
The Oder River Basin	30070	15	3405	64
The North German Coast				
Total from agriculture	193096		24078	

7.2 Baltic Sea environmental benefits

7.2.1 Water quality improvement

The action plan against pollution from agriculture will reduce the pollution load to the Baltic Sea especially with regard to the eutrophying substances. The cessation of the point sources as manure leakage, silage effluents, will cause the most pronounced effect. A better economizing with plant nutrients through optimal dosing and timing of fertilizer and manure, better conservancy through winter greens and catch crops and reduced erosion, will lead to reduced or at least stabilized runoff from agricultural fields.

Reduced use of pesticides, or at least stop the use of recalcitrant organics, especially the chlorinated ones, and also the use of heavy metal containing compounds as for example mercury treated seed grain, will in the long run contribute to the reduction of such compounds in the Baltic Sea sediments and biota.

Most of the negative effects listed in chapter 5 will be improved by the Priority Action Plan.

7.2.2 Reduced pollution load to the Baltic Sea

Adjusting the local pollution load reductions for retention in primary and secondary recipients the corresponding total load reductions to the Baltic Sea from agricultural runoff are estimated to:

39000 tons of nitrogen per year (23% reduction of present runoff load)
8400 tons of phosphorus per year (73% reduction of present runoff load)

According to the NILU study "Topical area study for atmospheric deposition of pollutants" it is possible to reduce the loading by ammonia deposition by 60% via measures within the agricultural sector. How much of the total ammonia deposition onto the Baltic Sea arises in the Prefeasibility regions is uncertain. We have in chapter 4.2.3 tried to estimate this to

44,000 tonnes N per year, of which 26000 tonnes can be removed by the measures in the priority action plan.

The total N load from agriculture of approximately 208 000 tonnes (runoff + deposition) can then be reduced by 65,000 tonnes N which equals a 31% reduction.

8. CAPITAL AND RECURRENT COSTS FOR IMPLEMENTATION OF THE PRIORITY ACTION PROGRAMME

8.1 Introduction

The recent political changes in the former communist countries bordering the Baltic Sea will most likely involve large structural changes in the agricultural sector. These changes will mainly be politically based and will take different directions in the different countries, and are not easy to predict. We can therefore only indicate the costs confined with the short term measures given above for:

A) a typical large Russian animal husbandry farm

B) the agriculture in each region as a whole.

8.2 Necessary investments on a typical Russian animal husbandry farm.

A Typical Russian State- or Collective farm in the area has a size of:

Arable land including meadows and culture pasture: 5000 ha.
Livestock: 3000 AU

8.2.1 Investments in Manure Storages - Technical and Cost Estimates

The primary manure production (Faeces + urine) of 1 AU is about 18 m3 per year. Adding saw dust and straw remains, and a minimum water addition to make it pumpable, a total manure volume of 30 m3 must be assumed per animal unit per year.

The manure should be scraped and screwed to a temporary mixing storage which are situated close to the animal houses. Here should the manure and urine be mixed, and water added if necessary to make the slurry pumpable. In piggeries a wash down technique is most commonly used in Russian farms. This involves use of a large quantity of water, about 20-50 litres per pig per day, which increase the manure volume dramatically, approximately by a factor of 5-6. If not the water consumption could be reduced considerably, one should consider to change to a scrape and screw technique which is most common in cattle husbandry. The existing animal houses should be used to the extent possible.

From the temporary mixing storage the slurry is pumped to 10 regional manure silos. 3000 AU will produce about 90 000 m3 pumpable manure per year. Evenly distributed to the regional storages and corrected for 9 months storage capacity gives each silo a volume of about 7000 m3. The silos are circular and made of concrete. With a height of 4 m the diameter will be 48 m.

The distance from the farm complex to the regional storages will be on average 3 km. In total this will comprise 30 km of 160 mm tubes to a unit cost of 8 ECU per m, amounting to a total of 0.25 mill. ECU.

Assuming that it is mostly loose soil material in the ground (little impediment), the trench digging will cost about 5 ECU per m, in total 0.15 mill. ECU.

The primary mixing storage should at least have the capacity of 2 days of manure production, which corresponds to about 500 m3, the height about 4 m and the diameter about 13 m. This storage will cost about 0.022 mill. ECU.

The mixing storage should also be equipped with stirring bars and 2 centrifugal pumps and distributor system. This will cost ca 0.015 mill. ECU.

Leakage proof outdoor manure storages made of concrete cost about 38 ECU per m3. Each of the 10 regional storages will then cost 0.27 mill ECU, which for all the storages adds up to 2.7 mill ECU.

It is also necessary to modify some of the cleaning and transport systems from the animal houses to the primary mixing storages. Assuming a fairly common number of 200 AU per animal house, the number of animal houses on this farm will be 15. The modification cost per animal house is estimated to about 15000 ECU which in total amounts to 0.23 mill. ECU.

Table 8.1 Necessary investments in manure storages on a typical Russian state and collective farm of 5000 ha and 3000 animal units.

Investment category	Cost mill ECU
Primary mixing storage	0.022
Mixing-, pumps-, and distribution system	0.015
Animal house modifications (scrape- and screw transport)	0.23
Transport tubes (30 km)	0.25
Trench digging	0.15
10 regional manure storages	2.7
Total investments in manure storage facilities	3.367

8.2.2 Investments in spreading equipment - Technical and cost estimates

The regional storages serve as starting points for spreading the manure in accordance with HELCOM recommendations A and C, which states that the manure should be spread when the plants need the nutrients. As mentioned above this implies that over the 3 months available there is only 15 effective days of spreading, some days prior to sowing in the spring and some days during the growing period and some days after the first harvest. In a crop rotation agriculture the timing of the field-running of areas belonging to the regional storages can be somewhat different, which makes the effective spreading period a little longer, assumably to about 25 effective spreading days. This will serve as basis for investments in spreading equipment.

If one tractor with modern spreader trailer can take out 5 m3 per load, and the number of loads that can be managed per tractor per day is about 20, one will need 3 tractors per regional storage. To be able to fulfil recommendation A and C one will need 30 tractors with spreading equipment.

No information on how much of this need can be covered by the present machine park on the farms is available. However, as the manure now according to current practices is spread over a much wider season, it seems likely that about half of the equipment demand must be supplied by new machineries, i.e. 15 tractors with spreading trailers. The unit price of these devices is estimated to 0.038 mill ECU, which totals 0.56 mill ECU.

8.2.3 Investments in Fodder Silage Storages - Technical and Cost Estimates

This chapter applies first of all to farms with milk cows, meat producing cattle, sheep and goats, i. e. the animals that most commonly are fed with silage fodder. In Norwegian husbandry it is common to feed one milk cow (= 1 AU) with 8.8 tons silage fodder per year on average. Assuming as in the previous chapter that the AU in the study area is given 2 tons silage per year.

The existing animal houses are assumed be used in the near future, that is the silage storage can not be included in the animal house building which is the most common practice in Western Europe. Separate silage storages are about 20% more expensive than silage storages included in the farm building.

Unit investment cost for a leakage free high fodder silo is approximately 1600 NOK per cubic metre, included tractor load bridge and roofed over, corresponding to about 200 ECU/m3.

The typical Russian farm with 3000 AU will require 6000 m3 of silage storage capacity which amounts to an investment cost of about 1.2 mill ECU.

8.2.4 Total Investment - Large animal husbandry farms

Table 6.2 gives the approximate investment needed to make the large animal husbandry state - and collective farms comply with the HELCOM recommendations (Average size of large farms set to 5000 ha and 3000 AU).

Table 8.2 Necessary investments on a typical Russian State- and Collective animal husbandry farm (5000 ha, 3000 AU).

Investment category	Cost mill ECU
Manure storages	
Primary mixing storage	0.022
Mixing-, pumps-, and distribution system	0.015
Animal house modifications (scrape- and screw transport)	0.23
Transport tubes (30 km)	0.25
Trench digging	0.15
10 regional manure storages	2.7
Sum manure storage	3.367
Manure spreading	
Tractors and spreading equipment	0.56
Silage storage	
Leakage proof fodder silage storage (High silo 6000 m3)	1.2
Total investments large animal husbandry farm	**5.127 mill ECU**

As a conclusion concerning large animal husbandry farms it seems like the necessary need for environmental investments will be in the 5 million ECU scale per farm to make it comply with the HELCOM recommendations.

The capital costs (pro annum) confined with these investments will depend on the conditions, rate of interest, and so on offered by the banks and financial institutions involved.

Recurrent cost, comprising operating and maintenance costs, are very low as the investments include mainly simple buildings and/or traditional farm machineries. There are no treatment plants which needs special trained or educated personnel, nor any expensive process chemicals. There will not be any increased demand for energy for heating.

The only recurrent costs will comprise normal maintenance of buildings and tractors, increased diesel consumption in manure spreading, and some electricity to run the manure pumps. These costs are at maximum 4-5% of the investment, i.e. about 0.2 mill. ECU per year.

The real lifetime of the buildings, manure storages, silage storages, pipeline systems are estimated to about 50 years, while the tractors and spreading equipment, pumps, etc. have a maximum lifetime of 15-20 years.

8.3 Necessary environmental investments in animal husbandry in each Prefeasibilty Region

As outlined in earlier chapters the main effort should be aimed at reducing the point sources and bad manure storing and handling practices within the animal husbandry. What could be achieved through measures against normal field runoff is minor compared to the obvious environmental misrunning within animal husbandry.

There is, however, a large variety of farm size and farm running practices both within each prefeasibility region and over the whole Eastern Baltic. No accurate informations on the total number of farms, nor the distribution between large and small farms are available. It could probably have been possible to get statistics for the large farms, as we for example have got from the Kalingrad Region where there are 189 large state- and collective farms. But for the smaller farms, necessary information to make cost estimates for environmental investments is quite impossible to provide within the time span available for this prefeasibility study.

The total number of farms in the different prefeasibility areas varies from a few thousands to several hundred thousands. In a detailed action plan each farm has to be treated as a separate enterprise concerning environmental investments as the technical solutions will be different on the different farms.

The smaller farms also lack leakage proof manure and silage storages which have to be built to make them comply with the HELCOM recommendations. Building small storages are generally more expensive per unit volume than larger storages. However, the smaller farms have a much less manure transportation problem and in this way it is more economic for them to use the manure as fertilizer than on the large farms.

In the following it is assumed that, what the smaller farms get in additional expenditure from building smaller storages is counteracted by reduced need for transportation and spreading equipment. The total investment need per animal unit is not far from equal, and independent of the farm size.

With the basis in Table 6.2 it can then be calculated that to secure an environmentally sound animal husbandry it is necessary to make the following investment per animal unit: 1122 ECU in manure storage, 186 ECU in spreading equipment and 400 ECU in fodder silage storages. Multiplied by the total number of animal units (AU) within the different prefeasibility area, the necessary investments appear i Table 6.3.

Table 8.3 Total investment need in animal husbandry farms to make them comply with the HELCOM recommendations.(mill ECU).

Region	Total livestock (AU)	Investments in manure storages	Investments in manure spreading equipment	Investments in fodder silage storages	Total investment in animal husbandry
St. Petersburg Region	610000	684	113	244	1041
Estonia	675000	757	126	270	1153
Latvia	2000000	2244	372	800	3416
Lithuania	2454000	2753	456	982	4190
Kaliningrad Region	418000	469	78	167	714
Vistula	9200000	10322	1711	3680	15713
Odra	5000000	5610	930	2000	8540
Former DDR	1187000	1332	221	475	2028
Schleswig - Holstein**	1491000				

**) The calculations are omitted for Schleswig-Holstein as the problems there are more a question of extensivation than lack of appropriate equipment and buildings.

Summarizing the right column gives a total investment need of 36.8 billion ECU to make the animal husbandry comply with the HELCOM recommendations, i.e. the point sources should be stopped and the manure should be used as fertilizers according to the plants requirements.

It should be noted that the cost estimates are based on the Norwegian price level (1991).

The capital costs (pro annum) confined with these investments will depend on the conditions, rate of interest, and so on offered by the banks and financial institutions involved.

Recurrent cost, comprising operating and maintenance costs, are very low as the investments include mainly simple buildings and/or traditional farm machineries. There are no treatment plants which needs special trained or educated personnel, nor any expensive process chemicals. There will not be any increased demand for energy for heating.

The only recurrent costs will comprise normal maintenance of buildings and tractors, increased diesel consumption in manure spreading, and some electricity to run the manure pumps. These costs are at maximum 4% of the investment, i.e. about 1.5 billion ECU per year.

The real lifetime of the buildings, manure storages, silage storages, pipeline systems are estimated to about 50 years, while the tractors and spreading equipment, pumps, etc. have a maximum lifetime of 15-20 years.

8.4 Investments in safe storages for mineral fertilizers and other agrochemicals

In the primary material collected by the consultants within the different prefeasibility areas, it is stated that there is large uncovered need of storage capacity for mineral fertilizers and other agrochemicals. This is both a loss for the agriculture and a threat to the environment. However, the lack of storages is not well quantified in the different areas. The need for investment will also be dependent on how this storing is organized.

In most Western European countries the agriculture have built up their own trading companies to supply the different farmers with the most necessary merchandises for farm running, i.e. disease proof seeds, fertilizers, agrochemicals like pesticides and so on, draining pipes and tubes, sprinkling and irrigation systems, harvesters, tractors, and a large variety of tractor equipment (harrows, , cultivators, etc.). These companies are often run in cooperation with the agrochemicals producers and equipment dealers on a profitable demand and supply basis.

These trading companies have stores scattered around in the agricultural areas, and they are seldom more than 50 km apart. The fertilizers are brought out to the farmers in winter packed in water proof polyethylene plastic and strategically placed out on the fields as starting points for the spreading in spring.

It will take a long time to establish such a self carrying trading company in the earlier communist countries. In the mean time preliminary simple leakage proof storages for fertilizers and other agrochemicals should be built as soon as possible.

Each storage will require a capacity of about 4000 m2. The storage must be built on insulated concrete foundation. Part of it must be insulated as some of the agrochemicals do not stand frost. Unit building cost for such a storage will be in the range of 3000 NOK per m2 which equals 625 ECU per m2. Each such storage will cost about 1.5 mill ECU.

Taking the above given store density as a basis along with the uncovered storage demand given in chapter 4.1, the following tentative Table 6.4 can be given:

Table 8.4 Estimated costs for fertilizers and agrochemicals storages.

Region	New storages of 4000 m2 (number)	Investment costs (mill ECU)
St. Petersburg Region	10	15
Estonia	10	15
Latvia	12	18
Lithuania	14	21
Kaliningrad Region	11	16.5
Vistula	10	15
Odra	8	12
Former DDR	7	10.5

8.5 Total investment needed in the agricultural sector to reach the goal in the Priority Action Plan

Based on the chapter 6.6.2 and 6.6.3 the total investment costs needed to reach the goal in the Priority Action Plan is set up in Table 6.5.

Table 8.5 Total investment costs confined with the Priority Action Plan in the agricultural sector in the different prefeasibility study areas.

Prefeasibility region	Investment Costs (mill. ECU)
St. Petersburg Region	1056
Estonia	1168
Latvia	3434
Lithuania	4211
Kaliningrad Region	731
Vistula River Basin	15728
Odra River Basin	8552
Former DDR	2039

Summarizing it gives total investment need of 37 billion ECU if the former DDR is included and about 35 billion ECU if DDR is omitted. The cost estimate is based on the Norwegian price level in 1991.

The capital costs (pro annum) confined with these investments will depend on the conditions, rate of interest, and so on offered by the banks and financial institutions involved.

Recurrent cost, comprising operating and maintenance costs, are very low as the investments include mainly simple buildings and/or traditional farm machineries. There are no treatment plants which needs special trained or educated personnel, nor any expensive process chemicals. There will not be any increased demand for energy for heating.

The only recurrent costs will comprise normal maintenance of buildings and tractors, increased diesel consumption in manure spreading, and some electricity to run the manure pumps. These costs are at maximum 4% of the investment, i.e. about 1.5 billion ECU per year.

The real lifetime of the buildings, manure storages, silage storages, pipeline systems are estimated to about 50 years, while the tractors and spreading equipment, pumps, etc. have a maximum lifetime of 15-20 years.

9 APPENDIXES

9.1 Appendix A: List of prepares

Dag Berge	Head of Research Department, Freshw. Ecol. and Water Management, Norwegian Institute for Water Research (NIVA).
Hans Olav Ibrekk	Research Manager, Norwegian Institute for Water Research (NIVA).
Hans Holtan	Senior Scientist, Norwegian Institute for Water Research (NIVA).
Gertrud Holtan	Scientist, Norwegian Institute for Water Research (NIVA).
Nils Vagstad	Head of Department, Centre for Soil and Environmental Research (Jordforsk).

9.2 Appendix B. List of Persons Contacted

Egil Berge	Professor, Institute for Technical Topics, Agr. Univ. Norway.
Ivar Gjerde	Dr. Scient, Institute for Technical Topics, Agr. Univ. Norway.
Jozef M. Pacyna	Dr. Scient, Norwegian Institute for Air Research., Norway.
Erik Børset	Norconsult., Norway.
Torben A. Bonde	Dr. Phil., National Agency of Environmental Protection., Denmark.
Matts-Ola Samuelson	Scientist, Swedish Environmental Research Institute (IVL), Sweden.
Matti Iikanen	Plancentre LTD., Finland
Erkki Tiainen	Plancentre LTD, Finland
Hans Ammendrup	Senior Manager, Carl Bro A/S, Denmark
Jan Rennerfelt	Professor, K-Konsult Water Projects, Sweden.
Douglas R. Clark	Ph.D., COWIconsult, Denmark.
Bent Andersen	Biologist, COWIconsult., Denmark.
Niels Erik von Friesleben	COWIconsult., Denmark.
Etienne Le Guellec	Sage Services, France.

Bengt Bengtson	Chief Engineer, SWECO, Sweden.
Ulrich Goerschel	Lahmeyer International, Germany.
A. Jürgens	Lahmeyer International, Germany.

9.3 Appendix C. List of References

Aspmo, R. 1985: Pollution from Agriculture -Resources off the Right Path. How can I as a Farmer reduce Water Pollution? Report from The Action Plan against Agricultural Pollution, GEFO/Jordforsk 1988: 111 sider. (in Norwegian).

Aspmo, R. 1988: Pollution from Agriculture -Resources off the Right Path. Revised Version. How can I as a Farmer reduce Water Pollution? Report from The Action Plan against Agricultural Pollution, GEFO/Jordforsk 1988: 111 sider. (in Norwegian).

Berge, D. and T. Källqvist 1990: Bio-availability of phosphorus in agricultural runoff compared to other pollution sources - Final Report. NIVA-Report O97079 (Lnr. 2367). 130 sider.

Bonde, T. A. 1991: Evaluation of National Action Plans for Reduction of Nutrient Discharges from Agriculture to the Baltic Sea. HELCOM-Report.........

Enell, M., S.O. Ryding and L. Wennberg, 1988: Impact of Agriculture on Air- and Water Environment. Review Report on Nutrient Losses - Sources- Effects and Measures. Lantbrukarnas Riksförbund. LRF/IVL-Report: ISBN 91-36-89059-6 :217 pp. (in Swedish).

Gjerde, I. 1992: Building costs for farm buildings. Price index and unit costs for 1991. ITF-Report 26/92, Institute for Technical Topics, Agricultural Univ. of Norway, NLH-Ås: 104 pp. (in Norwegian).

Holtan, H., and S. O. Åstebøl 1990: Handbook in collecting data on pollution loading to inland waters and fjords. Revised version. NIVA/Jordforsk-Report O-89043 (Lnr.2509): 53 pp. (In Norwegian).

Iversen, T., Halvorsen, N.E., Mylona, S., and Sandnes, H. 1991. Calculated budgets for airborne acidifying components in Europe, 1985, 1987, 1988, 1989, and 1990. EMEP/MSC-W Report 1/91, Norwegian Meteorological Institute, Oslo.

Jenssen, P.D. 1990: Treatment of point source effluent from agriculture: Silage Effluent. (in Norwegian).

Johnsen, S., V. Heide and I. Gjerde 1990: Investments cost for farm buildings. ITF-Report 3/1990, Institute for Technical Topics, Agricultural Univ. of Norway, NLH-Ås: 90 pp. (in Norwegian).

Lundekvam, H. 1983: Manure and effluents from farm buildings. Stensiltrykk nr. 1/83 from Institutt for Hydroteknikk, Norges Landbrukshøgskole,NLH. (in Norwegian).

Larsson, U., R. Elmgren and F. Wulff 1985: Eutrophication of the Baltic Sea: Causes and Consequences. AMBIO Vol 14, No 1: 9-14.

Libert, B., 1992: Basic Facts of Baltic Agriculture and Environment. Lecture at the symposium: AGRICULTURE, FOOD AND ENVIRONMENT IN THE BALTIC REPUBLICS, 141000 January 1992.

Lundekvam, H. and E. Berge 1989: Leakages from Silage- and manure storages. Technical note Aug 89. Inst. Bygningsteknikk of Inst. Jordfag., Norges Landbrukahøgskole, NLH. (in Norwegian).

Løfgren, S. and H. Olsson 1990: Loading of Phosphorus and Nitrogen to inland waters in Sweden. Underlagrapport til HAV-90, Aktionsprogram mot havsföroreningar. Naturvårdsverket Rapport 3692: 100 pp. (in Swedish).

Miljøstyrelsen 1991: Environmental Impacts of Nutrient Emissions in Denmark.Report 1/91 from National Agency of Environmental Protection, Ministry of Environment, Denmark: 208 pp.

NOFO 1987: Silage effluent - a problem waste or a resource? Notice from A/S Norsk Forkonservering, NOFO. (in Norwegian).

Olsson, H. and S. Löfgren 1990. Loading of Nitrogen and Phosphorus to the Sea. Underlagsrapport till HAV-90, Aktionsprogram mot havs föroreningar. Naturvårdsverket Rapport 3693.

Pacyna, J. M. 1992. The Topical Area Study for Atmospheric Deposition of Pollutants. The Baltic Sea Environment Programme, Draft Synthesis Report. Norwegian Institute for Air Research, NILU.

Randby, Å.T. and O. Kjus 1989: Ensilaging grass in round bales. A/S Norsk Forkonservering (NOFO), Rapport nr.2, 1989 from Hellerud Forsøks- of Eliteavlsgard, Det Kgl. Selskap for Norges Vel. (in Norwegian).

Rude, S. 1991: Nitrogen Fertilizers in Danish Agriculture - present and future application and leaching. Statens Jordbruksøkonomiske Institut, Landbrugsministeriet., Rapport nr. 62: 151 pp. (in Danish).

Samuelson, M.O. and H. B. Wittgren 1991: Agriculture in Latvia - A prefeasibility Study, Preliminary version. IVL-Publication B1040.

Sundstöl, F. and Z. Mrotz, 1988: Excetion of Nitrogen and Phosphorus in manure and urine from livestock animals in Norway. SEFO-Report no 4/88. Ås-NLH. (in Norwegian).

Söderström, J. 1988: Overgjødning av haven: "Fosfortilgången har en nyckel roll - Kvävenivån anpassar sig naturligt". Kjemisk Tidskrift nr. 2, 1988:40-48.

Undheim, G. 1989: Testing of measures against runoff from agricultural fields in the county of Rogaland, Norway. GEFO Report 5/89. (in Norwegian).

9.4 Appendix D. List of Sources of Data

According to the contract the data needed for the Topical Area Study for Agricultural Runoff should be provided by the consultants responsible for the different Prefeasibility Studies.
In the beginning of the study the following request for data was sendt out:

9.4.1 Original request for data

Climatic data:

1) Monthly precipitation sums from representative sites (normal values).
2) Monthly mean temperatures from representative sites.
3) Mean area specific water discharge (l/km2sek). It would be best if the could have been given as isohydat maps, showing regions with the same runoff.
4) Mean monthly water discharge from the main rivers.

Data on area distribution

1) Total area of cultivated land.
2) Total area of cereal grains.
3) Total area of meadows.
4) Total area of potatoes and vegetables, etc.
5) Total area of pastures.
6) Percentage of autumn plowed fields.
7) Percentage of winter seed (green fields).

Commercial fertilizer

1) Fertilizer nitrogen (total consumption and per ha).
2) Fertilizer phosphorus (total consumption and per ha).
3) Way of storages (Indoor, outdoor, leakages).

Livestock

1) Total number of cattle and horses.
2) Total number of pigs.
3) Total number of sheep and goats.
4) Total number of chicken.
5) Total number of other poultry (geese, ducks, turkeys).
6) HELCOM's factors (if developed) for conversion of the different livestock animals to animal units (AU).
7) Number of AU per ha, averaged over the total agricultural area.
8) Number of AU per ha within the animal husbandry farms, i.e. areas that in effect are available for manure spreading.

Fodder

1) Number of tons ensilaged fodder.
2) Percentage of free land silos (trench silos and silo heaps).
3) Percentage of indoor silos.
4) Judgements of degree of silage leakages.

Manure

1) Number of tons manure produced.
2) Outdoor storage of manure (% or tons).
3) Indoor storage of manure (% or tons).
4) Indoor storage capacity (months per year).
5) Judgements of leakages from manure storages.
6) Manuring intensity (tons per ha)
7) Autumn/winter spread manure (% or tons)
8) Spring spread manure (% or tons).
9) Any number for N and P content in manure.

Nutrient runoff studies.

Whatever studies there exists of empirical data pertaining to agricultural nutrient export will be of value to adjust our theoretical approach to agricultural pollution, particularly of the following kind:

1) Empirical nutrient runoff studies from agricultural fields
2) Nutrient transport values from rivers.
3) Nutrient concentration values from agricultural brooks.

Pesticides

1) Total consumption of herbicides
2) Total consume of insecticides
3) Total consume of fungicides
4) Consume of other pesticides

We have been in contact with the different Prefeasibility groups several times to remind them of our need for data. The reality is, however, that such statistics are in most cases not developed (available) for these specific catchments, which means that the field workers and local contact persons within the different Prefeasibility groups are having trouble to find such statistics.

9.4.2 Data received

The data received from these are not easy to address to the primary sources as the most often are copies of tables from statistics, or hand written tables.

To supplement from some areas we have copies from national official statistics via the embassies of the different countries in Oslo, Norway.

The Norwegian Central Bureau of Statistics has also provided some agricultural statistics.

Some material is provided by the HELCOM Secretariat in Helsinki, from the National plans for reducing pollution load to the Baltic Sea, and from the evaluation of this plans given by Torben A. Bonde, National Agency of Environmental Protection., Denmark.

9.5 Appendix E. Review of Cost Estimation Procedures and Assumptions

Cost estimates of Agricultural Buildings are provided by two reports from The Institute for Technical Topics, at the Agr. Univ. of Norway. These reports are:

Ivar Gjerde 1992: Building Costs for Farm Buildings. Price Index and Unit Costs for 1991. ITF-Report 26/92., The Institute for Technical Topics, at the Agr. Univ. of Norway. 103 pp.

Johnsen, S., V. Heide & I. Gjerde, 1990: Investment Costs for Farm Buildings. ITF-Report 3/91. The Institute for Technical Topics, at the Agr. Univ. of Norway: 90 pp.

In addition, the author Ivar Gjerde have been contacted a couple of times.

Concerning the cost estimates of pipelines, the pipeline dealer Setsaas Water, Sanitary and Heating LTD, have been contacted.

Concerning the price setting of tractors and manure spreading equipment, we have contacted the Agricultural Trading Company in Norway "Felleskjøpet".

The price are according to the Norwegian price level in 1991. No attempt has been made to transform the budgets to local price levels.

Norsk institutt for vannforskning NIVA

Postboks 69 Korsvoll, 0808 Oslo
ISBN 82-577-2129-8