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Environmental and macroeconomic impact assessment of different development scenarios to organic and low-input farming in Croatia

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CONTENTS

GLOSSARY OF TERMS AND ABBREVIATIONS

AE	Agri-Environment
AZO	Environment Protection Agency
DZS	Central Bureau of Statistics
EC	European Commission
EC	European Commission
EU	European Union
EUR	European Monetary Union currency
FAO	Food and Agriculture Organisation of the United Nations
FINA	Financial Agency
FTE	Full-time (employment) equivalent
FULS	Farm-upstream linked sectors
FUTURO	External costs measurement (1 FUTURO = 1 EUR)
FZOEU	Environmental Protection and Energy Efficiency Fund
GDP	Gross domestic product
GM	Gross margin
GVA	Gross value added
HGK	Croatian Chamber of Economy
HR	Croatia
IC	Intermediate consumption
HZPSS	Croatian State Extension Service
KZO	Cadastre of Emissions into Environment
LU	Livestock unit
MPŠ	Ministry of Agriculture and Forestry (pre-2004 name)
MPŠVG	Ministry of Agriculture, Forestry and Water Management
MZOPUG	Ministry of Environmental Protection, Spatial Planning and Construction
NCEA	National classification of economic activities
NGO	Non-governmental organisation
PPA	Plant protection agents
t-km	Tonne-kilometres
UAA	Utilised agricultural area

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1. BACKGROUND INFORMATION

1.1. FAO's assistance to Croatian organic and low-input farming

FAO project

Following the request of the Government of the Republic of Croatia, in September 2003 the Food and Agriculture Organisation of the United Nations (FAO) funded a technical assistance project for Croatia. The overall objective of this project was to improve rural income and food security through diversified production and specialty marketing of high-value and high quality products with environment-enhancing production methods.

Study on impacts of organic and low-input farming

One of the project's tasks was to produce an environmental and macroeconomic impact assessment of large-scale conversion to organic agriculture. The real impacts of large-scale conversion to organic and low-input agriculture are largely unknown and are subject to speculation. This assessment is meant to provide building bricks for future Croatian agriculture policies and measures required to support organic and low-input farming. In May 2004, the FAO commissioned the University of Essex to commence a study trying to assess the environmental and economic consequences of widespread adoption of organic and low-input farming in Croatia.

1.2. Croatia on the accession road to the EU

Turbulent recent history

After nearly a thousand years, Croatians have managed to achieve their long-sought independence. Croatia's recent history has been marked with turbulent events. The country has been passing through a process of deep transformation. In the course of the last fifteen years the country has struggled with several difficult and painful processes:

- the breakdown of the communist regime
- the shift to a more democratic society
- the transition to a market economy
- the war for independence and post-war recovery (return of refugees, reconstruction, war-crimes sanctioning, etc)
- accession to major international political and other associations (EU, NATO, WTO, etc.).

EU accession efforts

Croatia has been trying to access the economic and political mainstream of Europe. It aspires to join the European Union before 2010. All major political parties have defined Croatia's accession to the EU as a strategic national goal and support the county's application for EU membership. In its efforts to pursue new aspirations and catch up with modern developments, the country is encountering new challenges. In May 2004, the European Commission granted Croatia candidate country status. In order to nurture a positive relationship with the EU and to prevent itself from further lagging behind in the accession process, Croatia has taken the first steps towards the adoption of EU-based regulations in nearly all fields of policy. Like the previous one, the present Government is also determined to create a closer relationship with the EU. In order to accelerate the EU accession process the Government has initiated a challenging reform programme. Its main objectives are to complete the process of transition and achieve sustainable economic performance; enhance the democratisation of society and contribute to regional stability (EC 2004).

1.3. Croatian agricultural policy at the crossroads

Chance for sustainable agriculture

In its search for new social, economic and political models, Croatia is trying to pursue modern achievements and concepts, including those in the agricultural sector. Croatian agricultural policies are still at the crossroads. They are not yet fully developed and enforced. This situation enables the concept of sustainable agriculture to be embedded into policy makers' efforts for further policy improvements.

Croatia is in the process of creating the necessary conditions for its agriculture to face EU competitiveness and develop adequate working and living conditions in rural areas. It is therefore of the utmost importance to initiate the appropriate steps to bring agricultural and environmental policy in Croatia into line with that in the EU.

Small-scale farming prevails

Sixty five percent of the agricultural land is privately owned. It is small-scale family farming (average farm size is 3 hectares). The remaining thirty five percent is in the hands of the former co-operatives. These are now restructured (and partly privatised) and have continued practising high-input agriculture. The agricultural policy support, notably subsidies is designed mainly to support high-input farming. The same goes for the extension, research, education and market promotion. The official agricultural policy in Croatia is geared towards supporting high external input agriculture. Both scientists and policy makers tend to believe this is the best way to increase agricultural production and strengthen the national economy. However, in recent years this way of thinking has been under revision and several programmes supporting more sustainable ways of farming have been initiated.

Rapid development of organic farming

The need for a change of the present farming practices to more sustainable management has slowly been taking hold among Croatian policy makers, farmers, consumers and other societal groups. The current way of farming poses a serious treat to environment, food safety and animal welfare. In addition, there is growing consumer concern about food quality and its taste. In the last couple of years, Croatia has been recording an obvious growth of the area under organic management. The government has adopted legislation on organic farming and introduced direct payments to stimulate its further growth.

2. RESEARCH METHODOLOGY

2.1. Research questions

Key question

The key research question is what would be the environmental and economic consequences of the conversion of a substantial portion of Croatian agricultural land to organic and low-input farming.

How it is going to be answered

The research intends to answer this by comparing the economic and environmental performance of farming and farm-upstream linked economic sectors (FULS): energy supply, the farm inputs industry, transport and trade. The assessment is to be corrected for external costs (health, environment, social investments, etc.) arising from these activities. The comparison will be made between the baseline situation (2001-2003) and development scenarios having various shares of acreage under different farming methods (high-input, low-input and organic agriculture).

Impact categories

The impact of different scenarios will be examined against the following categories:

1. National agricultural output
2. Gross value added (GVA)
3. Employment
4. State of the environment.

2.2. Research objectives

The research objectives are to:

Provide methodological framework

1. Provide a methodological framework for the determination and quantification of causal links associated with large-scale adoption of organic and low-input farming so that it can be used for other similar studies in Croatia and elsewhere

Assess shift to organic and low-input farming including externalities

2. Provide first quantitative assessments on present externalities linked to Croatian farming and farm-upstream sectors
3. Assess the environmental and economic feasibility of widespread adoption to organic and low-input farming in Croatia taking into account externalities of farming and linked upstream sectors.
4. Identify gaps in current understanding, methodology and results

Stimulate wider debate and policy change

5. Outline policy actions needed to facilitate the adoption of the most desirable development scenarios and thus provide output of immediate policy relevance.

2.3. Research hypotheses

More organic and low-input farming is good for environment and farm economy

Achievements in farming practice, as well as a vast body of scientific evidence (see Chapter on organic farming) suggest that organic and other types of low-input farming can achieve a high degree of economic viability and environmental friendliness. Therefore it is expected that development scenarios comprising a substantial portion of organic and low-input farming exhibit equal or higher benefits for the national economy and national environmental account than the scenarios that have less area under such management regimes. It is presumed that these benefits are even greater if negative externalities associated with farm-upstream linked sectors were taken into account.

... but impact of widespread adoption is unknown

However the soundness of this hypothesis is highly questionable. Environmental and economic gains from organic and low-input agriculture have mostly been calculated at the farm level. Widespread adoption of these farming methods is most likely to have a range of impacts on the economic sectors linked to farming. These consequences are largely unknown and have hardly yet been assessed either in Croatia or elsewhere.

2.4. Research relevance

Tool for policy making

As this research attempts to address some fundamental but yet unanswered questions, it is hoped that its outcome will be highly relevant both for academics and policy-makers. The research aims at providing guidance for sensible judgement as to what the policy makers should do in order to promote sustainable agriculture. Its results are hoped to be a useful tool in helping Croatian policy-makers in shaping and implementing adequate policy measures supporting the development of the most promising development scenarios.

.. and their relevance

The assessed impact categories belong to key features associated with sustainable agriculture. The national agricultural output is an important element of food security. The GVA, corrected for external costs is a measurement of the size of the economy and indicates the “real” economic feasibility of various development scenarios. Employment is linked to social aspects, but is primarily the result of economic wealth. The GVA already includes the value of labour (and thus actual jobs or potential to create the new ones). However, employment is added as a separate category because it is an important “measure of success” for the general public and most policy makers. The state of the environment affects the quality of life and is essential for the well-being of future generations.

Pioneering work

This research represents a pioneering work not only in Croatia but also further afield. Its questions seem to have been only partly addressed and answered in sustainable farming debates so far. Therefore the methodology and approach to be developed through this research could also be a useful framework for similar studies in other countries.

2.5. Research steps and methods

The research path followed consists of the three main steps:

1. Construction and impact assessment of the baseline scenario
2. Construction and impact assessment of development scenarios
3. Considerations of scenario results on policy-making

Each of these three steps involved several sub-steps.

2.5.1 Step 1: Baseline scenario

The baseline scenario is based on the average results obtained for the period 2001-2003.

Sub-step 1.1

Inventory of Croatian agriculture

A brief inventory of the current state of Croatian agricultural sector was made. It covers natural resources, land use, key agricultural commodities, farm inputs and outputs, policies, institutional settings, etc. This part should provide sound background information on the socio-economic, political and environmental context in which Croatian agriculture is operating.

Sub-step 1.2

NCEA codes of farm-upstream linked economic activities

Farming is closely linked with several farm-upstream economic sectors, notably:

1. Energy supply (oil, gas and electricity)
2. The farm inputs industry (pesticides, fertiliser, feeds, seeds and veterinary medicine, farm machinery)
3. Transport of raw materials and final products of farm inputs and the energy supply industry
4. Trade (wholesale and retail) of farm inputs and energy

The relevant economic activities from these sectors were identified and coded in accordance with the Croatian national classification of economic activities (NCEA) (N.N. 2003). The NCEA is a universal key for classifying economic activities and the Croatian coding system is more or less in line with international standards. Further selection of the key organisations from each of the identified economic activities was made using the database of the Croatian Chamber of Economy (HGK 2004) and its selection criteria for the size of the business (turnover and number of employees).

Sub-step 1.3

Calculation of GVA and number of employees

Gross value added (GVA) and number of employees were calculated for farming and identified farm-upstream linked economic activities (FULEA) following the methodology provided by the Croatian Bureau of Statistics (DZS 2004; Crnogorac 2005) and financial datasets supplied by the Croatian Financial Agency (FINA 2005). A detailed description of this step can be found in Chapter on GVA Exchange rates in this as well in all other calculations were carried out using data from the Croatian National Bank (HNB 2005).

Sub-step 1.4

Environmental emissions and degradations data

The emission of soil and water pollutants and environmental degradation of soil caused by the FULEA were quantified using data from the following sources:

2.5.2 Quantification of environmental pollutants

The emissions of pollutants from economic activities linked to Croatian farming was quantified using data from the following sources:

1. Cadastre of Emissions into the Environment (KZO): This national database has been run by the Ministry of the Environment (MZOPUG) and the National Environmental Fund (FZOEU). The KZO database contains air and wastewater emissions from point sources and data on industrial and municipal waste generation and treatment (Jurić, Burek et al. 2005; MZOPUG 2005). The primary data for the Cadastre have been supplied by companies and other legal entities which are obliged to keep regular records and carry out annual reporting to the authorities. The KZO proved to be an important source of information, providing the type and quantity of pollutants for major companies of the interest for the study. In cases of doubts and unclearness regarding the KZO data, additional consultations were made with experts from MZOPUG (Nećak 2004; Šolić-Gavranović 2004), FZOEU (Muškardin 2004; Muškardin 2005) and the Environment Protection Agency (Kufrin 2004).
2. Water Pollution Cadastre. The public company Croatian Waters maintains its own cadastre (database) on water pollution. Companies that have obtained water permits from Croatian Waters are obliged to submit regular reports on water pollution. The water pollution data reported here are more detailed than those to the Cadastre of Emissions into the Environment.
3. Environmental information directly obtained from industries. The key companies were contacted in order to obtain new or check previously collected pollution information. Most of these, especially agri-chemical companies reacted positively to this request, providing various useful information: Herbos (Ivanković 2004; Smolčić 2004), Chromos (Čović 2004), Veterina (Benko Tomić 2004; Benko Tomić 2005; Stilinović 2005) and Dalmed (Vujčić 2004). Petrokemija (Avirović 2004; Vešligaj 2004; Avirović 2005) submitted particularly detailed and useful environmental data.
4. Corporate environmental reports, such as (HŽ 2001; HŽ 2002; Petrokemija 2002; Petrokemija 2002b; HEP 2003; INA 2004; Petrokemija 2004b).
5. Governmental environmental reports, such as (Hrvatske vode 2002; Hrvatske vode 2003; MZOPU 2003; CCPC 2004; Hrvatske vode 2004; MZOPUG 2004; MZOPUG 2004b).

6. Research and consultancy organisations dealing with environmental pollution: EKONERG (Jurić 2005; Vešligaj 2005), the Hrvoje Požar Energy Institute (Vuk 2005) and the Croatian Centre for Cleaner Production ((Belamarić Šaravija 2004; Horst 2004). These organisations prepare various environmental analysis for national authorities and international projects and have unrivalled expertise in the field of air pollution and energy-related environmental issues.

Sub-step 1.5

Assessment of external costs

A methodological framework for assessing external costs related to damage to air, water and soil, as well as social investments was developed. Using various environmental accounting methods, an attempt was made to assign monetary value to the identified external costs throughout FULEA. The final external cost was named FUTURO (since most of these costs are to be paid in the future). The final real value added, that is value corrected for external costs was named PURO (since it represents added value "purified" from external costs). Some external costs were not possible to valuate due to the lack of data and/or appropriate valuation methods. More detailed information on the methods employed to assess external costs can be found in the chapters on air, water and soil damage and the chapter on social investments.

Figure 1 outlines the key building blocks used in constructing the baseline situation. The boxes framed in red indicate areas in which fundamental calculations had to be performed to the lack of data or inaccuracy, inconsistency and/or unreliability of the official data. More detailed explanation is given in the relevant chapters.

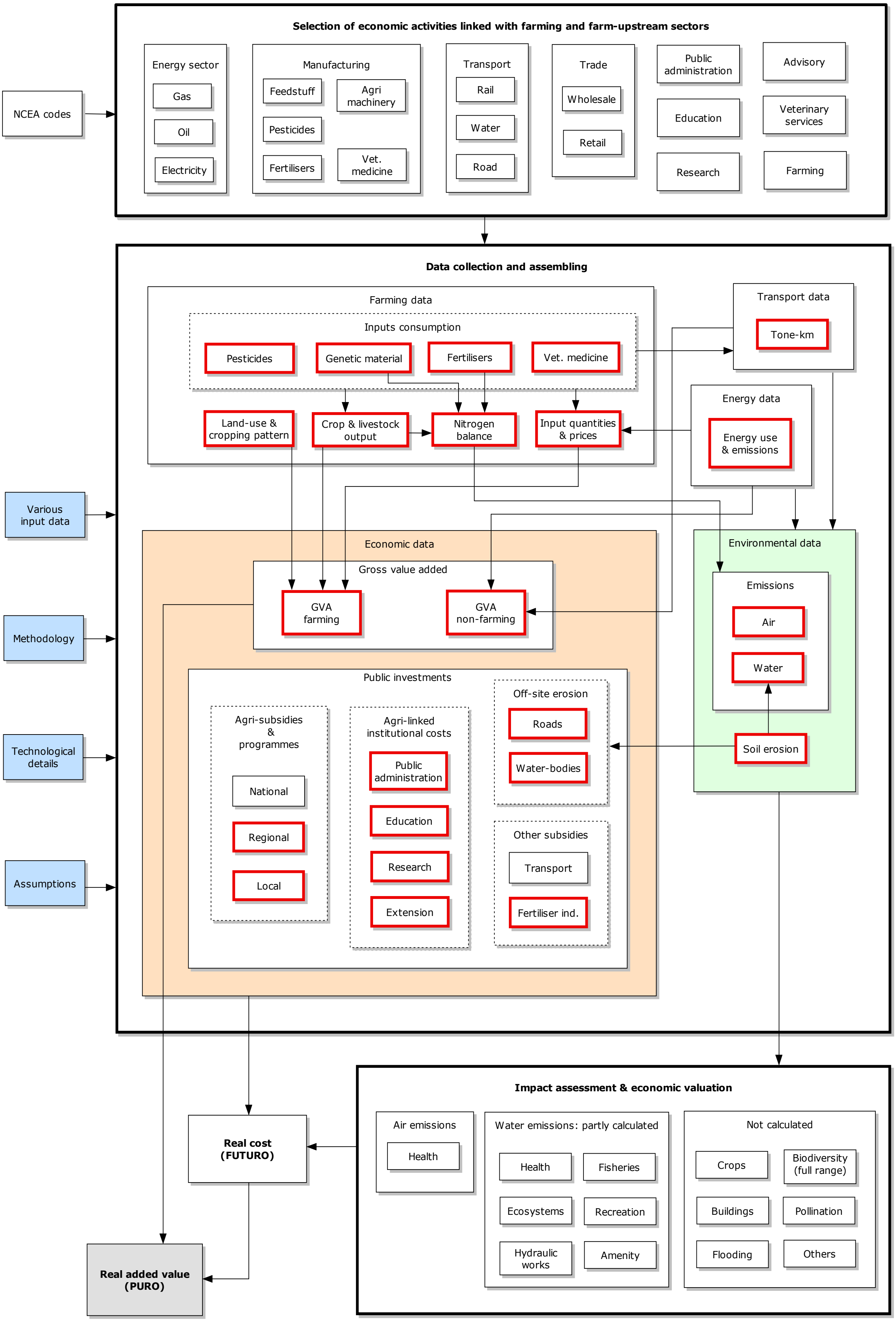


Figure 1 Building blocks for the baseline scenario (2001-2003)

2.5.3 Step 2: Development scenarios

Sub-step 2.1

Assessment of organic and low-input farming performance

The environmental and economic achievements of organic and low-input farming were assessed in order to be able to build sound assumptions on their performance under Croatian circumstances. This information was obtained from a literature review and a survey made among Croatian organic farmers. Based on this information, assumptions have been made regarding the performance of organic and low-input farming in Croatian conditions. Assumptions on conventional farming, as well as on the performance of FULEA have been made from the baseline scenario.

Sub-step 2.2

Build development scenarios and asses their achievements

Several development scenarios have been constructed. The share of different farming styles (organic, low-input, conventional, etc.) and their impact on FULEA is the main difference between these scenarios. The contribution of different scenarios to national agricultural output, GVA, employment and quality of environment has been assessed by using a static comparison approach.

Sub-step 2.3

Discussion

Results obtained from assessing environmental and economic performance of different scenarios and their comparisons have been analysed and discussed. Figure 2 outlines the building blocks used in constructing development scenarios.

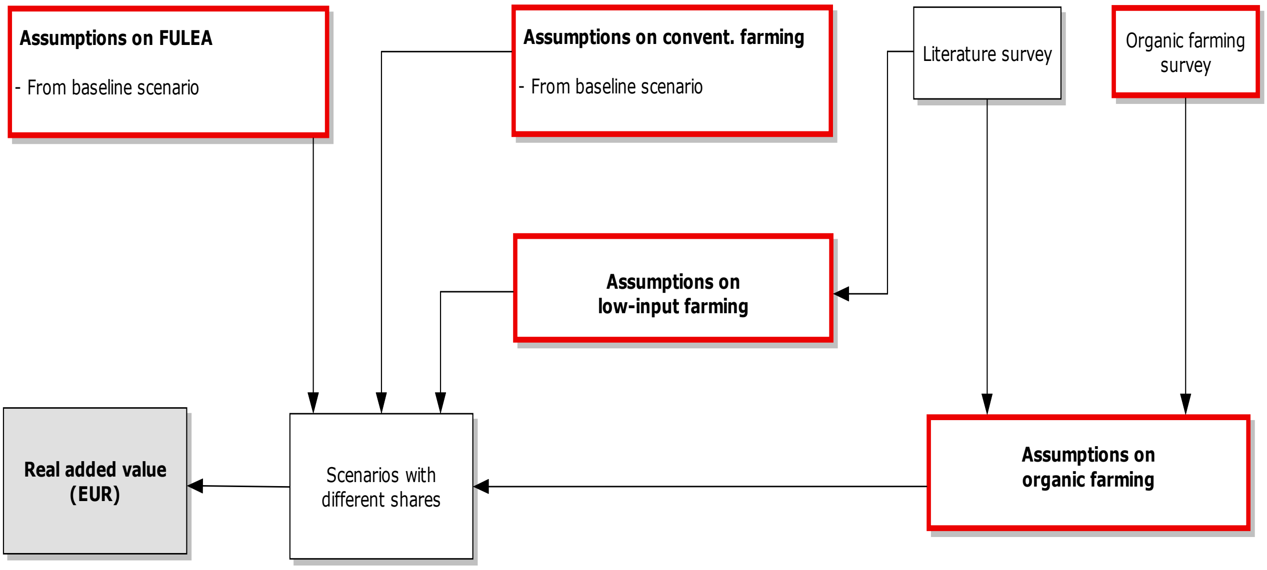


Figure 2 Building blocks for development scenarios

2.5.4 Step 3: Implications for policy-making

Policy options

The results obtained have been discussed in the light of policy making. Their implications for policy making have been analysed as well as the impact of the present Croatian agricultural and environmental policies on the development of desirable scenarios. Policy recommendations have been outlined and the likelihood of their realisation discussed.

2.6. Research boundaries

2.6.1 Sectoral boundaries

Farm-downstream linked sectors excluded

Agriculture is linked to many economic sectors and human activities. Conversion to large-scale sustainable farming is most likely to have a range of impacts on various economic activities. The research focuses only on the FULEA. The farm downstream sectors such as the food processing industry, transport and retail are believed not to be significantly affected by the widespread adoption of organic and low-input farming and are thus excluded from the assessment. Several other socio-economic activities linked with farming have also not been assessed, because they are deemed to be insignificant for the final outcome. These activities include:

- Hunting and forestry
- Fisheries
- Coal, solar and wind power
- Tourism

2.6.2 Type of externalities

Positive externalities excluded

The research addresses only negative externalities - costs. In order to obtain the “full picture” of the impact of the scenarios discussed, besides negative, positive externalities (health, biodiversity, human capital, etc.) should be included, too. However, in a number of cases, these might not be significant and their impact is often difficult to assess.

... and not all negative valuated

As already mentioned earlier, due to the lack of sound data and/or valuation methods, some external costs had to be excluded from the assessment, such as:

- Odour and noise
- Navigation restrictions and flooding caused by the reduced retention capacity of water bodies due to erosion
- Biodiversity and nature services
- Pollination losses
- Resistance to pesticides and antibiotics
- Animal welfare
- Decreased food quality

However, where appropriate these externalities have been discussed in qualitative terms.

2.6.3 Impact categories

Four essential categories included

The scenario impact has been assessed for the four categories that are essential features of sustainable farming: agricultural output, GVA, employment and quality of environment. Several other categories that are also important elements of sustainability have been left out from the quantitative assessment and where appropriate have been discussed only in qualitative terms. These include:

- Gender issues
- Impact on rural life and development
- Impact on consumers in urban areas

2.6.4 Geographical boundaries

Croatia only

The research focused only on the impacts the widespread conversion to organic and low-input farming would have in Croatia and not elsewhere. This boundary is necessary, as the consideration of the wider impact on these sectors abroad (e.g. on foreign industry exporting pesticides to Croatia or raw phosphate mining industry in Africa) would complicate the already complex calculations even further. Widening the horizons outside the borders of Croatia itself is certainly needed and worthwhile, but this would make the assessment virtually impossible. Since the objective of this study is primarily to provide an answer as to whether the large-scale conversion to sustainable types of agriculture is economically viable and environmentally sound from the Croatian (national) policy point of view, calculation expansion to other countries is of less relevance.

However, the external costs on damage to air have been given both for Croatia and elsewhere because these costs have been generated in Croatia by Croatian farming and its upstream-linked economic sectors.

National vs. regional level

All assessments have been aggregated at the national scale, and are given as the average for the period 2001-2003.

2.7. Uncertainties, cavities and constraints

Methodological issues

This research is rather complex and holistic. It tries to explore and assess a number of economic and environmental linkages between farming and farm-upstream sectors. Besides it attempts to quantify major external costs involved. In such “fragmented” research, results cannot be obtained by applying uniform methods and methodology. These have had to be developed from case to case. The methods employed in this research have been described in relevant chapter and comprise:

- Willingness to pay
- Cost: benefit analysis
- Contingent valuation
- Literature survey
- Proxy
- Extrapolation from primary data sources
- Farm surveys

- Case study results
- Consultation with opinion leaders
- Unobtrusive measures or indirect observation (documentary analysis, content analysis, archival analysis).

Data-poor context

Much of the data needed to perform such a study was not available or was of questionable quality. In other words, the research had to be performed in a data-poor context. Unexpectedly, but in a number of cases, even some of the most fundamental calculations had to be made from scratch (e.g. national agricultural output, GVA of farming and other economic activities, land use area and pattern, consumption of fertilisers and pesticides, nitrogen balance, etc.). All these data are usually available in national statistics, government reports and academic research. Unfortunately, this is not the case in Croatia. These fundamental calculations required an enormous time and energy input by the project team.

Contributions by some 130 organisations and experts

During the course of the research approximately a hundred and thirty organisations and individual experts both from Croatia and elsewhere were contacted. These provided very useful advice, information, comments and data. Various methodological issues and calculations have been discussed and cross-checked with relevant opinion leaders in Croatia and elsewhere.

Pareto rule: question of efficiency

Due to time and finance constraints, where necessary the Pareto 20:80% rule was applied. The rule says that instead of investing time, energy and resources on numerous “trivial many”, in purchasing goals, focus should be made on the “vital few” that are essential for reaching 80% of the desired result. The rule is named after Italian economist Vilfredo Pareto (1848-1923) who first described this principle.

Results confidence

Sincere efforts have been made to bridge the gaps and overcome methodological and other problems encountered in this study. The results and calculations presented here are just first approximations and are certainly open for improvements. After all the objective of this study was first of all to provide a sound framework for discussion and first estimates of the consequences of widespread adoption to organic and low-input farming, rather than to provide meticulous calculations. However, the results presented here are essential starting points for further analysis and debate that should help in overhauling agricultural, economic and environmental decision-making.

3. CROATIAN FARMING SECTOR

3.1. Croatia in a nutshell

The Republic of Croatia was established after the disintegration of the former Yugoslavia in 1991. It comprises a territory of 56.538 square kilometres and has 4.4 million inhabitants. Croatia has a boomerang-like shape consisting of two arms: the continental one stretching from the capital city Zagreb eastward, and the coastal one stretching along the Adriatic Sea (Figure 3). Due to its geographic location at the meeting point of the Mediterranean, the Alps and the Pannonian plain, Croatia exhibits great geographical and natural diversity in a relatively small area.

Figure 3: Location map of Croatia.

Diversified ecological conditions

Due to the influence of several types of climate meeting and mixing, the natural vegetation is highly diverse. Similarly, Croatia is a natural compendium of soil types and nearly every European soil type can be found here (Martinović 1997).

3.2. Natural resources

3.2.1 The climate

Under the Köppen classification (Figure 4), the largest part of Croatia has a moderately warm rainy climate, with mean monthly temperature in the coldest month of the year above -3 °C and below 18 °C. The highest mountain regions (> 1,200 m of altitude) alone have a snowy, forest climate, with the mean temperature in the coldest month below -3 °C. In the continental mainland, the hottest month of the year has mean temperature lower, and in the coastal area higher than 22 °C.

Mean annual air temperature in the coastal area ranges between 12 °C and 17 °C. The northern part of the coast has somewhat lower temperature than the southern part, and the highest temperatures are recorded at the seashore and on the islands of the central and southern Adriatic. The lowland area of northern Croatia has mean annual temperature between 10 °C and 12 °C, and in the areas above 400 m the temperature is below 10 °C. The coldest areas of Croatia are the regions of Lika and Gorski Kotar, with temperatures ranging from 8 to 10 °C at lower altitudes and from 2 to 4 °C at the summits of the Dinara Mountain. Due to the impact of the sea, air temperature amplitudes and anomalies have for years been less pronounced in the coastal area than in the inland area, and the autumn has been warmer than spring. The difference between mean maximum air temperatures in the continental and coastal part of Croatia is less significant than the difference between mean minimum air temperatures in those parts. The absolute air temperature extremes have been measured in the continental part of Croatia (-35.5 °C in 1929 and 42.4 °C in 1950).

Figure 4. Köppen’s classification of Croatian climate

Mean annual precipitation in Croatia ranges between 600 and 3,500 mm. The outlying islands have the lowest precipitation values of the Adriatic Sea (<700). Approaching the Dinaric massive, mean annual precipitation increases and reaches peak values of up to 3,500 mm at the summits of Gorski Kotar (Risnjak and Snježnik). In the western part of northern hinterland annual precipitation ranges between 900 and 1000 mm and in the eastern part of Slavonia and in Baranja it is somewhat below 700 mm. Although this area is the driest in Croatia, the distribution of precipitation during the year is such that the largest precipitation occurs during the growing season. Northern inland has no dry periods, and annual precipitation cycle is of continental type with the primary maximum in the warm part of the year and the secondary maximum in late autumn. The northern Adriatic, Lika and Gorski Kotar do not have dry periods, have two maximums, but the primary precipitation maximum occurs in the cold part of the year and the secondary maximum at the turn of spring into summer. At the central and southern Adriatic, annual precipitation cycle is of maritime type with dry summers and the precipitation maximum occurs in the cold part of the year.

3.2.2 The soil

Poor soils

Due to their origin and management, Croatian soils are relatively poor in organic matter (Martinović 1997; Moller 2003), which has been subject to a constant decline since the mid sixties (Martinović 1997; Vidaček, Racz et al. 2003). The main bottleneck for achieving high and stable crop yields is the unfavourable water ratio between the soils' water and air holding capacity, leading to a constant or temporary water surplus or shortage . Consequently, nearly 1.8 million hectares (57% of total agricultural land) of mostly arable land suffers from seasonal waterlogging. This situation enhances soil acidity, which is considered to be the major factor hindering the fertility of Croatian soils and the effective utilisation of applied nutrients (particularly phosphorus). It is estimated that 1,15 million hectares (35% of total agricultural land) have a pH value less than 5.5 (Moller 2003). In year 2000, less than 0.1% of all agricultural land (0.2% of arable land) received irrigation (FAO 2003)

3.2.3 Biodiversity

3.2.1.3 Diversity of Croatian nature

Diversity of Croatian nature

Croatia is famous for its nature and is among most the biologically rich countries in Europe. At the European level, it ranks second for the number of fish species, third for the estimated number of invertebrates, fifth for number of reptiles and seventh for the number of vascular plants and mammals (DUZPO 1999). When the number of species is expressed in relation to land area, Croatia ranks third for the number of plant species per area and fourth for the number of vertebrates per area. Croatia has an unusually high concentration of endemic species, particularly in the Karst (calcium carbonate limestone) region. Approximately six percent of the taxa of flower plants and algae (of a total of four hundred and thirty nine) are endemic to Croatia. Out of 4,924 known plant species in Croatia, five hundred and fourteen (10.4%) are endangered. But in spite of this, there are only 44 protected plant species, while an additional 92 deserve strict protection because they are seriously threatened (DUZPO 1999). It is estimated that Croatia harbours some 56,121 animal species (eight hundred and eight are endemic), of which only 39% have been identified (MZOPU 2002).

The high biodiversity in Croatia is enhanced by its location in quite different climatic, (geo)morphological and hydrological zones: the Danube floodplain, the Karst limestone zone, the Dinaric Alps and the Mediterranean Coast with its unique islands. A substantial part of Croatian biodiversity and many protected natural areas were devastated during the recent war and are still suffering from this destruction (Welp, Hamidović et al. 2002).

3.2.2.3 Biodiversity on agricultural habitats

Species in agricultural habitats

Although many valuable species are in decline, some of these can still be found in agricultural habitats. According to the Biodiversity Strategy (DUZPO 1999) agricultural habitats harbour many rare and threatened species. The wild plants include the Corn Cockle (*Agrostemma githago*) that has disappeared from the areas of intensive agriculture (Slavonia and Baranja) and the Tulip (*Tulipa praecox*), which is locally limited to vineyards of the island of Korčula. Oriental Knight's Spur (*Conosolida orientalis*) and the White Poppy (*Papaver dubium* ssp. *lecoquii var. albifolium*) can be found only in the eastern part of Croatia. Croatian arable land and grassland still host some birds of important European conservation status such as Corncrake (*Crex crex*), Partridges (*Perdix perdix*) and Quails (*Coturnix coturnix*), Stone-Curlews (*Burhinus oedicnemus*) (Krk and Pag islands), Shrike (*Lanius minor*) and Calandra Lark (*Melanocorypha calangra*) (Mediterranean areas). Furthermore, some of the rarest Croatian breeding birds, such as the Imperial Eagle (*Aqueila heliaca*), Lesser Kestrel (*Falco naumanni*), Redfooted Falcon (*Falco vespertinus*) and Saker Falcon (*Falco cherrug*), as well as the Common Redshank (*Tringa totanus*) which nests only in two places in Croatia) also live in agricultural habitats.

Croatian grasslands are habitats for numerous endangered plants, among which the most important are the whole family of orchids (Orchidaceae) and exemplars of diverse other families or genera such as Anemone, Arnica, Daphne, Dianthus, Edraianthus, Eryngium, Gentiana, Iris, Lilium, Ligularia, Linum, Narcissus, Primula, Scilla, Veratrum, etc. The most important rare mammals living on Croatian grasslands are hamsters (*Cricateus cricateus*) and mound-building mice (*Mus spicilegus*) and among endangered species, the European ground squirrel (*Citellus citellus*) and lesser mole rat (*Nannospalax leucodon*). Grassland habitats in Croatia have a rich fauna of grasshoppers and butterflies. The majority of its 187 species of daily butterflies can be found in meadow habitats. Two genera are particularly important: the endemic subspecies and species of the arguses (genus Erebia) and the myrmecophyllous genus of large blue Maculinea. These are either endemic taxa or species endangered at the European level.

Lowland grassland

During the last 50 years, a major part of Croatia's lowland grassland has been converted into arable land. Extensive land reclamation and regulation of watercourses has left hardly any marshy and wet grassland. They are now very extensively and only temporarily used for grazing and mowing. If this trend continues, lowland grassland in Croatia will entirely disappear. Formerly diverse swampy and wet grassland (communities Caricetum, Deschampsietum, Molinietum) are turning into less wet areas, predominantly communities of tall oatgrass (Arrhenatheretum). This results in a significant decline in biodiversity.

Karst grassland

Croatian karst ecosystems are widely acknowledged not only because of their plant and animal biodiversity, but also because their fragile hydrological and geological features (caves, lakes, waterfalls, “underground rivers”, limestone phenomena, etc.). These subterranean and terrestrial karst ecosystems are interconnected and dependent upon the maintenance of a delicate balance between relief, hydrology, climate and vegetation. Karst regions account for more than half of Croatia's territory.

The major cause of Karst grassland degradation is depopulation and changes in traditional agricultural practices in mountainous regions of Croatia (Gorski kotar, Lika, Velebit, etc.) where cattle breeding used to be much more developed. Without grazing and regular mowing large areas are increasingly overgrown by woodland. Similar processes are ongoing in Mediterranean karst areas on littoral dry grassland and rocky pastures. Although due to the dry and hot climate the natural succession here is rather slow, the long-term result is the same: shrubby vegetation is suppressing valuable grassland species adapted to survive on sparse soil or in holes between rocks with a shortage of water.

Agriculture in protected areas

Protected natural areas in Croatia cover approximately 10% of the country (excluding territorial seas) and are made-up of 450 protected sites. The best known among these are the eight national parks (IUCN category II): Plitvice Lakes, Paklenica, Risnjak, Mljet, Kornati, Brijuni, North Velebit and Krka and 2 strict nature reserves (IUCN category I): Hajducki i Rosanski Kukovi and Bijele i Samarske stijene. Several of these have been listed as internationally valuable natural areas. The Plitvice Lakes are included in the UNESCO World Natural Heritage List and the Velebit Mountain is in the UNESCO MaB (Man and Biosphere) scientific programme. Four areas are included in the Ramsar Convention List (Kopački rit, Lonjsko polje, the lower Neretva and Crna Mlaka).

Appropriate agricultural management is essential for the biodiversity and wildlife of many Croatian protected natural areas. However, most of these areas either are without significant agricultural production or depopulated (or sometimes both). Therefore, agriculture-dependent biodiversity is in decline. A particular threat is the absence of moving and grazing operations in protected natural areas. Shrubs and other pioneering vegetation take over vast areas and thus diminish the biodiversity of the rich meadows and pastures. Neglected or abandoned land or land that has become afforested or overgrown by scrub decreases the biodiversity value of grassland. Besides, such land is at risk of fire that can arise if excess biomass is not subject to grazing pressure. Therefore, the forest area in Croatia has been gradually and continuously increasing at the expense of species-rich grassland. This trend is worrying and has to be stopped. The encouraging news is that the remaining (agricultural) population in protected areas is becoming increasingly aware of the problem. The same goes for the management teams in protected areas of nature. These have started to work on management plans and prescriptions for specific agricultural measures.

Although the existing Croatian regulations limit the application of agricultural inputs, notably pesticides and fertilisers, as well as some other agricultural practices in nature-protected areas, they are not precise enough. Thus, their interpretation is quite liberal and monitoring and control over farming protected areas is moderate.

3.2.4 Agro-ecological zones

Regionalisation

In regard to the geological, climatic and vegetation conditions, the country may be divided into three geomorphologic and agronomic regions (Figure 5) featuring different climate, soil, relief and other agro-ecological conditions. Each of these regions is further divided in several sub-regions.

Figure 5. The three main agro-ecological zones.

Mediterranean region

The Mediterranean region comprises the area along the Adriatic cost. It is characterised by mild winters and dry, hot summers. According to Koeppen`s classification such climatic conditions fall under Csa type, which is also known as olive climate. Due to centuries of agricultural exploitation and the origin of the parent rock, the soils in this region are not very fertile. Nevertheless, the agricultural production in the region is rather intensive with small fragmented family farms prevailing. The region is favourable for the growth of subtropical fruits, wine and early vegetables. The Mediterranean part of Croatia comprises 31.9 % of the country's territory.

Pannonian region

The Pannonian region is the most southern extension of the great Hungarian plain and occupies the northern and northeastern part of Croatia. It covers as much as 54.8 % of Croatia's territory. The area is mostly flat and has very fertile alluvial soils, including the world's most fertile soil type- chernozem. Cold winters and hot, dry summers (< 600mm rainfall-yr) are the main attributes of the climate. Although private farms prevail, all the major former co-operatives are located here. This is Croatia's prime agricultural area (also called the Croatian breadbasket) where the majority of the country's cereals and industrial crops are produced.

Hilly and mountainous region

The hilly and mountainous region is located between the two above-mentioned areas. The agriculture here is based on small-scale private farms, with animal husbandry prevailing. The entire region is in a karst area with hilly and mountainous relief. Due to very cold winters and a long snow-melting period, the vegetation season is rather short. The soils are poor and shallow (Martinović 1997). The area is mostly under grassland and has some orchards, too. In the scarce (karst) valleys, there is some crop production, too (mostly potatoes and cereals). This area accounts for 13.3% of the Croatian territory.

3.3. Legacies of the past

The communist regime

Although it did not formally belong to the former Soviet Union block, being part of the former Yugoslavia, Croatia also experienced a communist regime and its agricultural management and policy.

Communist agriculture

The Communist style of agriculture, operating in a centrally planned economy, was characterised by excessively high levels of inputs of energy and agri-chemicals, as well as the use of heavy mechanisation to operate in endless fields. Wide crop rotation was hardly practised, resulting in a monoculture, mainly of cereals and industrial crops. The energy to power the whole system was "cheap" and environmental protection was not an issue. Agriculture's main role was to produce immense quantities of cheap food for the population and raw materials for industry. The Communists believed that technology, fertilisers and pesticides could produce an infinite increase in crop yields and that agriculture could consume soil resources infinitely (Fesbach and Friendly 1992). Consequently, some Communist countries, such as Ukraine, lost up to 25% of their organic soil matter in the last three decades (Morgan 1996). Similarly, Croatian soils have also lost some 30% of the stable and some 50% of the "active" organic matter (Martinović 1997; Vidaček, Racz et al. 2003). In 1989, out of 750 million hectares of cultivated land in the Soviet Union, nearly half was seriously imperilled (Fesbach and Friendly 1992).

Social setting and productivity

However, it is not only the environment that suffered under this system. The planned economy, a distorted market system and de-motivated workers produced also questionable economic returns. In spite of the high-input levels of agri-chemicals and energy, Communist-style agriculture proved to be highly inefficient and yielded low outputs. This can be best illustrated by a striking figure from the former Soviet Union. Although private plots made up only 1-2% of the total land of the former Soviet Union, these plots produced about 75% of the potatoes and eggs, and about 40 % of meat, milk and vegetables consumed in the 1960s (Fesbach and Friendly 1992). Two hundred million hectares were saline, 150 million hectares have been eroded, and 30 million were waterlogged or swampy, while an additional 13 % was marginal (rocky, hilly, or overgrown).

Croatia retained private agriculture

Having being a part of the Socialist Federal Republic of Yugoslavia, Croatia adopted and practiced a socialist system with self-management and social ownership. But unlike other Communist countries, Croatia retained private land ownership in agriculture even during Communist rule and some 60 % of the total Croatian agricultural land remained in the hands of private farmers. These were allowed to have their own land up to a maximum of 10 hectares of arable land and 30 hectares of grassland. However, private farmers were often considered as “ideologically low-conscious outcasts of the bourgeois class” (ref) and were not favoured by the regime. The communists favoured large, state-owned agricultural co-operatives. These co-operatives were usually part of even greater agribusiness units, so called agri-industrial complexes, better known as “agrokombinates” or “PiK”s.. These tried to unite primary agricultural production; processing and retail activities within a single company and often employed several tens of thousands of people.

Dual agriculture even today

Today’s Croatian agricultural sector is to a large extent reflection of this historical development. Even nowadays, the Croatian agricultural sector has two parallel production systems: private family farms and big agricultural companies that have mainly evolved from the ex-state owned agricultural co-operatives.

3.3.1 The fall of state-planned agricultural economy

The economic transition in Croatia over the last fifteen years resulted in rather drastic changes in the agricultural sector, particularly the agricultural inputs. Since the costs of (expensive) inputs do not pay back through the (cheap) agricultural commodities the Croatian farmers substantially reduced the use of agri-chemicals or refrained from using them altogether (ref). This resulted in a drop of fertilisers and pesticides consumption by over XY% in comparison with levels applied in 1985-1990 (to be checked). However, like in other CEE countries the shift from high-input to low-external-input farming in the Croatia was not the result of a designed agri-environmental policy, but rather the consequence of an evolution from state economy to market economy (Kieft 1999).

3.4. Agricultural statistics

At present, in Croatia there are two official sources of agricultural statistics: the recent Agricultural Census 2003 (DZS 2003) and the Statistical Yearbook of the Republic of Croatia for 2003 (DZS 2003). Unfortunately, these sources significantly differ in some very basic figures, such as land use and the number and type of livestock and inputs (some figures differ by as much as 1,800%).

At present, in Croatia there are two official sources of agricultural statistics: the recent Agricultural Census 2003 and the Statistical Yearbook of the Republic of Croatia for 2003. Both are published by the Central Bureau of Statistics. Unfortunately, these sources significantly differ in some very basic figures, such as land use and the number and type of livestock and inputs (some figures differ by as much as 1,800%).

It is debateable which of the two methodologies provides more reliable data and which ones are closer to reality. The census data seem to have some advantage, as these are very recent and involved nearly all agricultural households and agricultural companies.

Agricultural census 2003

The agricultural census took place in June 2003 and was the first census made since Croatia gained independence. It involved nearly all Croatian agricultural households and all registered agricultural companies except a minor number consisting of:

- Stockless households with less than 0.1 ha land
- “Agricultural” households having only forest land
- “Unavailable” households which for various reasons were unable to take part in the census

The census consisted of 29 questions for agricultural households and 31 questions (each question having several sub questions) for agricultural companies. It engaged 15,000 people in making the interviews. They were paid per interviewed household and were motivated to cover as many households as possible. Non-response to the census and the provision of flawed information were subject to penalties of up to 1,330 EUR. The census cost approximately 17 million EUR. The data were published at the end of December 2003, very shortly before the completion of this project.

Statistical Yearbook

While the agricultural census was based on statements collected by interviewing private farmers and figures provided by the agricultural companies, the Statistical Yearbook for 2003 used a different methodology. Most of its agricultural data are compilations of data provided in statistical annual reports by agricultural companies and expert estimates for the private sector. While the first should be quite accurate, the later can be problematic, as is explained in the chapters on land use and inputs.

It is debateable which of the two methodologies provides more reliable data and which ones are closer to reality. The census data seem to have some advantage, as these are very recent and involved nearly all agricultural households and agricultural companies.

3.4.1 Number and size of farms

3.4.1.1 Family farms

Small-scale family farms prevail

The family farms prevail (Table 1), as their number (448,532) by far outstrips that of the agricultural companies (1,364) (DZS 2003).

Table 1 Number and size of farms in Croatia, after (DZS 2003)

	Farm households		Agricultural companies		Total	
Ha	Number	ha	Number	ha	Number	ha
0-1	227,434	50,759	327	71	227,761	50,830
1-2	71,933	67,103	51	77	71,984	67,180
2-3	40,129	65,330	45	108	40,174	65,438
>3	109,036	670,004	941	216,952	109,977	886,956
Total	448,532	853,196	1,364	217,208	449,896	1,070,404

Private farming (family farms) constitutes the core of the agricultural sector of Croatia. It occupies 80% of the total utilised agricultural land and 75% of the arable land, owns 82% of the livestock, and 99% of all tractors, and accounts for approximately 95% of the total workforce in agriculture (DZS 2003). The average family farm in Croatia is 1.9 hectares in size (DZS 2003). However, the farms are very fragmented and split into eight plots on average- mostly due to the inheritance law- allowing farm splitting (VRH 2000). As much as three quarters of all Croatian family farms are smaller than 3 hectares and they farm only 21% of all utilised agricultural land owned by the private sector (DZS 2003). However, a recent survey (AF 2002) suggests that the average size of a vital, commercial family farm is substantially bigger- 11.5 ha. Seventy-five percent of all private farms have three cows or less, while only 200 private farms keep more than 15 cows (MZOPU 2003). Croatian farmers also lack modern management practices and equipment and their yields are lower compared to those of the agricultural companies (USDA 2000; DZS 2003; DZS 2004).

War suffering

Croatian farmers suffered a lot from the recent war (1991-1995). During this period, a third of the livestock (half of the cattle) and a quarter of agricultural machinery were destroyed (MPŠ 2003). More than 200,000 farmers were dislocated and turned from agricultural producers into consumers (MPŠ 1996; VRH 2000).

3.4.2.1 Agricultural companies

Number and destiny

According to the latest agricultural census from 2003, Croatia has some 1,364 agricultural companies (DZS 2003). Most of today's agricultural companies are the remaining or reorganised structures of the ex-state-owned agricultural co-operatives. In the process of economic transition, the former state co-operatives have changed their structure and ownership. Some went bankrupt, while some evolved into truly commercial companies. Most of these newly established business operations face low profitability, excess capacity, over-employment, old debts and difficulties in adapting to market conditions (USDA 2000). Eight biggest co-operatives are still predominately owned by the government, but are on the way to become fully privatised.

Resources used

In 2003, the average size of the agricultural companies was 160 hectares and they occupied 217,208 hectares, of which as much as 199,910 hectares of arable land (DZS, 2003a). The agricultural companies are still geared towards industrial, high external input, often monoculture farming, aimed at maximising yields (ref).

3.4.2 Land use and cropping pattern

Different statistics

The statistics on land use are the most problematic of all agricultural data, as these exhibit the greatest difference of all figures presented in the Statistical Yearbook and the agricultural census (Table 2). This is because the first one is based on the cadastre data, while the census uses data directly provided by farmers and agricultural companies.

Table 2 Land use in Croatia

	Statistical Yearbook	Agricultural census	Difference (%)
Agricultural land	3,143,000	1,391,622	126
Arable land	1,462,000	802,093	82
Utilised arable land	1,096,601	802,093	37
Fallow land	363,215	102,423	255
Meadows	399,000	149,790	166
Pastures	1,156,000	60,561	1,809
Vineyards	58,000	27,688	109
Orchards	68,000	31,163	118

The cadastre problem

There is widespread consensus in Croatia about the cadastre: it is inaccurate and unreliable. The Croatian cadastre has not been updated for a long time and is not able to provide reliable data on land use. It seems that the last time the Croatian cadastre was completely updated was at the very beginning of the 20th century, while Croatia was still part of the Austrian monarchy. However, the official evaluators use cadastre maps to determine the structure of land use and the area sown with different crops. As this job has been done for years by the same people, their annual estimates might be influenced by the data they provided in previous years. This problem has been recognised and documented for along time. Reports from the mid sixties as well as from the early nineties (RZS 1964; Stipetić 1991) emphasise cadastral inaccuracy in terms of land use. Stipetić (Stipetić 1991) stresses that Croatia "has less arable land than shown in the cadastre and statistics on crop production". According to the same sources, it was quite common for evaluators to report the surface under wheat and maize as being 20% greater than actually sown. The same goes for grassland development into shrubs and later forest. This was not recorded either, partly because the owners did not report on it. An additional problem was also cadastre regulations, which "did not accept conversion of arable land into grassland" (RZS 1964). This is because the municipal land tax was paid according to the land use categories from the cadastre, with arable land, vineyards and orchards being taxed much higher than grassland. Therefore, each municipality claimed to have lot of agricultural land, particularly under arable and permanent crops (Stipetić 1991). On the other hand, for the same reason, most farmers did not declare grassland conversion into arable land or permanent crops. This system of land taxing was abolished in 2000. Because of this, as well as because of the new subsidy scheme, farmers and agricultural companies have no interest in declaring a smaller area under arable crops, vine, fruits and vegetables, as these are entitled to high subsidies. Therefore, it is quite unlikely that the agricultural census data is "missing" a lot of agricultural land, particularly arable and land under permanent crops.

Lost agricultural land

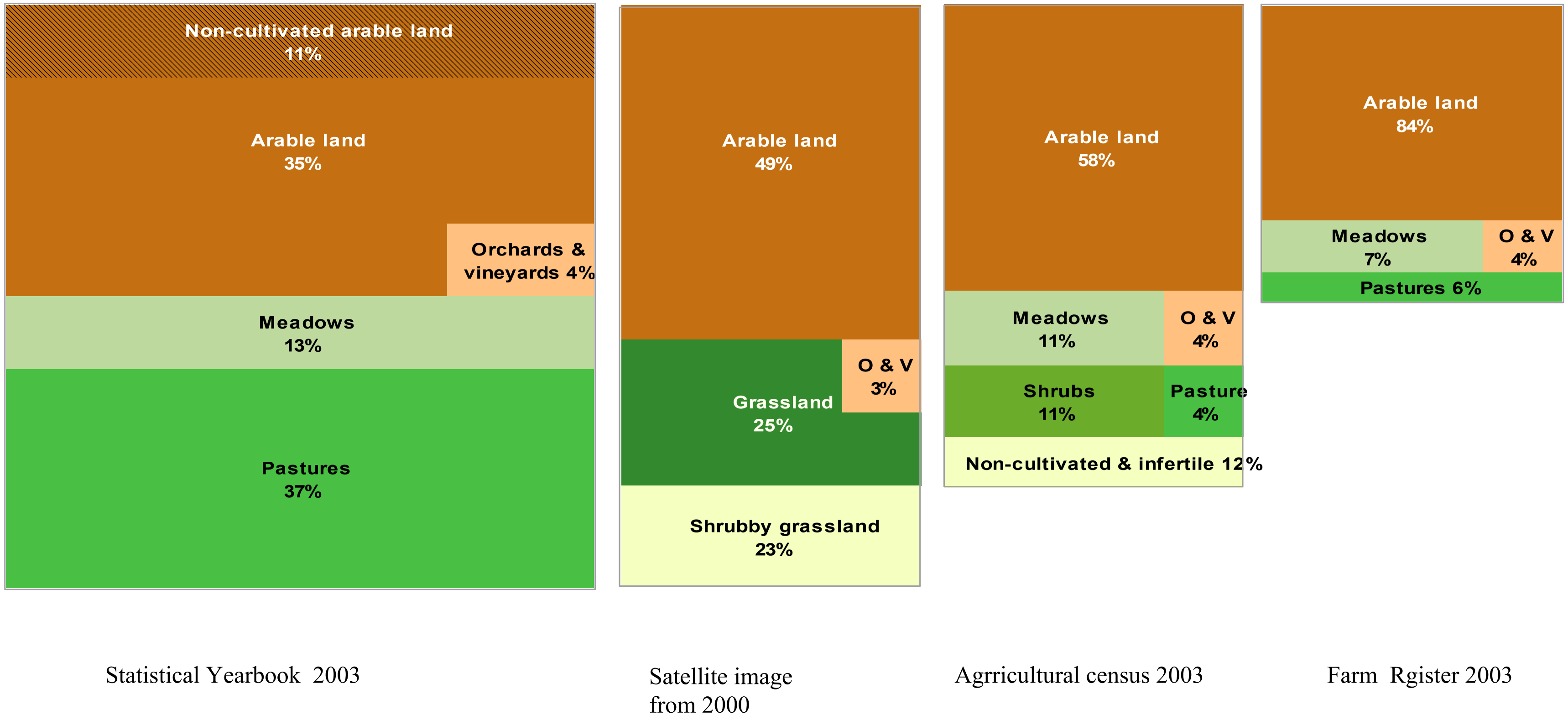
Croatia covers 56,538 square kilometres. According to the cadastre-map-based estimates, agricultural land comprises 55.8% of the territory (DZS 2003). However, the census data give quite a shocking figure, suggesting that Croatia's agricultural land area is only 23.3% of the total land area. This suggests that 1.75 million ha of agricultural land (56% of the total) has been lost! The difference is most likely due to the evolution of neglected grassland into forest and infrastructure and settlements spreading. In addition, some common or state-owned land that is used for grazing might have not been reported by farmers in the census, as this land is not their property and most likely not leased either.

The Statistical Yearbook (DZS 2003) indicates a rather bipolar land use pattern in Croatia: arable land occupies nearly half (46.2%) of the total agricultural land while the other half is grassland: meadows and pastures. However, the census data give quite a different picture, with grassland occupying just 15% of the total agricultural land. Arable land and meadows unused for longer than 5 years did not qualify in the census under these categories, and nor did pastures unused for longer than 10 years (DZS 2003).

Satellite image and Farm Register

Two other sources suggest that agricultural census figures on land use reflect the actual situation. Preliminary figures from a satellite image of Croatia (DZZP 2004) prepared for a project on habitat mapping indicates that Croatia has far less agricultural land than has been presented in DZS Statistical Yearbooks. Although this satellite image was made in 2000, its figures correspond quite well with those from the census.

Similarly, to the census, it shows 1.37 million hectares of “pure” agricultural land and an additional surface of 0.4 million hectares of neglected (mostly karstic) grasslands mixed with shrubs and forest-like vegetation. This area seems to be out of agricultural production and by 2003 (census year) is most likely to have turned even more into scrubland. MPŠVG’s Farm Register for 2003 also shows that the area of Croatia's agricultural land is much smaller than suggested by the Statistical Yearbook. Farmers and farm companies only registered 870,334 hectares (of which 728,447 hectares of arable land)- an area that is some 3.5 times smaller than the agricultural land area in the Statistical Yearbook! Similar share of meadows and grassland can be found in both Farm Register and agricultural census. The Farm Register covers nearly all farmland in Croatia. It includes all farms receiving any kind of financial support from the MPŠVG, as well as all smallholdings selling their produce at local markets and all farms that have ever been inscribed into any kind of register by MPŠVG.



Statistical Yearbook 2003

Satellite image
from 2000

Agrricultural census 2003

Farm Rgister 2003

Figure 1 Agricultural land use structure in Croatia according to different sources (all drawings are on the same scale).

Lot of uncultivated land

Land use has been strongly influenced by the process of economic transition and the exodus of the rural population caused by the war. The dissolution of a number of large state co-operatives and the failure of the state-planned economy resulted in the abandonment of vast areas of land. During the period 1991-2002, on average 26% of all arable land remained uncultivated (DZS 1996; DZS 2003). This is substantially more than during socialism time. In the period 1981-1991 the average percentage of uncultivated arable land was only 9.2% (VRH 2000). With meadows and pastures, this must be even worse, but the figure on unused grassland is not available in the statistics. Such a high share of unutilised agricultural land is caused by:

- the shift to a market economy and non-concerted agricultural policies
- the lack of updated land cadastre, land register and a land transfer mechanism which allows the easy transfer of ownership and/or tenancy
- the recent war (1991-1995). During this period, 29% of agricultural land remained inaccessible for cultivation and agricultural land remained "contaminated" by numerous minefields. With an estimated 450,000 hectares under minefields, 1-1.2 million mines and unexploded ordnance devices (Welp, Hamidović et al. 2002), Croatia belongs to the worlds' top ten countries contaminated by landmines Approximately one out of three minefields were laid on agricultural land. The mines occupy 140,000-180,000 hectares of Croatia's cultivated land (7-9 percent of total cultivated land) (MPŠ 2003; FAO 2004).

Narrow crop rotation

Cereals (incl. maize) are planted on 72% of the arable land in Croatia (Figure 6). Maize alone is planted on more than one third of the total arable land and is the most important cereal crop grown throughout Croatia. Wheat is the second most important grain, covering about 20% of the arable land (USDA 2000; DZS 2003). This cropping pattern results in a very narrow crop rotation with a small proportion of legumes and grass-clover mixtures. Too few farmers include grass-clover mixtures or green manure crops in the rotation and grass-clover mixtures (incl. alfalfa) occupy only 6.3 percent of Croatian arable land (DZS 2003). A three-year crop rotation consisting of winter wheat, maize and potatoes forms the most popular crop rotation design (Znaor and Karoglan Todorović 2004). However, many farmers apply a crop rotation consisting of just maize and winter wheat (Sumelius, Mesić et al. 2005). The narrow crop rotation that is practised by the majority of Croatian farmers certainly enhances erosion and is detrimental on soil fertility (Znaor and Karoglan Todorović 2004).

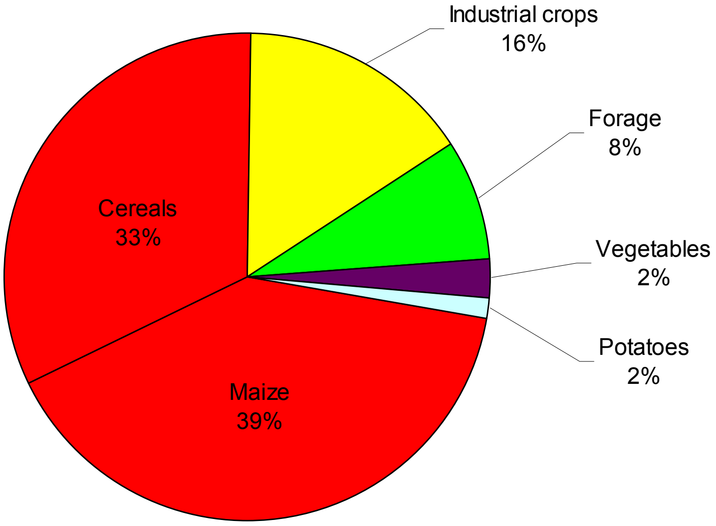


Figure 6 Arable land cropping pattern in 2003, after (DZS 2003)

3.4.3 Livestock

Declining number of livestock

The current number of livestock in Croatia is some 2.5 times less than at the beginning of the 20th century and approximately 2 times less than in the eighties (UPR 2000) (Figure 7). The data from the agricultural census (DZS 2003) indicate that at present, Croatia has some 744,109 LU (1 LU being equal to a supply of 85 kg of nitrogen), that is equal to the livestock density of 0.69 LU per hectare of UAA, or 0.92 LU per hectare of arable land. This is quite low compared with other, notably EU countries.

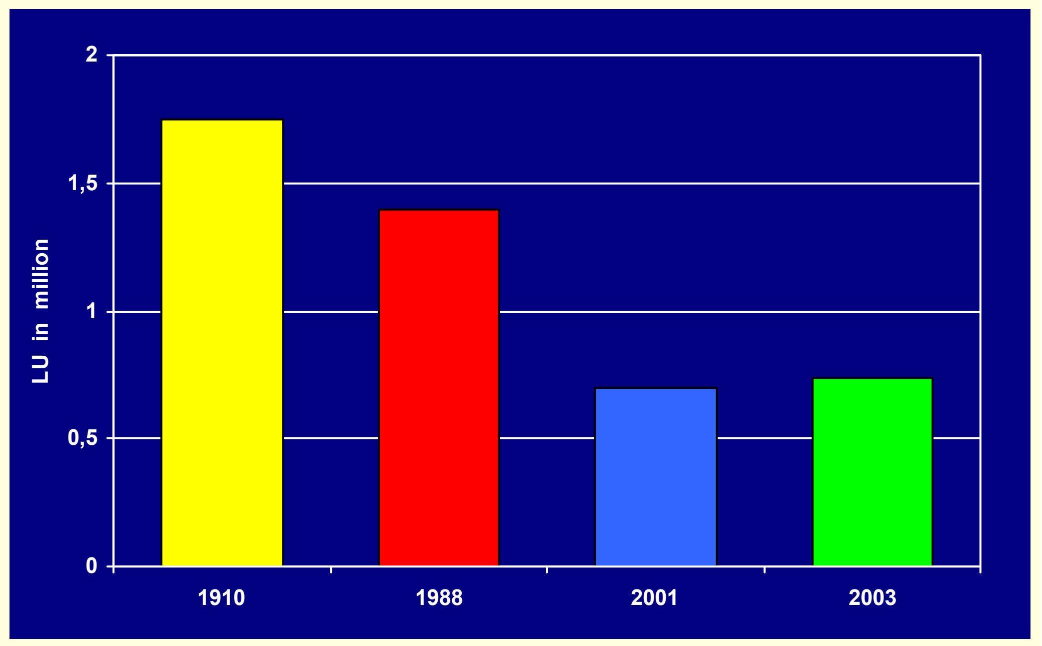


Figure 7 Livestock number in Croatia (Znaor and Karoglan Todorović 2004).

Manure

It is estimated that Croatian livestock produce some 65,000 tonnes of nitrogen and 33,000 tonnes of P_2O_5 annually (UN-ECE 1999) (MZOPU 2002). While in 1991 the Croatian farming sector consumed 16 million tonnes of manure, due to a decreased number of animals, this figure has been reduced to 10 million tonnes in 2001 (Institute for Special Animal Husbandry, 2002). In 2000, only 35 % of the total nitrogen applied originated from livestock manure (Mesić 2002).

3.5. Agricultural inputs

Inputs and agricultural area

Croatia has no comprehensive statistical method of data collection with regard to the use of agricultural inputs. In other words, all sources used provide only partial data with limited reliability. Thus, the official figures can vary a lot, depending on the source of primary data used and the purpose for which it is gathered. However, the most common problem and mistake in these calculations is the surface of agricultural land. As demonstrated in chapter on the land use, Croatia has today some 50% less agricultural land than shown by the Statistical Yearbook. Therefore, calculations on per hectare consumption of agri-chemicals based on this large agricultural land surface do not seem to be feasible and accurate. However, this approach is used with no exception! Thus, no wonder that Croatian authorities and scientists report on relatively low per hectare fertiliser and pesticide consumption (Grgić, Franić et al. 1999; ICID 2001; Igrc-Barčić 2002; MZOPU 2002; MPŠ 2003; VRH 2003). However, the environmental pressure caused by fertiliser and pesticides in Croatia is much greater, since these substances are spread over a relatively small surface.

Another problem related to the assessment of consumption of agri-chemicals is whether to use total agricultural land, utilised agricultural land or arable land. Croatia practices bipolar agriculture. On one hand, there are areas of abandoned or extensively managed land, mostly grassland. On the other hand, arable and permanent crops are managed quite intensively. In practice, grassland in Croatia is hardly ever treated with fertilisers or pesticides. The only areas receiving application of agri-chemicals are arable and permanent crops. Therefore, it is more appropriate to assess environmental pressure of agri-chemicals in Croatia by expressing their consumption per hectare of actually treated arable land and permanent crops or per hectare of arable land.

Because of the varying intensity of agricultural production in different regions, agrichemicals are unevenly spread in Croatia. Regions with plenty of arable land and intensive agriculture (Slavonia, Međimurje, Podravina, etc.) record quite high applications of pesticides and fertilisers, while karstic Croatia with vast areas under (neglected) grassland uses far less of these (Mesić 2002; DZS 2003; Moller 2003).

3.5.1 Fertiliser consumption

Believed to be low and predicted to rise

There is a widespread consensus that the consumption of fertilisers in Croatia is “relatively low” (MPŠ 2003) and “certainly some 30 % lower than before 1990” (MPŠ 2003). In other words, the consumption level of pre-1990 is inter alia set as a reference and desired target that is to be reached again. However, although some studies predicted a sharp recovery of the consumption in mineral fertilisers and a return to pre-1990 levels by 2000 (MPŠ 1996; Grgić, Franić et al. 1999).

DZS data

Croatia has too few figures on agricultural inputs at the farm level and the official statistics consist only of aggregated national figures. The DZS data on fertiliser consumption presented in the Statistical Yearbook are derived from two sources: annual statistical reports from agricultural companies and estimates based on questionnaires carried out among some 9,000 family farms. While the figures for the usage of fertilisers by companies should be quite accurate, estimates based on interviewing representatives of small number of farms are certainly less accurate. The fertiliser data presented in the Statistical Yearbook are incomplete and have been subject to criticism (Mesić 2002). The agricultural census (DZS 2003) does not give information about the quantity of fertilisers consumed, but it does give figures on the land area treated. According to these, fertilisers are spread on as much as 755,517 hectares- a surface that is equal to 70% of the total UAA or 93% of arable land.

The fertiliser data in the Statistical Yearbooks (DZS 2003; DZS 2004) are expressed as the total quantity of fertilisers used, by both family farms and companies. Unfortunately, this figure does not tell us much about the environmental load of fertilisers, as it is not expressed in terms of active ingredients. Different types of fertilisers contain different quantities of nutrients (N, P_2O_5 and K_2O). Thus a figure indicating consumption of 100 kg fertiliser gives no idea about how many nutrients were loaded into the environment. For instance 100 kg of urea fertilisers contains 46 kg N, while the same amount of calcium ammonium nitrate (CAN) contains only 25-28 kg N -just over half as much. In both cases, consumed is 100 kg fertiliser, but the consumption of nutrients is quite different The quantity of fertilisers consumed, expressed in terms of active ingredients is given only for companies and a similar figure for the private sector cannot be obtained by the DZS.

Nevertheless, the DZS data indicate that the consumption of fertilisers in Croatia in the period 2000-2002 was stable (in average 416,000 t), with the difference between the year with the lowest and highest consumption being only 8%.

FAO data

FAO statistics give also data on fertiliser consumption in Croatia (FAO 2005). However, FAO figures are expressed as nutrients and are approximately four times higher than figures on nutrients reported by the DZS in the Statistical Yearbook. This is because DZS gives data only on nutrients used by the agricultural companies. FAO statistics are based on the figures provided by Petrokemija (Deur 2004; Piršić 2004) - the sole Croatian fertiliser producer and biggest fertiliser trader. Therefore, FAO statistics do not include fertiliser quantities imported and distributed by other companies. As the FAO calculates fertiliser consumption per agricultural year (July 1- June 30) this also causes some difficulties in comparing its figures with those from the Croatian statistics, which are always recorded per calendar year. FAO figures also indicate quite a stable use of mineral fertilisers over the last couple of years.

Data from recent studies

According to a recent study assessing agricultural impact on water in Croatia, conducted by experts from the Faculty of Agronomy at the University of Zagreb (Mesić 2002), in 2000 Croatia consumed 505,000 tonnes of fertilisers (or 215,000 of nutrients). This figure is much higher than the figure shown in the Statistical Yearbook (403,316 t total fertiliser)! Data for this study were also largely provided by Petrokemija and its results have been already been quoted in some policy documents (Moller 2003; MPŠ 2003; FAO 2004).

3.5.2 Pesticide consumption

No reliable statistics

It is very difficult to obtain reliable statistics on pesticide consumption in Croatia, as there is no organisation responsible for keeping track of this. Pesticide consumption is also not reported in the Statistical Yearbook and DZS has no data related to pesticides. Some policy documents suggest that the consumption of synthetic plant protection agents in Croatia has been quite stable over the last couple of years, amounting to approximately 3,300 tonnes of active ingredients per year (MZOPU 2002; MPŠ 2003). The MPŠVG's Department for Plant Protection estimates that the use of pesticides in Croatia is between 7,200-9,000 tonnes (Moller 2003). According to census data, pesticides are spread at least once a year on as much as 656,426 hectares - a surface that is equal to 61% of the total UAA or 82% of arable land (DZS 2003). Herbicides seem to account for 50-60% of all agents used, while fungicides make up 35-45% and insecticides only 5-6% (MZOPU 2002). Currently there are some 700 approved pesticides (based on some 280 active ingredients) on the Croatian market. Illegal pesticide trading/smuggling from neighbouring countries is a problem that occurs due to cheaper prices abroad. This practice is known to the public, but the quantities of illegally imported pesticides are never estimated and/or reported.

Pesticide consumption higher than EU average

Although Croatian plant protection specialists suggest that the use of pesticides per hectare in Croatia is approximately 2.5 times lower than in the EU (Igrc-Barčić 2002), this does not seem to be the case. A recent calculation (Znaor and Karoglan Todorović 2004) shows that when calculated per actual surface of arable land, Croatian pesticide consumption in the period 1999-2003 amounts to 4.2 kg of active ingredients per hectare of arable land. This is substantially higher than the figure of some 3 kg that can be found in other recent documents (Znaor 2002; Moller 2003; WRI 2003). The new data from EUROSTAT (EUROSTAT 2003), suggest that the average pesticide consumption in 1999 (last year with complete statistics) for EU-15 was 3.1 kg of active ingredients per hectare of arable land. In the same year, Croatian consumption was 3.6 kg- a mere 16% higher than the average of the EU-15. However, the average pesticide consumption in the EU-15 has most likely lowered in the meantime. This is because several EU countries (notably Benelux and Scandinavian) have initiated serious national pesticide reduction programmes since then. In addition, new pesticides containing less active ingredients are being applied and a number of farms have been enrolled into agri-environment programmes. However, during this time consumption in Croatia has remained quite stable.

3.5.3 Machinery and irrigation

Outdated machinery

The machinery used is outdated and inappropriate for modern agricultural operations (MPŠ 1996; MPŠ 2003). The average age of the tractors used in Croatia is more than fifteen years (VRH 2000), with former co-operatives having substantially younger tractors than private farms, whose average tractor is older than twenty years (UN-ECE 1999). The amount of agricultural machinery in use has been in constant decline since 1994, particularly in the former co-operatives (Sviržnjak 2001). In 2003 these had only 3,934 tractors (DZS 2003), which is equal to only 0.018 tractors per hectare of the companies' UAA, and represents a drop of some 40% in comparison with 1994. At the other hand, the family farms seem to be well equipped. In 2003, these had 86,243 single and 185,954 two-axis tractors (DZS 2003), an equivalent of even 0.21 two-axis tractors per hectare of the UAA cultivated by the family farms. However, this is still some 40% less than in 1995 (DZS 1996).

Poor irrigation

According to the government's figures, up to 1.8 million hectares of agricultural land (50 % of the total) requires drainage systems (UN, 2002). However, these are built on only 600,000 hectares (on 33.5% of the area needed) and only partly on 520,000 hectares, while 670,000 hectares (37.5%) of excessively moist soils have no drainage systems at all (UN 2002). Subsoil pipe drainage has been installed on only 162,000 hectares (out of 823,000 hectares requiring this system (UN 2002). Since almost the entire Croatian drainage system was built before 1990 and has been inadequately maintained, it is in rather bad condition (MPŠ 1996). Only 0.2% of cropland is irrigated (according to the FAO's

AQUASTAT Information System on National Water Extraction from Agriculture (FAO 2003), 0% of total water extracted in Croatia goes to agriculture).

3.6. Environmental impact of agriculture

Environmental impact

Agricultural land covers a considerable part of Croatia's territory and agriculture is by far the biggest single influence on Croatian nature and the countryside. Agricultural activities affect both the quantity and quality of nature and the environment. Agriculture has a substantial impact on soil, water, and air, as well as on species, habitats and landscape diversity.

3.6.1 Perceptions on environmental impact of agriculture

Negligible environmental impact?

For decades, Croatian policy makers and scientists have believed and declared that the state of the Croatian environment is quite good and certainly much better than in most other, notably EU, countries (DUZPO 1999; Grgić, Franić et al. 1999; UN-ECE 1999; VRH 2000; Grgić and Mesić 2001; MZOPU 2002; UN 2002). A similar attitude was held relating to agriculture and the environment. A widespread and dominant belief was that agriculture is not a significant source of environmental pollution and nature degradation, especially when compared with other countries (RH 1998; UN-ECE 1999; VRH 2000; RH 2002; UN 2002). The 1998 "Report on the state of environment" (RH 1998) does not at all list agriculture among the sources of environmental pollution, while the latest review on the state of the Croatian environment (MZOPU 2003), states: “*Because of the low intensity of production and extensive management, in comparison with other countries, Croatian agriculture is not considered to be a significant source of environmental pollution*”.

Further examples of similar opinions:

- “Although there was no adequate attention paid to the problem of environment protection up until a decade ago, the soil, water and air in Croatia are among the best most preserved in Europe” (Grgić, Franić et al. 1999)
- Agriculture “has a significantly small role as a polluter” (Grgić, Franić et al. 1999)
- “The soil of the Croatian mountainous region is among the cleanest in Europe” (UN-ECE 1999).
- “Compared with other countries, Croatia’s agriculture is not a serious source of pollution” (UN-ECE 1999).
- “…agricultural impact on biological and landscape diversity in Croatia is comparatively better” than in Europe, where this problem is “particularly serious” (DUZPO 1999).
- “Agricultural activities have not caused serious soil or environmental pollution” (UN-ECE 1999)
- Croatian soils are “one of the best preserved in Europe” (VRH 2000)
- “Croatia has the most preserved soils in Europe” (Grgić and Mesić 2001)
- “In agriculture there is, however, a relatively low level of production intensity which has little significance in soil pollution (Grgić and Mesić 2001).

- “Because of its low intensity of production and extensive management, in comparison with other countries, Croatian agriculture is not considered to be a significant source of environmental pollution” (MZOPU 2002).
- “Today, agriculture is not a serious source of pollution in Croatia” (MZOPU 2002).
- “Agriculture does not cause any significant pollution of soil or environment” (RH 2002).
- “Although nowadays agriculture is mentioned as a potential source of pollution of surface and ground water, due to low consumption of mineral fertilizers and chemicals, in particular on private farms, surface and ground water in Croatia is not seriously burdened from this source” (UN 2002). An identical text appears also in the report made by the International Commission on Irrigation and Drainage (ICID 2001).
- “Due to low consumption of pesticides and fertilisers, surface and ground water in Croatia is not polluted by the substances deriving from these agents” (UN 2002).
- “The level of pollution from agricultural production is moderate” (UN 2002)
- “The consumption of fertilisers in Croatia is relatively low” (MPŠ 2003).

In the recent accession document submitted to the EC the Croatian government declares that Croatia has no special measures for the reduction of fertiliser and pesticide use, since “the use of these products in the Republic of Croatia is below the European average” (VRH 2003). The same opinion is shared by the key pesticide industry leaders. Čović for instance (2004) states that Croatia «uses slightly more pesticides than Albania». Mesarić stresses that Croatian farmers use 50% less fertilisers than those in EU (Mesarić 2004) and that Croatia should be using at least 1.2 million tonnes of fertilisers (Mesarić 2003; Mesarić 2004), which is more than double is uses today. Key agricultural media also stresses that due to the low use of agri-chemicals, Croatia is one of the most ecologically preserved countries in (Grgurić 2004).

“Superiority” is not well backed-up

The above-mentioned statements require further analysis. In all of these documents, statements appear without any reference to the corresponding studies and data. These conclusions are more assumptions (and wishful thinking), rather than statements drawn from sound research and analysis. Several important policy reports recognise the lack of data and reliable (scientific) monitoring regarding the state of soil and environmental impact of agriculture in general (UN-ECE 1999) GRC, 2000).

The Environmental Performance Review (UN-ECE 1999) for instance states that Croatian agriculture is not a serious source of pollution and praises the environmental state of the Croatian soils. However, the same document states that due to the "absence of a soil inventory and of regular soil monitoring..." "...the true condition of the soil is practically unknown". The Report for the Food Summit prepared by the Croatian government (UN 2002) also states that the Croatian soils are “one of the best preserved in Europe”. However, the same document, just two sentences further, concludes that “analysis shows that in spite of relatively low contamination levels, damage in the pedosphere has reached a level which requires investigation and measures for the protection and preservation of soil quality”. It is interesting to notice that almost identical text has already appeared in (Grgić, Franić et al. 1999), several years earlier. This indicates that some of the text appearing in official documents has been “recycling.

Environmental degradation is caused only by big farms?

Even if agriculture was recognised as a source of (potential) environmental pollution and nature degradation, it was believed that the problem does not lie with the family farms, which occupy majority of agricultural land, but rather with the agricultural companies (mostly former co-operatives) (DUZPO 1999; Grgić, Franić et al. 1999). According to Grgić *et al*. (Grgić, Franić et al. 1999) these operations “use more of the potentially harmful inputs (fertilizers, pesticides, fossil/solid fuels) and have larger livestock farms (harmful gases and waste). However, since “agricultural development in Croatia is not based on large-scale farms that could possibly be greater polluters of the environment“ (Grgić, Franić et al. 1999)- consequently the total (possible) polluting effect of agriculture is thought to be negligible.

Changing attitude

However, things have been slowly changing. A deeper analysis raises doubts as to whether Croatian agriculture is as environmentally friendly as it was thought to be. Some recent studies question the environmental “friendliness” of Croatian agriculture (Znaor 2002; Moller 2003), while a recent FAO document on rural development in Croatia concluded that the situation concerning the environmental impact of Croatian agriculture “is far away from being satisfactory” (FAO 2004). A recent agri-environment programme for Croatia (Znaor and Karoglan Todorović 2004) has highlighted heavy use of pesticides and fertilisers in Croatia. However, the data presented in this report were heavily criticised by the fertiliser industry and academics linked to it (Hrvatsko tloznanstveno društvo 2004; Maceljski 2004; Petrokemija 2004; Petrokemija 2004; Petrokemija/AF 2004). Moreover, the MPŠVG was requested not to accept presented calculations (although just few months later, MPŠVG issued its annual report (MPŠVG 2004) in which it recognised the basis of the calculations provided by Znaor and Karoglan Todorović (Znaor and Karoglan Todorović 2004)).

Promising recent developments

However, several recent developments indicate that Croatian policy makers have been taking an approach to the subject that is somewhat more critical. A good example is a recent President’s speech on agri-environment programme for Croatia (Mesić 2004). Awareness of the causal link between agriculture and the environment/nature (regarding both small and large farms) is slowly taking root in Croatia, too. Several recent policy initiatives are quite encouraging. These include work on several regulations, introduction of some new economic instruments (e.g. subsidies for local breeds and organic farming) and important institutional changes (e.g. within MPŠVG and the extension service). Besides, the government has initiated several interesting international projects dealing with protection of the environment/nature and agriculture (DZZP 2004; FAO/MPŠVG 2004). A positive change can be noticed among the scientific and NGO communities, too. Whereas earlier, environmentally oriented scientists and NGOs have perceived agriculture, farmers and agronomists as "enemies", now there is a slow shift in their attitude. The opposite is true, too. For many farmers and agronomists, environmentalists are no longer just dreamers wishing to abolish agriculture, but a concerned group whose remarks are relevant for the future of agricultural sustainability.

The above-mentioned clearly indicates a positive evolution in attitudes regarding agriculture and the environment. This development is quite encouraging and creates a favourable momentum for the introduction of concepts like organic farming.

3.6.2 Biodiversity

Loss of biodiversity

Farmland, especially grassland and meadow orchards are very biodiversity rich habitats, hosting numerous valuable species. Agriculture also shapes the landscape and influences its quality and character.

The changes in farming practice that have taken place during the last decades are mainly a result of intensification of farming. These comprise the specialization of production, a decrease in traditional farming, the use of high quantities of industrial fertilisers and plant protection preparations, narrow crop rotations, changes in the types of crops grown, loss of field boundaries, etc. Intensive farming increases environmental pressures including soil erosion, loss of organic content, water pollution and a decreased number of wildlife species. The scheme will be applied on arable land and therefore will target Croatian areas with the most intensive farming practices (Slavonija, Baranja, Međimurje, etc.). These areas have lost a considerable part of their landscape characteristics and consequently a number of wildlife habitats. In addition, these are the areas with the highest mineral fertilizer and pesticide use.

Ironically, in Croatia both intensive and extensive agriculture have an adverse impact on landscape, habitat, species and genetic diversity. Intensive use of agri-chemicals, as well as reduction of the genetic pool caused by narrow crop rotations, lack of mixed-cropping and the use of limited number of breeds and varieties have had a significant negative impact on biodiversity (MZOPU 2002). Drainage of wetlands (among most important in Europe) and their conversion to arable land, as well as removal of hedges and trees from agricultural land has had a negative biodiversity impact, too (DUZPO 1999). Although Croatia has numerous local breeds and crop varieties, these have been replaced by modern stock that is likely to better suit the demands of the modern market. (MZOPU, 2002). Some less favoured areas and less-productive breeds, and crop varieties have been neglected or left out from production all together. All this has resulted in monotonous landscapes, and a decrease in genetic, species and habitat biodiversity.

Other losses of biodiversity

The narrow crop rotation that is practised by most Croatian farmers and co-operatives is considered to have a negative impact on soil fertility and biodiversity (DUZPO 1999), although small farms with fragmented plots provide a good starting position for nature protection. In the period 1945-1990, huge grassland and wetland areas were reclaimed and converted to arable land. During this operation a thousand kilometres of hedgerows, stonewalls and farm woodlands have been removed, that used to be part of the traditional Croatian landscape. Unfortunately, many private farmers have also lost touch with nature and have eradicated valuable habitats and landscape elements from their farms, too. Besides, some less favoured areas (e.g. terraces and steep slopes), less-productive breeds, and crop varieties have been neglected or left out from production all together. All this has resulted in monotonous landscapes of some regions, and a decrease in genetic, species, habitat and landscape biodiversity.

The Ministry of environment claims that due to the small size, extensive management and numerous small plots "with rich hedges" and "vast pastures", family farms (particularly those in the western, mountainous and karst regions) do not pose any treat to biodiversity (DUZPO 1999). According to the same source, the remaining structures of the ex-cooperatives, mostly situated in the eastern part of Croatia and practising intensive agriculture are associated with poor biodiversity. These operate on large fields that were converted into monoculture arable land and are "without hedges and groves that would at least slightly mitigate the effects of a disastrous reduction of the biological and landscape diversity" and "the consequence of such management, combined with the excessive use of chemicals, is the considerable degradation of land" (DUZPO 1999).

Undergrazing problems

Due to the lack of livestock both organic soil matter and grassland biodiversity is in decline in Croatia. The stocking density is particularly low in areas of high natural value (Znaor and Karoglan Todorović 2004). This results in reforestation and the loss of species-rich grasslands and the open landscape important for migratory birds and many other species. The under-grazing also prevents the beneficial influence of animals on biodiversity, such as species selective grazing, seed dissemination, re-rooting of pasture flora, maintenance of soil organic matter, pest and disease control, etc. According to some estimates, in the period 1992-2002, bush re-encroachment has taken place on approximately 300,000 hectares (Moller 2003). However, this figure seems to be severely underestimated, as in the same period more than 400,000 hectares of arable land alone remained uncultivated and exposed to invasion by bushes. Most animals in Croatia (with the exception of sheep) are kept in stables all year round (DUZPO 1999). This practice together with decline in the number of animals does not allow for efficient utilisation of grassland. This has impoverished biological and landscape diversity, threatening the existence of numerous plant and animal species associated with grassland ecosystems and/or management practices (DUZPO 1999). This problem is particularly pronounced in the biodiversity-rich karst and mountainous regions (DUZPO 1999).

3.7. Agricultural outputs and employment

3.7.1 Production volume and yields

The national agricultural output is still approximately 30% lower than in 1990 (DZS 2003; VRH 2003), before Croatia's independence and a shift to market economy. The topic on agricultural production volume and yields is further elaborated in Chapter 4.

3.7.2 Agricultural trade balance

Great food importer

The former state-owned agrokombinats still dominate food processing and distribution. Their restructuring resulted in huge declines in agricultural production and processed food that is now being compensated for by imports. Croatia is a substantial food importer! Since independence (1991), Croatia has been facing an accelerated growth in import value for agricultural and food products. Agricultural imports increased from $400 million in 1993 to $865 million (average imports from 1997 to 1999). For the same period, agricultural exports increased only marginally- from $497 million to $506 million (MPŠ 2000; USDA 2002). The average annual deficit in agricultural and food trade at the end of 90s was about $411 million or approximately 20% of agricultural GDP (DZS, 2001). For the same period, the average agricultural and food imports accounted for about 40-50% of the agricultural GDP. The value of imported agricultural products grew approximately 40% between 1997 and 2000 (USDA 2002).

Agriculture enables survival (food and some income) for approximately 500,000 rural inhabitants. These people are not formally registered as employed, but are rather subsistence farmers. In addition, agriculture provides free food for numerous urban inhabitants who have relatives in the village or practice some form of part-time farming or urban gardening on their own.

In the period 1991-2001 Croatia imported over $10 billion in food (Hedl 2001). This is an exceptionally high amount taking into account that Croatia's average annual budget for the same period was just slightly over $9 billion. In 2000 Croatia spent approximately 1 billion dollars on imported food, which accounts for 5% of GDP (DZS, 2001). Almost half of the imported food originates from the EU (USDA 2002), while the countries of the former Yugoslavia account for 15% and Hungary for an additional 10% (VRH 2000).

Insufficient in agricultural commodities

In the last ten years, Croatia has been self-sufficient in only five products: wheat, maize, eggs, poultry meat and wine (MPŠ 2000). Livestock production accounted for 43% of gross agricultural output in 2001 (DZS 2003), but the Croatian self-sufficiency index in 2001 for beef was still 6 %; pork 85 % and milk 83% (Moller 2003).

Optimistic officials but scarce land

The officials claim that taking into account natural conditions and technological potential, Croatia can produce much more and achieve self-sufficiency for all “strategic” agricultural products and even export them (VRH 2000). However, such statements have to be treated with caution. Although MPŠVG emphasises that with its 0.72 hectares of agricultural land per capita (MPŠ 2003) Croatia exceeds the average for Western Europe, census data suggest that Croatia has only 0.31 ha of agricultural land and 0.18 ha of arable land per capita (DZS 2003). This low figure puts Croatia in the group of countries under 0.5 ha of agricultural land per capita- the FAO's figure for a minimum subsistence level (Znaor and Karoglan Todorović 2004). This is also one of the main reasons why Croatia is a substantial food importer.

3.7.3 Employment

Question of definition

The population census from 2001, suggests that Croatia has an agricultural population of 245,987, of which only 165,942 (67.5%) are economically active in agriculture (DZS 2003; MPŠ 2003). Economically active is defined as the part of the economically active population engaged in or seeking work in agriculture. According to FAO (FAO 2005) the economically active population (labour force) refers to the number of all employed and unemployed persons (including those seeking work for the first time). It covers employers; self-employed workers; salaried employees; wage earners; unpaid workers assisting in a family, farm or business operation; members of producers' co-operatives; and members of the armed forces. FAO's (2003) figure for the Croatian "agricultural population" in 2001 is substantially higher: 370,000 people. This is probably because FAO's category "agricultural population" includes all persons and their non-working dependants whose livelihood depends not only on agriculture, but also on hunting, fishing and forestry (FAO 2003). Here, too- FAO's figure is somewhat higher- 174,000 people.

Farming population in decline

The size of both the rural and agricultural population has been in constant decline. In the period 1991-2001, the number of "active farmers" has dropped by 40% (DZS 2003). In 2001, the rural population accounted for 44.4% of the total population, while the agricultural population accounted for only 5.5% of the total population and for 11% of the rural population in Croatia (DZS 2003; FAO 2003). The figures from the last agricultural census (DZS 2003) indicate that agricultural households have nearly 1.5 million people (34% of total population in Croatia).

Agricultural sector in Croatia employed 8.3% of the labour force in 2002 (DZS 2004). The USDA (USDA 2002) estimates that Croatia has approximately 100,000 full-time private farmers, 400,000 part-time farmers and 33,000 employees in former co-operatives. According to the agricultural census (DZS 2003) 66% of all agricultural household members are engaged in agricultural activities. However, 51% of these do farming only 2 hours a day in average, while only 16% farm more than 6 hours a day in average. Less than 20% of family farms have more than one active member of the family working primarily on the farm itself (DZS 2003). In most cases, farming is part-time job that is often combined with a job in industry or services. The agricultural workforce on family farms consists of middle aged and elderly people who have very poor education. The younger (and usually better-educated) rural inhabitants see farming as a labour-intensive and unprofitable business and tend to work elsewhere. More than 50% of the Croatian farmers are older than 50 years (USDA 2002; DZS 2003). Some 90% of farmers have an education level equal or lower to primary school, while a huge 98% of all farmers do not have any agricultural education at all (DZS 2003).

3.8. Agricultural policy

New support schemes

Most of the governmental support for agriculture and rural areas operates through one of the aid schemes run by MPŠVG. In January 2003, Croatia implemented the Act on State Aid in Agriculture, Forestry and Fisheries (N.N. 2002; N.N. 2003). This act introduced a new subsidy scheme for farming and rural areas. It has replaced an old and quite complicated support scheme, consisting of nearly 150 different subsidies- all of which were production-oriented subsidies and none aimed at supporting environmentally friendly farming practices. The new policy consists of two pillars: production linked direct payments and structural policy measures.

The new policy distinguishes between support measures for commercial and non-commercial farms. In order to be eligible for support, both commercial and non-commercial farms have to be included in the Farm Register at MPŠVG (introduced in 2003). The Farm Register keeps records on production resources, land use, the number of livestock and other important data. All farmers whose production volume is bigger than a prescribed minimum and those who sell their products at the market are obliged to register. By the end of 2003, some 160,000 farms had been included in this register (MPŠVG 2004).

3.8.1 First pillar: production subsidies

Eligible production and subsidy levels

The first pillar is a set of production stimulation measures, providing direct payments (subsidies) basically to commercial farmers. It grants support for the six production categories: arable farming, animal husbandry, plantations (fruits and vineyards), organic farming, game birds and fishery. The subsidy level for each commodity should have been based on the coefficients derived from a standardised gross margin (production value minus variable costs of production). However, these coefficients were only used to determine farm business size and whether the farmer has the minimum size to qualify for a payment. They were not decisive for determining the payment level of the current subsidies. The payment levels were rather results of lobbying and political pressure from various interest groups- therefore no wonder that many subsidies support processing industry, rather than private farmers (Znaor and Karoglan Todorović 2004). While the subsidy for pastures and meadows is linked (coupled) to the requirement of a minimum of 0.5 LU per hectare, there are no similar restrictions for animals. In other words, animal husbandry farmers can obtain subsidies even if landless. This policy is detrimental to environmental protection. The maximum subsidy that can be paid to an individual farm in 2005 will be 267,000 EUR.

The subsidy cannot be claimed for just any production volume. For each of the above-mentioned production categories there is a minimum annual production volume set for the period 2003-2005 (Table 6). This is determined per type of production per individual commodity or production type and is equivalent to some 3 hectares of wheat or 3 dairy cows or various combinations. The objective with arable farming subsidies is to reach production on at least 3 hectares by year 2005. For fruit and vegetables, this target is lower - 0.5 ha. The minimum number for milking cows is 5 animals, while the lowest quantity of cow milk eligible for subsidy is 12,000 litres per year.

The requirement for the minimum production volume is quite low in organic farming. To be eligible for a subsidy organic farmers are required to have at least 0.5 ha and do not have to comply with a minimum area under a particular crop.

Subsidies for LFA

Less favoured areas (LFA) obtain higher premia than other regions. For some commodities, subsidy levels are 35% higher than in other regions, with the exception of cow milk, which attracts 62% higher premia per litre. Organic farmers in LFA receive the same amount as their organic colleagues in non-LFAs. The exception are milking cows, sheep and goat milk for which they receive 35% more per head and cow milk, which receives a 59% higher subsidy per litre of milk.

According to the Agriculture Act (NN, 66/01 and 83/02), the less favoured areas in agriculture include the following:

- hilly and mountainous areas as defined in the Act on Hill and Mountain Areas - NN, Nos. 12/02, 32/02 and 117/03).
- all Croatian islands and the Pelješac Peninsula
- areas with unfavourable hydrologic and pedologic properties (these are yet to be determined by the government)
- the first and second group of areas of special state concern (mostly ex-war areas) as defined by the Act on Areas of Special State Concern (NN, 26/03).

3.8.2 Second pillar: structural policy measures

The second pillar of state aid to farmers is still not fully functioning and only few aid lines have been in operation. The second pillar consists of three schemes:

1. an income support scheme
2. a farm capital investment scheme
3. a rural development scheme

Income support scheme for senior farmers

The income aid model was designed bearing in mind the need to provide additional income for small non-commercial or uncompetitive family farms run by elderly farmers who have not yet reached retirement age, but are paying retirement and social security benefit tax. Eligible for the support under this scheme are all male farmers older than 55 years and all female farmers older than 50 years on farms that are smaller than 3 hectares. Thus, this scheme is regarded as aid during the bridging period between 55 years (or 50 years for female farmers) and retirement. Once entitled to a pension, farmers are no longer permitted to benefit from the agricultural income support scheme. The maximum annual support is 960 EUR per person and this aid cannot be combined with aid from other schemes, except from rural development scheme. Currently some 42,000 farmers benefit from this scheme.

Farm capital investments scheme

The farm capital investments scheme is set up to ease farmers' relations with commercial banks. The scheme provides aid to the farmers who are granted investment loans by commercial banks for the purchase of livestock, establishment of vineyards and orchards, agricultural machinery and equipment, or construction of stables and storage facilities. The aid is limited to 25% of the loan value. The minimum size of bank loan eligible for support under this scheme is 10,700 EUR, while the maximum aid that may be granted under this scheme is 33,000 EUR per applicant per year.

Rural development scheme

The rural development scheme consists of three sub-schemes under Pillar Two. It consists of three sub-schemes supporting:
1) marketing activities enabling a successful product launch
2) the preservation of traditional and protected breeds
3) development of rural areas in general

The second sub-scheme provides support for keeping traditional and protected breeds. The subsidy is paid per head. The payment levels and the minimum quantity eligible for this support are given in Table 3. For particularly endangered varieties whose population is less than 100 individuals, the subsidy level may be increased by 50%. In 2002, the government spent 1.3 million EUR on this sub-scheme, nearly twice as much as in 2001 (MPŠ 2003).

Table 3 Payments for traditional and protected breeds

	unit	minimum unit quantity			EUR
		2003	2004	2005	
Cattle	head	1.00	1.00	1.00	392.16
Horses	head	1.00	1.00	1.00	261.44
Pigs	head	1.00	1.00	1.00	91.50
Sheep	head	1.00	1.00	1.00	45.75
Donkeys	head	1.00	1.00	1.00	78.43
Turkeys	head	5.00	5.00	5.00	11.76

While the first two sub-schemes are already operating, the last one has still to get started. The sub-scheme to support the development of rural areas consists of 16 programme areas. One of these is dedicated to environmental protection of rural areas. This sub-scheme is still in its early phase of development and no concrete projects have been awarded yet. Its design might be changed soon. The National Programme for Agriculture and Rural Areas- a policy document that is soon to be adopted by the Croatian Parliament - requires the government to develop a comprehensive Rural Development Programme. This is to define in detail all measures and aid to be provided under this sub-scheme.

The grants to be awarded under the sub-scheme on rural areas development are subject to public tenders. Financial means for its implementation are to be provided not only by the MPŠVG, but also by counties and municipalities.

Agricultural support budget for 2003

The total state support budget for agriculture, fishery and forestry in 2003 was approximately 300 million EUR and comprised some 90% of the entire MPŠVG budget. Some 98% of the agricultural aid has been earmarked for Pillar One production support subsidies. The farm capital investments scheme receives 0.9%, the income support scheme 0.7% and the rural development scheme only 0.4% of the total budget (Znaor and Karoglan Todorović 2004).

3.8.3 Other support schemes

The former Ministry of Small and Medium-sized Enterprises used to run a support programme providing grants to organic agriculture co-operatives. This aid financed conversion plans, inspection and certification, training and technical advice, as well as product marketing. It was a one-off payment and was limited to 8,000 EUR per co-operative. So far, the support has been granted to 9 co-operatives receiving a 60,000 EUR in total (Znaor and Karoglan Todorović 2004).

3.8.4 Penalties

Apart from stimulating economic instruments (subsidies, grants, etc.), Croatia also has several economic instruments preventing and penalising adverse impacts of agricultural activities on the environment and nature. These include various forms of fines, charges and penalties. A number of these are prescribed by the Directive on the Protection of Agricultural Land from Contamination with Harmful Substances (NN, 15/92) and the Regulations on Plant Protection (NN, 10/94 and amendments). Penalties are laid out for the discharge of agricultural pollutants into water (e.g. direct discharge of slurry or farm wastewater), application of slurry and liquid manure during winter and in excessive quantities, as well as the improper use of pesticides. However, the enforcement of these penalties is inadequate and insufficient. It mostly affects the big cooperatives and hardly touches the private farming sector.

Local authorities prescribe measures for maintaining farmland and its boundaries (hedgerows, field margins, farm roads, etc.). The Act on Agricultural Land and the Act on the Financing of Local Self-Government and Administration Units, allow local governments to penalise landowners and impose upon them a tax for land negligence. However, this practice has not been enforced.

3.9. Organic farming

Early stage of development, but rapid expansion

The Croatian organic agriculture sector is still in an early stage of development but has recorded a very fast expansion over the last two years. Interest in organic agriculture is rapidly increasing among all actors: producers, NGOs, education and research organisations, businessmen and policy makers (Znaor and Karoglan Todorović 2004). According to the latest estimates by the Ministry of Agriculture, Croatia has some 7 000 hectares under organic management (Figure 8), managed by some 250, mostly family farms (Čulo 2005). Cereals seem to account for more than 50% of the total organic production in Croatia.

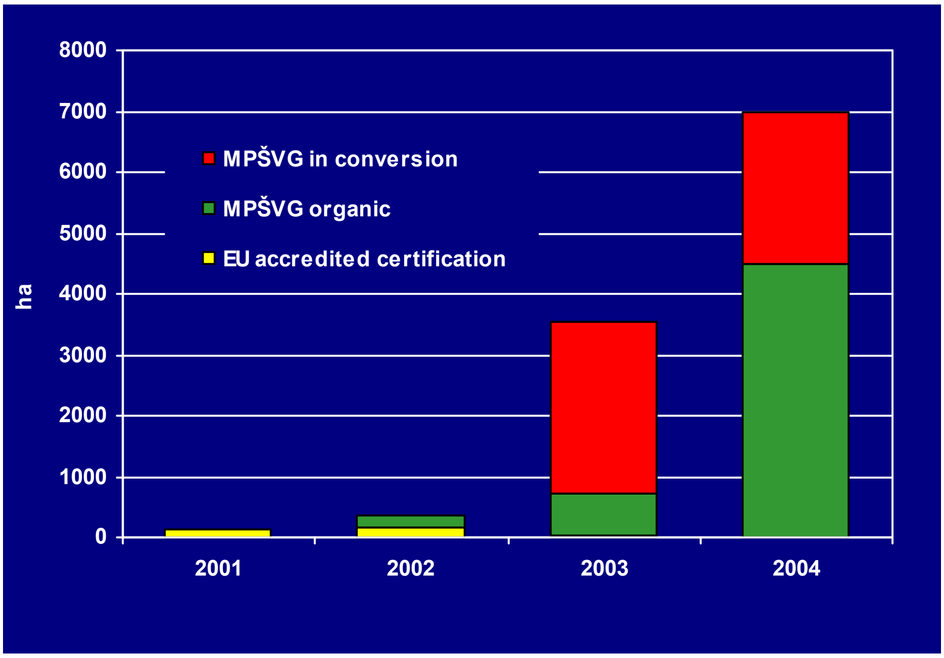


Figure 8. Evolution of organic farming area in Croatia

Organic data collection

There is no structural data collection on organic agriculture in Croatia. Production data are based on the information recorded by the inspection and certification bodies, which have to report to the MPŠVG. The Croatian Statistical Office until now hasn't collected any data on organic farming but preparations have been made to start with collection of some basic production data. Data on the market volumes, imports and exports as well as price statistics are not yet available. Several private market research companies occasionally conduct surveys on consumer's attitudes and behaviour related to organic products.

Many farmers interested

According to the agricultural census (DZS 2003), as many as 2,269 agricultural households and 44 agricultural companies declared they had been preparing for conversion to organic agriculture (or had already converted). Assuming that all these were going to convert the whole surface area of their farms, Croatia would soon have between 4,800 and 11,600 ha under organic management (Table 4 and Table 5).

Table 4 Potential conversion to organic agriculture by private farms

Farm size	No. of potential organic farmers	Potential conversion surface (ha) Best case scenario	Potential conversion surface (ha) Worst case scenario
Up to 0.10 ha	319	32	32
0.11 - 0.50 ha	698	349	77
0.51 - 1.00 ha	351	351	179
1.01 - 2.00 ha	345	690	348
2.01 - 3.00 ha	162	486	326
3.01 - 5.00 ha	180	900	542
5.01 - 10.00 ha	120	1,200	601
10.01 - 20.00 ha	59	1,180	591
Over 20.00 ha	35	1,360	735
Total	2,269	6,548	3,430

Table 5 Potential conversion to organic agriculture by companies

Farm size	No. of potential organic companies	Potential conversion surface (ha) Best case scenario	Potential conversion surface (ha) Least case scenario
Up to 1 ha	4	4	4
2 ha	2	4	2
3 ha	2	6	4
4 - 5 ha	4	20	16
6 - 10 ha	5	50	30
11 - 20 ha	7	140	77
21 - 30 ha	2	60	42
31 - 50 ha	5	250	155
51 - 100 ha	5	500	255
Over 100 ha	8	4,000	800
Total	44	5,034	1,385

Legislation

The Act on Organic Farming (Official Gazette No. 12/01), followed by several related ordinances proclaimed by the Minister for Agriculture (Official Gazette Nos. 91/01, 13/02, 81/02, 85/02, 101/03 and 15/04), has been operative since 2003. However, Croatian organic farming legislation still requires substantial improvement and should be harmonised with that of the EU (Znaor and Karoglan Todorović 2004).

National public policies related to environmental protection and rural development (e.g. *The National Environmental Strategy of 1999, The Strategy and Action Plan for Protection of Biological and Landscape Diversity of 2002, The 2002 National Agriculture and Fisheries Strategy, The 2001 Programme of Sustainable Development of Rural Areas, The 2003 Draft Rural Development Strategy, The 2004 National and Pilot Agri-Environment Programme*) recognize the need to adopt organic agriculture on a larger scale. However, Croatia's regulations that should be regulating and restricting the negative impact of agriculture on the environment and biodiversity are still in an early stage of development (Znaor 2002; Moller 2003; FAO 2004; Znaor and Karoglan Todorović 2004). Some positive efforts have been initiated recently, but in general, there is no comprehensive legislation on this subject yet. Croatia still has to develop codes of good agricultural practice - a set of basic environmental farming measures that are preconditions for any agri-environmental programme. Although the recently adopted law on fertilisers and soil additives obliged the Ministry of agriculture to prescribe codes of good agricultural practices by November 2004 at the latest, this has still not been done.

Institutional base

The institutional base for organic agriculture is established, with:

- a dedicated Unit for Sustainable and Organic Agriculture within the Ministry of Agriculture, Forestry and Water Management;
- the National Board for Organic Agriculture - a think-tank and advisory body to the Minister of Agriculture with a membership composed of public and private institutions, as defined in the Organic Law;
- an Organic Agriculture Accreditation Committee and an Ecolabels Committee, both composed of Government bodies;
- an ad hoc Committee for Organic Production, assigned to adjust the Organic Law.

These institutional structures as well as regulatory instruments are in an early stage of implementation and are subject to change to better adapt to EU accession negotiations and EC Regulation 2092/91 on organic agriculture (Karoglan Todorović and Znaor 2005).

Extension service

The Croatian Agricultural Extension Service is the main agricultural farm advisory service in Croatia. This organisation is independent legal entity, but has to implement the policy of the Ministry of Agriculture, Forestry and Water Management. The Croatian Agricultural Extension Service employs some 150 people and has branches throughout the country. It has recently established a section for organic farming, consisting of eight experts. This group has just begun its work and its experts have been actively acquiring additional training and knowledge on the subject. At present, they are mostly focused on giving advice on conversion. In addition, technical advice on organic agriculture is provided by several NGOs.

Inspection and certification

An inspection and certification system in organic farming has been established and started to operate. Vital in this process is not only the role of the MPŠVG, but also the NGOs and companies appointed to carry out inspections and certification. Croatia has a fully functioning domestic inspection and certification system with six inspection (AgriBioCert, Biopa, Biotechnicon, Croatiainspect, Croatian Forests and PEZ) and two certification (AgriBioCert and Biopa) organizations accredited by the MPŠVG. The costs of inspection and certification are 30-100 EUR/ha, depending on the farm size. Due to complex and duplicative procedures to acquire the organic label the administrative burden is put on farmers. The existing organic inspection and certification system should be simplified and more responsibility and authority should be given to inspection and certification bodies in guaranteeing conformity with organic standards (FAO 2005).

Government projects

In 2002 the government announced a programme that would initiate organic production on de-mined agricultural land (VRH 2002). However, so far no concrete projects have been started. The FAO and MPŠVG have jointly produced a strategy for organic farming (FAO/MPŠVG 2004). It envisages conversion of 10% of the UAA to organic management.

Donors

There have been several internationally funded projects on organic agriculture in Croatia in the last couple of years. Most of these projects have focused on the war-affected areas of Slavonija (Osijek) and Dalmatinska Zagora (Knin). These projects have been primarily focused on extension, certification as well as production and processing of organic products for export to the EU market. Foreign investments in the organic farming sector in the period 2000-2005 are estimated to be at about 2.7 MEUR and have been financed by the Netherlands, Swiss and Italian government, as well as by the FAO and Regional Environmental Centre based in Hungary. In the same period, the national and regional governments have invested an additional 1.5 m EUR in the form of various subsidies and promotion programmes (Karoglan Todorović and Znaor 2005).

Organic NGOs

The organic NGOs have done a major job in promoting organic agriculture in Croatia (Karoglan Todorović, Znaor et al. 2000; Znaor 2003). Their work encompasses a wide range of activities, such as training and education, publishing, consultancy, inspection and certification, awareness campaigns, etc. However, their limited political influence, manpower and financial means are their main obstacles for initiating further changes. At present there are some fifteen NGOs that are specialised in organic agriculture. However, the trend of flourishing new NGOs dealing with various forms of organic agriculture has slowed down. With some exceptions, most of the existing NGOs are voluntarily driven and lack professional capacities and infrastructure to run serious projects. Most are also active only in their specific region, and very few act on the national level (Znaor and Karoglan Todorović 2004; Karoglan Todorović and Znaor 2005).

3.9.1 Organic subsides

Subsidies available

From January 2003 the government introduced subsidies to support organic farming. The introduction of the organic farming subsidy had an immense impact on the development of this sector. The area under organic management in 2003 increased by about 10 times as compared with 2002. All registered organic farmers (both in conversion and fully converted) are entitled to subsidies. Depending on the type of production, these are 30%-140% higher compared to conventional farming (Figure 9). The only exception is sugar beet and field (industrial) vegetables where the premium is equal for conventional and organic production. Organic farmers can also receive subsidies for poultry, lambs and kid-goats, while conventional ones are not entitled to this support. However, subsidy rates for different organic production types seem to be inconsistent. Orchards and vineyards for instance receive the same payment rate per hectare (392 EUR) as cereals or fodder crops. On the other hand, meadows and pastures receive only 17 EUR - an amount that does not seem to adequately compensate for the income foregone and additional costs incurred. Although the organic (as well as all other farming subsidies) in Croatia appear to be high, the reality is slightly different. These subsidies are just hypothetical! In practice there are always more subsidy claims than the MPŠVG can accommodate in its budget. Consequently, the MPŠVG pays only a portion of these hypothetical subsidies and in the period 2003-2005, Croatian farmers (both organic and conventional) received about 60 per cent of the hypothetical subsidy levels. This practice makes potential organic farmers less enthusiastic about conversion, which bears some additional costs, notably those related to inspection and certification.

Regional subsides

The current administrative and legal system in Croatia allows regional authorities (Counties) to introduce their own subsidy programmes for agriculture and rural development. Therefore, farmers in some counties, beside the subsidies issued by Ministry of Agriculture, Forestry and Water Management, also receive subsidies awarded by their regional authority. These subsidies differ from county to county and are in the range between 150 and 700 EUR per hectare, depending on the crop. Besides, several counties are covering inspection and certification costs for organic farming. These are paid either to organic farmers or directly to inspection organisations.

Table 6 Subsidies in conventional and organic farming

		Conventional				Organic
	unit	minimum unit quantity			EUR[h]	EUR[h]
		2003	2004	2005		
Bread cereals	ha	3.00 [a]	3.00 [a]	3.00 [a]	215.69	392.16
Fodder cereals	ha	3.00 [a]	3.00 [a]	3.00 [a]	163.40	392.16
Oil crops	ha	1.00 [b]	2.00 [b]	3.00 [b]	294.12	392.16
Fodder crops	ha	1.00 [c]	2.00 [c]	3.00 [c]	163.40	392.16
Sugar beet	ha	1.00	2.00	3.00	392.16	392.16
Vegetables	ha	0.50 [d]	0.50 [d]	0.50 [d]	163.40	392.16
Field (industrial) vegetables	ha	0.50 [d]	0.50 [d]	0.50 [d]	392.16	392.16
Herbs	ha	0.50 [e]	1.00 [e]	1.00 [e]	163.40	392.16
Vineyards	ha	0.25	0.25	0.25	163.40	392.16
Orchards	ha	0.50 [c]	0.50 [c]	0.50 [c]	163.40	392.16
Olive trees	tree	50.00	50.00	50.00	2.09	2.72
Olive oil	litter	100.00	100.00	100.00	0.52	0.68
Pastures and meadows [f]	ha	-	-	-	13.07	16.99
Milking cows	head	3.00	4.00	5.00	104.58	135.95
Suckling cows	head	15.00	20.00	25.00	196.08	343.79
Poultry	head	-	-	-	-	2.61
Lambs and kid goats	head	-	-	-	-	3.92
Sheep and goats for breeding	head	15.00	20.00	25.00	26.14	33.99
Fattening pigs	head	25.00	50.00	80.00	13.07	16.99
Sows	head	5.00	7.00	10.00	39.22	50.98
Cow milk	litter	6,000.00	9,000.00	12,000.00	0.08	0.11
Sheep and goat milk	head	1,500.00	2,000.00	2,500.00	0.13	0.17

[a] Minimum 3 ha under all cereals, but not less than 1 ha under a single crop

[b] Minimum 1-3 ha (depending on year) under all oil crops, but not less than 0.5 ha under a single crop

[c] No minimum per crop/fruit type area is required

[d] Minimum 0.5 ha under all vegetables, but not less than 0.25 ha under a single crop

[e] Minimal area for each single crop (herb)

[f] Linked to a minimum stocking rate of 0.5 LCU/ha of pastures and meadows

[g] Minimally required is 0.5 ha, regardless the type of crops produced. No min. requirements for livestock

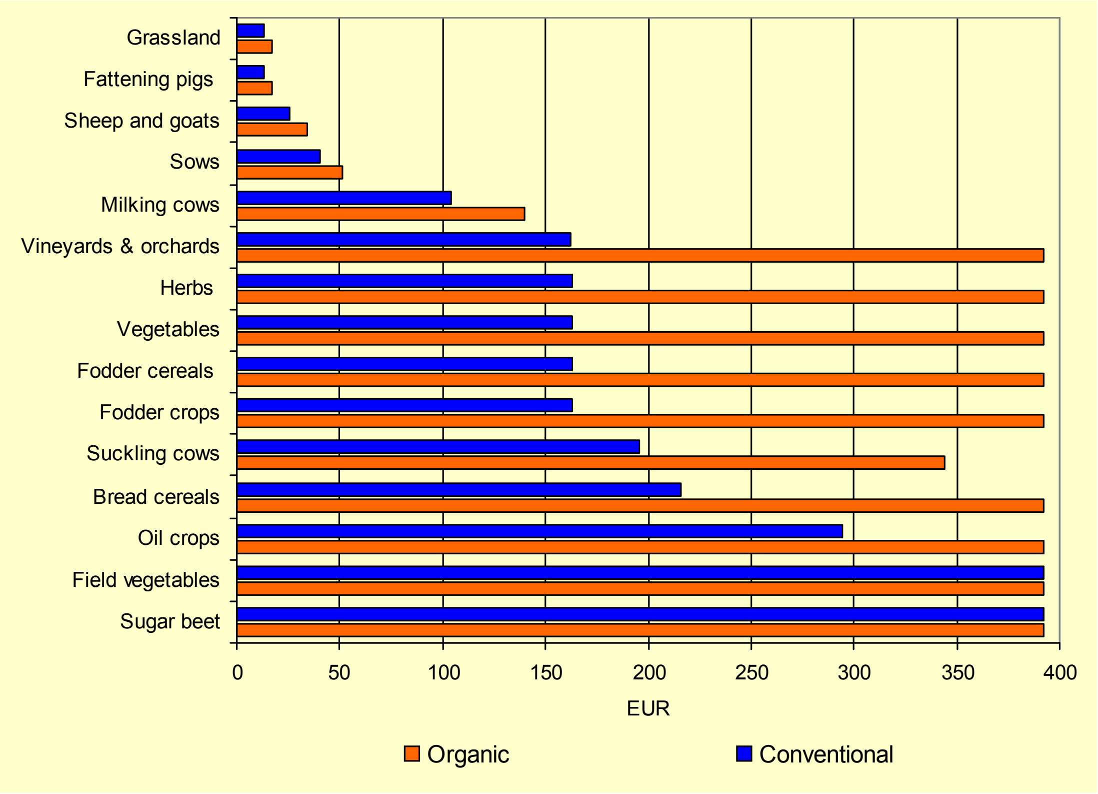


Figure 9 Comparison of subsidies for organic and conventional production for selected commodities.

3.9.2 Organic market

Organic market

Neither data on the organic market nor a thorough market analysis exists and the value of the Croatian organic food sector is difficult to estimate. There are numerous importers of organic produce and the statistics on the quantity and market value of the imported organic food are not available. Almost all organic products are sold on the domestic market either directly at the farm and farmers markets or at numerous health food shops. Almost all supermarket chains also sell organic products but most of these are imported. The imported organic food includes pasta, cereals, juices, sweets, biscuits and soya products. Hardly any shops sell organic fruits, vegetables, or meat and dairy products. Some Croatian organic farmers have tried to make arrangements with the big supermarket chains. However, it turned out that they couldn’t meet the supermarket chains’ demands in terms of quantity, quality (e.g. uniform appearance) and especially regular supply (Karoglan Todorović and Znaor 2005). Only a few organic producers export their goods, mostly herbs and spices. The total export value in 2003 was about 0.65 million EUR (Znaor 2001; Karoglan Todorović and Znaor 2005). Due to the low bulk of produce, there is hardly any organic processing taking place.

Price

The price of Croatian organic food differs a lot, depending on the product, farmer, and season, as well as the supply and demand. Some organic products attract an extremely high premium price (e.g. organic products can be sold for a price that is > 150% higher than conventional ones). However, most organic products still seem to be sold as conventional, or obtain a 20-40% higher price than the conventional ones.

Consumers

Consumer awareness on organic agriculture is still very weak and this point requires further attention. The link between organic agriculture and the environment/nature protection is missing too. Both the public and experts know very little about the fine links between society and agriculture. Health, fashion and ideological reasons, rather than nature and the environment are the driving forces for organic consumers (Znaor 2001; Karoglan Todorović and Znaor 2005). The current organic logo has never been promoted and is thus not well recognised by consumers.

4. GDP OF FARMING AND FULS

4.1. Croatian GDP

GDP definition and size

Croatian GDP is calculated by the Central Bureau of Statistics applying internationally accepted methodology used by the UN System of National Accounts - SNA 1993 and the European System of National Accounts (DZS 2003). The GDP in Croatia is expressed as the sum of the gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products (DZS 2003). According to the statistics, the average annual GDP in the period 2001-2003 was 24.18 billion EUR or 5.451 EUR per capita (DZS 2004).

GVA from agriculture

Agriculture represents an important component of the Croatian economy, accounting for 6.8% of and employing 5.5% of the labour force GDP (DZS 2003). Other sources indicate that the economic importance of agriculture is even higher, estimating that its gross value contributes around 10% to total GDP (EC 2004). A strategic development document produced by the Office of the President of the Republic of Croatia states that agriculture is "*justifiably proclaimed as the most important economic sector in Croatia*" (UPR 2000). According to the same document, agriculture is linked to the chemical, fertiliser and oil industries, production of veterinary drugs, transport, tourism, etc. Therefore, it is estimated that as much as 45 % of production in Croatia is linked to agriculture (UPR 2000).

4.2. Problems with calculation of the value added of Croatian farming

Unreliable value added from farming

The official reports of DZS (2003; 2004) and MPŠVG (2003; 2003; 2004) do not specify the value added by Croatian agriculture. The value added reported under code A.01 of the national classification of economic activities (NCEA) includes forestry and hunting in addition to agriculture (farming). This aggregation makes it impossible to determine the value added by farming alone. Another problem is that the present figures on value added from the agricultural sector (including forestry and hunting) seem to bear little resemblance to reality due to the following reasons:

1. Intermediate consumption is based on very old figures. The intermediate consumption in farming is calculated from the farm data on GMs and fixed costs. At present, none of the institutions in Croatia seems to have calculated the average national GMs for different crops and livestock production (Grgić 2005; Njavro 2005; Šutalo 2005; Žimbrek 2005). The Faculty of Agriculture of the University of Zagreb does have some GM calculations. However, these are made for specific (often large) agricultural enterprises (Grgić 2005; Njavro 2005) and thus do not reflect the national average. In determining the intermediate consumption of the agricultural sector (in order to calculate farming value added at the national level), DZS simply applies a 45 percent flat rate across the estimated overall farming output (Kiš 2005). The 45 percent rate is extrapolated from the data obtained from a survey made more than fifteen years ago, still during

the state-planned economy of the former Yugoslavia (Jurišić 2005; Šutalo 2005). Needless to say, these figures require an update and such an approach is most likely to result in unreliable data, especially if one bears in mind that the prices of a number of agricultural inputs of the centrally planned economy were heavily subsidised.

2. Farming value added is calculated from the non-existent agricultural area of 3.15 million hectares, instead of the current 1.08 million hectares actually used for farming according to the agricultural census (DZS 2003).
3. Family farms are not obliged to do bookkeeping. A vast majority of family farms in Croatia are not registered as business entities. Instead, these are just inscribed in the Farm Register of the MPŠVG and as such are not subject to compulsory bookkeeping. Therefore no authority in Croatia has a sound overview of the financial performance of family farms. Consequently, the value added they create remains unknown! Exceptions are agricultural operations that are registered as companies. These are, like any other legal entity in Croatia- subject to fiscal and financial inspection and thus required to do the bookkeeping and to submit financial reports to FINA.
4. Reported value added from farming includes various non-farming activities. A number of big companies listed under NCEA A.01 are, besides primary agricultural production (farming), involved in several other economic activities, notably food processing, wholesale and retail (of all kinds of commodities), tourism, etc. Although farming makes up just a part of their business, their entire income and expenditure is reported under NCEA code 01. In other words, these companies are formally (*de iure*) registered under NCEA code A.01, but in practice (*de facto*), their value added is created through a variety of economic activities, of which farming is sometimes just a minor part (Šutalo 2005; Viduka 2005). This situation has some historical roots. Most of these “mixed” companies are former agricultural-cooperatives. They’ve in the meantime undergone a major re-structuring and business re-orientation, but decided to keep the old company name (e.g. because of the good image among customers, brands, etc.) and the registration number belonging to NCEA code A.01.

Not in tune with the EU methodology

A further problem with the current Croatian calculation of value-added from farming is that it doesn’t make adjustments for the economic categories required by the EU methodology on economic accounts for agriculture (EC 2004; EUROSTAT 2004) to be taken into account, such as:

Losses: field, harvesting and other losses occurring on farms due to the perishable nature of the products, weather influences, such as frost, drought, etc.

Initial stocks: finished or semi-finished stocks of products existing at the beginning of the reference year.

Intra-unit consumption: goods subjected to treatment and processing and their by-products which are sold by one agricultural unit to other units (e.g. animal feed, organic manure, seeds, wine grapes and olives used for processing, etc.).

Processing by producers: quantities produced for further processing (e.g. milk processed to make butter or cheese, apples processed to make apple must or cider, etc.

Own final consumption: products consumed by the farmers' households which produced them and products stemming from the agricultural unit (holding) and used for payment in kind in the form of remuneration paid to holding workers or exchanged for other goods.

Own-account produced fixed capital goods: these include work done (e.g. use of labour, machines and other means of production) for the own-account establishment of plantations and animals transferred to the account of fixed capital.

Final stocks: stocks of finished products or work-in-progress and at the end of the reference year.

Change in stocks: change in stocks during the reference year.

Problem is recognised

The above-mentioned shortcomings and inaccuracy regarding the present methodology employed to calculate value added from Croatian agriculture is recognised by the key institutions concerned and involved in measuring the farm business size in Croatia: DZS (Šutalo 2004; Crnogorac 2005; Kiš 2005; Šutalo 2005), MPŠVG (Jurišić 2005), HGK (Gelo 2005) and AF (Franić 2005; Grgić 2005; Njavro 2005; Žimbrek 2005). However, various limitations related to the institutional settings of these institutions and above all the lack of political interest in reliable statistics seems to have prevented more accurate calculation so far.

4.3. Methodology

Calculation method for this study

For the purpose of this study, the contribution to national added value has been calculated for the farming sector, as well as for the linked farm-upstream economic activities. The methodology applied involves three steps:

1. Selection of relevant economic activities according to NCEA
2. Quantification of agricultural inputs and outputs
3. Calculation of value added by farming and FULS

4.4. Selection of relevant economic activities

NCEA

All Croatian business entities (organisations) are assigned a code from the NCEA list. This code shows the nature of organisation's business and is determined on the basis of its predominant economic activity. A selection of economic activities that are believed to be linked with farming and farm-upstream goods and services is made from the official Croatian NCEA list (N.N. 2003).

4.5. Value added from farming sector

Calculation from the scratch

As the official figures of added value from the Croatian farming sector are not reliable, this had to be calculated from scratch. In order to be able to perform this calculation it was necessary to estimate the agricultural output, intermediate consumption and fixed costs. The gross value added of Croatian farming was calculated by subtracting agricultural output from intermediate consumption as laid down in the EUROSTAT methodology on economic accounts for agriculture (2004). The calculation presented in this study concerns only the primary agricultural production of crops and livestock. Processing of agricultural commodities, as well as any other economic activities of agricultural holdings (e.g. tourism) is not taken into account as they are beyond the study's research boundaries.

Output depends on yields, prices and subsidies

The agricultural output (revenue) basically depends on yields, prices of agricultural commodities and subsidies received. The average 2001-2003 yields per unit (hectare or livestock head) are calculated from the DZS annual agricultural reports (2002; 2003; 2004). The TISUP database (TISUP 2005) and the Croatian extension service (Mikšić, Murguić et al. 2004) were used to determine the average price per commodity, while the amount of subsidies paid for each commodity is taken from MPŠVG annual reports (MPŠ 2003; MPŠVG 2004). The output is calculated by multiplying the average yield per crop or livestock unit with an average price and by adding the amount of subsidies received on the top. While the crop output can be calculated straight because each crop gives only one product, this is not the case with livestock. The meat output is calculated according to the standard DZS methodology (DZS 2004), by adding the market surplus (the difference in selling and buying) to the weight of the slaughtered livestock and the difference in the herd weight (difference between last and this year's herd weight). The milk sale revenue includes revenue from milk, factory premium (subsidy of 15 l for cow milk), meat value (replacement rate of 12% per cow is applied) and the value of the born animals. The value of the offspring animal is again included as intermediate cost in the meat production.

The agricultural area and the number of livestock is considered to be a constant for the period 2001-2003 and is taken from the agricultural census (DZS 2003). In the calculation, both crops and animals are sorted according to the EUROSTAT Cronos codes (EUROSTAT 2004).

4.5.1 Intermediate consumption

Goods and services used in production

Intermediate consumption represents the value of all used or transformed goods and services employed as inputs in the production process (DZS 2003), excluding fixed assets whose consumption is recorded as fixed capital consumption (EUROSTAT 2004). According to the EUROSTAT methodology (2004) intermediate consumption in farming consists of the following cost categories:

- Seeds and planting stocks
- Energy and lubricants
- Fertilisers and soil improvers
- Plant protection products and pesticides
- Veterinary expenses
- Animal feedstuffs
- Agricultural services
- Maintenance of materials
- Maintenance of buildings
- Other goods and services.

We were able to allocate most of these costs per each crop and animal type. However, the exceptions are the last three intermediate costs: maintenance of materials, maintenance of buildings and other goods and services. The last one is particularly difficult to determine as it includes:

- Rental paid for use of non-residential buildings and other capital assets
- Fees for workers medical examination
- Fees for agricultural consultants, surveyors, accountants, tax consultants and lawyers
- Purchases of services of scientific research, market research and advertising, expenditure on staff training and similar services;
- Postal and telecommunications costs;
- Remuneration for services contained in gross premiums of insurance
- Expenditure of (certain) transport services
- Stud fees
- Billed bank charges
- Subscriptions and fees for membership of professional associations
- Subscriptions to agricultural co-operatives;
- Costs of dairy tests, shows and entries in pedigree registers;
- Expenditure on artificial insemination and castration
- Payments for the use of non-produced intangible assets such as patented assets, trade marks, copyright, milk quotas or other production rights, etc.
- Payments made to public bodies for the purpose of obtaining licences or permits to carry out commercial or professional activities
- Purchases of small tools, working clothing, spare parts and durable equipment of low value
- Purchases of tools, equipment and working clothing

Fix costs

The three excluded intermediate cost categories are largely fixed costs and as such cannot be allocated to the production of any particular crop or animal. Their magnitude is extremely difficult to assess, because they are not recorded in Croatia. We have therefore assigned for these costs a flat rate of 50 EUR per month per farm, resulting in a total cost of 269.94 MEUR. This estimate is based on the assumption that each of 448,532 agricultural households and 1,364 agricultural companies in Croatia (DZS 2003) has average fixed costs of 50 EUR per month. This is a conservative estimate because it is the equivalent of two pairs of rubber boots, for instance.

Seeds

The average yields in Croatia are substantially lower than those taken in the gross margin calculations of the extension service (HZPSS 2003; Mikšić, Murguić et al. 2004). We believe that one of the reasons for the lower yields is also due to the use of lower quality, cheaper seeds. Therefore we applied a 40 percent lower cost for seeds than calculated by the extension service. This hypothesis was also reinforced through discussion with some commercially-oriented farmers (Sever 2005).

Energy

The cost of energy is estimated from the national energy balance (Vuk 2005), the price of agricultural diesel (N.N. 2002) and the per crop use from the extension service data (HZPSS 2003; Mikšić, Murguić et al. 2004; Čuljak 2005). It is basically fuel use and the cost we applied is about 60 percent on average of those used in the extension service GM calculations (Mikšić, Murguić et al. 2004).

Fertilisers

The fertiliser consumption is calculated from the production, import and export data provided by DZS (DZS 2005) for the period 2001-2003. Additional data were provided by Petrokemija (Piršić 2004; Klopček 2005; Mesarić 2005; Piršić 2005) and the final calculation has been checked with Petrokemija too (Piršić 2004; Piršić 2005). The fertiliser price is derived from the extension service data (HZPSS 2003; Mikšić, Murguić et al. 2004) and TISUP database (TISUP 2005). The data obtained on the average fertiliser consumption at the national level (quantity and value) were then compared with those derived by multiplying the extension service recommended fertiliser quantities per crop (HZPSS 2003; Mikšić, Murguić et al. 2004) with the area of each crop - determined by adjusting the DZS cropping pattern (DZS 2002; DZS 2003; DZS 2004) with the UAA reported in the agricultural census (DZS 2003). The comparison between fertiliser quantities recommended by the extension service and the quantity actually consumed in the period 2001-2003 shows that in the period 2001-2003, Croatian farmers applied about 70 percent of the fertilisers recommended by the extension service (Table 15).

Calculated in terms of expenditure, it is about 64 percent of what is given as fertiliser costs in the standard extension service gross margin calculations (Mikšić, Murguić et al. 2004). We have therefore in our gross margin calculations for fertiliser cost applied on average only 60 percent of what is used for fertiliser costs in the extension service calculations.

Pesticides

Similarly to fertilisers, the quantity of pesticides consumed is calculated from the production, export and import balance, based on the data provided by DZS (2005) and MPŠVG (Ljubetić 2004). Pesticides consumed by the forestry sector and railways are deducted from the calculation according to the information provided by Croatian Forests (Hrvatske šume 2005) and Croatian Railways (Marinić 2005). The price of pesticides is derived from the extension service data (HZPSS 2003; Mikšić, Murguić et al. 2004). As with fertilisers, the data obtained on the average national pesticide consumption (quantity and value) are further compared with those derived by multiplying the extension service recommended per crop pesticide rates (HZPSS 2003; Mikšić, Murguić et al. 2004) with the area of each crop as reported in the agricultural census (DZS 2003). The comparison between the recommended and actually used pesticide quantity and their costs suggests that Croatian farmers have on average applied about 88 percent of what is indicated in the extension service gross margin calculations (Mikšić, Murguić et al. 2004). Consequently, our calculation of gross margin included only 88 per cent of the pesticide cost indicated by the extension service.

Feeds

The use of feedstuff is Croatia based on the figures provided by DZS (2005), HGK (Knjaz 2005) and Krmiva d.o.o, the biggest Croatian feedstuff producer (Weigant 2005), and (Grbeša 2005). On average a 50 per cent lower feedstuff intake is applied than the values used by the extension service.

Veterinary medicine

The estimate of the quantity and value of the veterinary medicine on the Croatian market is based on the information provided by MPŠVG (Brstilo 2005) and the biggest Croatian producer of veterinary medicine, Veterina d.o.o. (Benko Tomić 2004; Benko Tomić 2005; Stilinović 2005). These figures suggest that the value of veterinary medicine used in Croatia is about 50 percent lower than the value assessed by the extension service. Consequently, we have applied a 50 per cent lower cost for veterinary medicine that used in the GM calculations of the extension service.

4.6. Value added from FULS

GVA calculation method

The gross value added of FULS identified per NCEA codes is not readily available in Croatia. This is because the GVA is calculated at the level of major economic activities (two-digit NCEA codes) but not for the levels lower than two-digit NCEA codes. However, as the economic actors in the FULS are registered legal entities, contrary to the family farms, these are obliged to do bookkeeping and regularly submit financial progress data to FINA. Detailed financial performance data of the identified NCEA codes were obtained from FINA (2005) and their gross value added (output minus intermediate consumption) was calculated following the methodology employed by DZS (Crnogorac 2005). Additional instructions and clarifications regarding the GVA calculation methodology and FINA's revenue and expenditure codes (so-called AOP codes) were received by DZS (Crnogorac 2004; Šutalo 2004; Crnogorac 2005; Šutalo 2005) and FINA (Viduka 2005). Besides GVA, the number of employees (expressed as FTE) was also calculated from FINA data. Although (un)employment is basically an economic category (if there is enough money people can be employed), this category is often used to express the size of a business and to many laymen it is "the measure" of economy.

GVA correction for export and portion linked only to farming and FULS

After having calculated the GVA of the selected economic activities, it was necessary to determine the GVA portion connected to Croatian farming and FULS. Namely, the GVA of most of the identified economic activities is only partially related to the Croatian market and its specific segment, farming and FULS. A substantial portion of the GVA of some businesses is generated from exports (e.g. the fertiliser industry) while some other sectors (e.g. energy supply and transport) for instance deliver only a minor portion of their goods and services to farming and FULS. Therefore the overall GVA of each of the identified economic sectors was first corrected for the portion relating to the Croatian market, using FINA data on the relevant revenue and expenditure costs linked to the domestic and export market. Assessing the percentage at which these correlate to farming and FULS made a further GVA adjustment. For instance, pesticide manufacturers, in addition to plant protection agents, also produce some non-agricultural chemicals (e.g. dyes) and building materials. The GVA generated by these activities is excluded from our calculation. In the case of fertiliser, pesticide, feedstuff and veterinary medicine manufacturers these estimates were obtained directly from the companies (Benko Tomić 2004; Ivanković 2004; Vujčić 2004; Mesarić 2005; Stilinović 2005; Weigant 2005) and corporate financial reports (Chromos Agro 2003; Herbos 2003; Petrokemija 2003). For other sectors the share of GVA associated with farming and FULS is calculated as indicated below.

Energy

Farming and FULS' share in the extraction of gas and oil, as well as in the production, import, export and domestic consumption of electricity, gas, and various petroleum products is calculated from the national energy balance data (Vuk 2005; Vuk 2005). The share of these sectors in the national consumption of electricity, gas and petroleum products is taken as the percentage these sectors contribute to the GVA generated by the oil and gas extraction, manufacture of petroleum products and production and distribution of electrical energy.

Transport sector

From the data on t-km of road, marine, river and rail freight generated by agricultural inputs (seeds and breeding animals, fertilisers, pesticides, feedstuff and veterinary medicine), raw materials required for their production (raw phosphates, potassium salts, etc.), gas and petroleum products (DZS 2004; DZS 2005; HŽ 2005), we calculated t-km associated with farming and FULS. Their share in the total t-km of road, marine and rail freight is considered to be their share in the GVA of these sectors. The same approach has been applied to derive the share of farming and FULS of the Croatian ports. The air freight linked to farming and FULS is not considered because it is believed to be trivial – similar results have been found for the UK (Pretty, Ball et al. 2005). Besides, globally 50 percent of air-freight is carried in the belly of passenger planes (Garnett 2003) and this makes a sound calculation even more complicated.

Wholesale and retail

This sector includes basically companies selling agri-chemical machinery and inputs, as well as the fuel consumed by agricultural vehicles and lorries transporting agricultural inputs. The list of wholesale companies dealing with agri-chemicals is derived from the HGK company database (HGK 2004), the list of authorised pesticide importers and distributors (HDBZ 2001; HDBZ 2004) and information provided by MPŠVG (Ljubetić 2004; Brstilo 2005) and business representatives (Černjul 2004; Ivanković 2004; Vujčić 2004; Weigant 2005). The share of these companies in the overall GVA calculated for their NCEA code is assessed by extrapolating the ratio between their revenue and the revenue of their NCEA code. We assume that their share in the overall GVA of the group is the same as their share in the overall group revenue. The GVA generated by the retail companies selling agricultural inputs is based on the assumption on the number of companies/outlets selling them. The retail of these goods in Croatia is mostly organised through the network of the so-called agri-pharmacies. These are mostly small companies with 1-3 employees and only one, at most two outlets. According to the MPŠVG register, in 2002 there were six hundred and ninety agri-pharmacies in Croatia (Ljubetić 2004). However, according to Černjul (2004), only about four hundred of these seem to be active, while Maceljski (2005) estimates that there are about nine hundred outlets selling agri-chemical inputs in Croatia. However, Petrokemija estimates that the number of outlets selling fertilisers is much higher than those selling pesticides, because shops trading fertilisers do not have to meet legal conditions required for pesticide sale, suggesting that the number of these shops might be as high as ten thousand (Klopček 2005). Although there is no doubt that due to less stringent regulations, more shops sell fertilisers than pesticides, this estimate seems to be too high. Namely, according to FINA (2005), in the period 2001-2003 there were only 2,001 companies registered under code 52.11 (retail in non-specialised shops) and 2,531 companies registered under the code 52.12 (other retail in non-specialised shops), while under the code 52.48.7 (retail of other specialised goods) there were only 431 companies registered. The retail of agricultural inputs, tools and machinery can basically be registered only under one of these three codes. Some of the companies belonging to the code 52.48.7 are in particular supposed to be specialised in the retail of fertilisers. We have therefore estimated that about 1,200 companies are involved in the retail of agricultural inputs, tools and machinery, representing 24 percent of all retail companies registered under the three above-mentioned codes. Their share in the GVA of the economic activity group (NCEA code) they belong to is assumed to be proportional to their number.

Administration, research, education and advice

Administration, research, education and advice organisations that are linked to Croatian agriculture have been identified from the recent key national reports on agriculture (MPŠ 2003; MPŠ 2003; VRH 2003; MPŠVG 2004). In the period 2001-2003 these organisations included:

- The Ministry of Agriculture, Forestry and Fishery
- Administrative structures in twenty one counties, a hundred and twenty three cities and four hundred and twenty five municipalities
- Fifteen research institutes and research stations
- Three universities (two agricultural and one veterinary) and two colleges
- About fifteen private companies offering agricultural advice and consultancy.

Most of these organisations are financed by public money. The GVA from those that are not financed by public money is calculated from the data provided by FINA (FINA 2005). However information on the financial performance of the organisations financed by public money is neither available at FINA (Viduka 2005; Žeželj 2005), nor can it be instantly accessed from the national treasury accounts (Karačić 2005). The GVA of these organisations is thus estimated by multiplying the number of their employees with the average estimated GVA per employee. The average number of employees is obtained from the HGK register (2004) or information obtained from direct telephone or E-mail contact with the administration departments of these organisations. Unlike for research, education and advisory organisations, the number of agriculture-related employees in the regional and local administration was particularly difficult to determine. Namely, only a few counties and municipalities have departments or sections for agriculture. In most cases these are integrated in the regional and local departments of economy. The City of Zagreb and Zagrebačka County have substantially higher budgets than other regions. The first employs thirty three (Vlasta 2005) and the second six (Trninić 2004) full time persons working in agriculture. Because of the lower budgets, we assume that all other counties employ on average two persons in agricultural administration. For the cities, this is assessed at 0.5 and for the municipalities at 0.2 full-time units. The GVA per employee is derived from the financial reports of some of these organisations (Grad Zagreb 2003; Službene novine Primorsko-goranske županije 2003; AF 2004; Glasnik Zagrebačke županije 2004) and MF data (2002; 2003). On average about 65 percent of their operational costs (excluding budgets of subsidies and support programmes) is spent on salaries and depreciation - which we assume to be equal to their GVA. Since the operational budgets from the organisations based in Zagreb and Rijeka are most likely to be higher than for the organisations based elsewhere, we assume that the GVA per employee of such organisations is some 25 percent lower. Table 7 gives the estimated operational budgets and GVA of agriculture-linked organisations financed by the public money. The overall GVA of the economic activity codes indicated here is however greater, because it is the sum of GVA generated by the organisations financed by the public money (Table 7) and those that are not.

Table 7 Estimated operational budgets and GVA of agriculture-linked organisations financed by the public money.

NCEA code	No. of employees	Operational budget per employee	Total operational budget	GVA
K.73	645	21,000	13,545,000	8,804,250
K 74	203	20,500	4,161,500	2,704,975
L 75.11	390	22,000	8,580,000	5,577,000
L 75.12	77	25,000	1,925,000	1,251,250
L 75.13	147	20,000	2,940,000	1,911,000
M 80	892	22,000	19,624,000	12,755,600
Total	2,354	21,570	50,775,500	33,004,075

Veterinary services

Veterinary service in Croatia is organised through a network of veterinary ambulances and stations. Based on the information provided by veterinary medicine experts (Gorša 2005; Kubiček), we assume that livestock accounts for about 70 percent of their GVA, while the rest is generated from pets.

4.7. Results

4.7.1 Economic activities selected according to NCEA

NCEA codes

Faming and farm-upstream economic activities considered to be relevant for the study are listed in Table 8. As well as farming, these include oil and gas extraction; manufacturing of farm inputs; energy supply; trade; transport and research, education, advisory, veterinary and administrative services. The list presented in Table 8 is certainly not exhaustive, but we believe it comprises nearly all economic activities that make farming possible. Some of these activities are entirely linked with farming (e.g. manufacture of agricultural inputs), while others deliver only a portion of their goods and services to farming and FULS (e.g. energy supply, transport and trade sector).

Agricultural inputs sector

The agricultural inputs sector covers the manufacture of fertiliser, pesticides, veterinary medicine and agricultural machinery. All fertilisers in Croatia are produced by a sole fertiliser manufacturer- Petrokemija. Croatia has three herbicide producers: Herbos, Chromos and Veterina, while feedstuff is produced by about thirty, mostly small and medium companies. The veterinary medicine sector is dominated by Veterina, which supplies about 70 percent of all veterinary medicine sold on the Croatian market. Agricultural machinery is produced by Torpedo, Tomo Vinković and a few small companies.

Energy sector

The energy sector is completely under the control of two big companies. Oil and gas production, wholesale (and partly retail) is run by INA, a 75 per cent government-owned company. HEP, a 100 government-owned company produces and supplies all electricity in the country.

Wholesale and retail

This sector is dominated by about thirty pesticide, and a few fertiliser, seeds and veterinary medicine wholesalers. Most of these companies are direct importers of agricultural inputs, while some combine trade of imported and domestically produced agricultural inputs. About a thousand small, mainly family-run companies run the retail of agricultural inputs, mostly in so-called “agri-pharmacies”.

Table 8 Selected farming and FULS according to NCEA

NCEA code	NCEA subcode	Economic activity
A		**Agriculture, hunting and forestry**
A	01-04	Farming
C		**Mining and quarrying**
CA	11	Oil and gas extraction
D		**Manufacturing**
DA	15.71	Feedstuff production
DF	23.2	Manufacture of refined petroleum products
DG	24.15	Manufacture of fertilisers
DG	24.2	Manufacture of pesticides
DG	24.42	Manufacture of veterinary medicine
DK	29.3	Manufacture of agri. and forestry machinery
E		**Electricity, gas and water supply**
E	40.1	Production and distribution of el. energy
G		**Wholesale and retail trade; repair**
G	50.5	Retail of vehicle fuel
G	51.18	Trade mediation in miscellaneous products
G	51.19	Trade mediation in specialised products
G	51.21	Wholesale of feeds, cereals and seeds
G	51.46	Wholesale of pharmaceutical products
G	51.51	Wholesale of fuels and liquid gas
G	51.55	Wholesale of chemical products
G	51.88	Wholesale of agricultural machinery
G	51.9	Wholesale, other
G	52.11	Retail in non-specialised shops
G	52.12	Other retail in non-specialised shops
G	52.48.7	Retail of other specialised goods
I		**Transport, storage and communication**
I	60.1	Railway transport
I	60.24	Road freight
I	60.3	Pipeline transport
I	61.10.2	Marine freight
I	61.2	River freight
I	63.11	Transshipment of goods
K		**Real estate, renting and business activities**
K	73.10.2	Technical and technological research and development
K	74.14	Business and mngm. advisory services
K	74.30	Technical testing and analysis
L		**Public administration, defence and social security**
L	75.11.1	Central government
L	75.11.2	Regional governments (counties)
L	75.11.5	Local governments (municipalities)
M		**Education**
M	80.3	Higher education
N		**Health and social work**
N	85.2	Veterinary services

Transport sector

Numerous, mostly family-run companies carry out the road freight transport in Croatia. A state-owned company, Croatian Railways, runs the entire railway network and railway freight, while the government-owned companies Janaf and Plinacro carry out the pipeline transport of oil and gas. Marine freight is organised by a few companies and mostly directed to Šibenik port, which is the most important point for handling fertilisers and the raw materials required for their production (it is partly owned by Petrokemija). However, some agricultural inputs and notably petroleum products are shipped via the port of Rijeka. The port of Vukovar is by far the most important river port as it handles fertilisers.

Basic information regarding the administrative, research, education and advice organisations linked to Croatian agriculture, as well as veterinary services are already given in the previous chapter.

4.7.2 Fertiliser and pesticide consumption

Fertiliser consumption

A detailed calculation (**Error! Reference source not found.**) based on the data of domestically produced, imported and exported fertilisers shows that the consumption of fertilisers in Croatia over the period 2001-2003 was quite stable, in the range of 203,975-215,551 tonnes of nutrients. In spite of the presence of imported fertilisers, those produced by Petrokemija still account for 80-90 per cent of the entire market. The average consumption of nutrients (N, K_2O and P_20_5) per hectare of UAA is 191 kg and for arable land 261 kg. However, if the consumed quantity of nutrients is divided over the area that actually receives fertiliser application (as reported in the census data), the average consumption is 277 kg of nutrients. Figure 10 shows graphically the fertiliser balance in Croatia in the period 1999-2004.

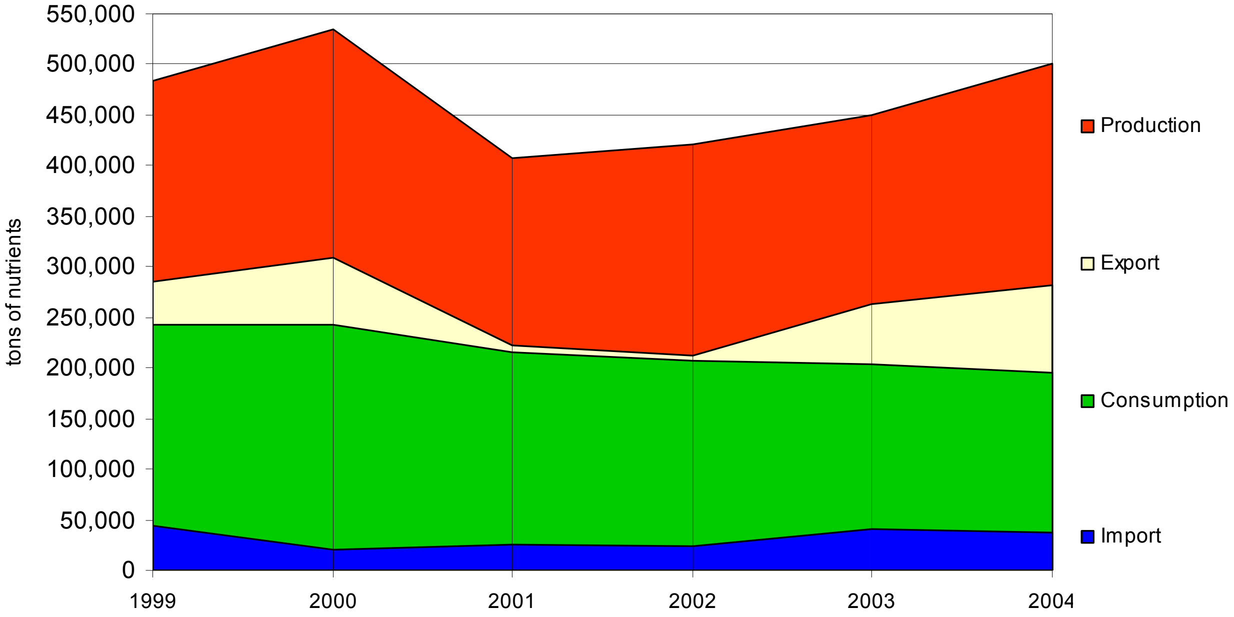


Figure 10 Production, import, export and consumption of fertilisers in Croatia.

Table 9 Fertiliser fact sheet for Croatia

	Unit	2001	2002	2003	2001-2003
Production					
Fertilisers	t	986,098	1,002,465	1,055,080	1,014,548
Nutrients	t	407,638	420,989	449,014	425,880
Import					
Fertilisers	t	54,286	56,652	95,889	68,942
Nutrients	t	24,695	23,736	40,287	29,572
Export					
Fertilisers	t	577,352	517,710	650,335	581,799
Nutrients	t	223,136	211,384	263,292	232,604
Exported of produced fertilisers	%	59	52	62	57
Available for HR market					
Fertilisers	t	463,032	541,407	500,634	501,691
Nutrients	t	209,197	233,340	226,009	222,849
Sold by Petrokemija					
Fertilisers sold to other industries	t	7,090	12,760	14,691	
Sold to agriculture					
Fertilisers	t	475,159	440,021	381,160	432,113
Nutrients	t	190,816	183,652	163,688	179,385
Sold by fertiliser importers					
Fertilisers	t	54,286	56,652	95,889	68,942
Nutrients	t	24,695	23,736	40,287	29,572
Fertilisers sold of available	%	114	92	95	100
Petrokemija's market share	%	90	89	80	86
Consumption					
Fertilisers		529,445	496,673	477,049	501,056
Nutrients		215,511	207,388	203,975	208,958
Consumption per land-use category					
Per ha of UAA					
Fertilisers	kg	491	461	443	465
Nutrients	kg	200	192	189	194
Per ha of arable land					
Fertilisers	kg	660	619	595	625
Nutrients	kg	269	259	254	261
Per ha of actually fertilised land					
Fertilisers	kg	-	657	631	663
Nutrients	kg	-	274	270	277

Pesticide consumption

The average annual pesticide consumption by the agricultural sector in the period 2001-2003 was 3,898 tonnes of active ingredients. It corresponds with 3.6 kg per hectare of UAA and 4.5 kg per hectare of arable land (Table 10).

Table 10 Pesticide fact sheet for Croatia

	Unit	2001	2002	2003	2001-2003
Production					
Pesticides	t	7,722	6,998	5,649	6,790
Active ingredients	t	3,306	2,935	2,427	2,889
Import					
Pesticides	t	3,144	3,120	3,614	3,293
Active ingredients	t	1,406	1,348	1,446	1,400
Export					
Pesticides	t	1,278	1,180	1,676	1,378
Active ingredients	t	489	496	669	551
Balance					
Pesticides	t	9,460	8,770	7,817	8,682
Active ingredients	t	4,713	4,283	3,873	4,289
Pesticide consumption					
forestry	t	851	789	704	781
railway	t	12	11	12	12
Active ingredients consumption					
forestry	t	424	385	349	386
railway	t	6	5	6	6
Agricultural pesticide consumption	t	8,596	7,970	7,102	7,889
Per ha od UAA	kg	8.0	7.4	6.6	7.3
Per ha of arable land	kg	10.6	9.9	8.8	9.8
Active ingredients consumption	t	4,283	3,892	3,518	3,898
Per ha od UAA	kg	4.0	3.6	3.3	3.6
Per ha of arable land	kg	5.3	4.8	4.4	4.8

Figure 11 gives a graphic overview of pesticide balance in Croatia in the period 1999-2003. It shows a slight increase in consumption from 1999-2001 and a slightly decreasing trend afterwards.

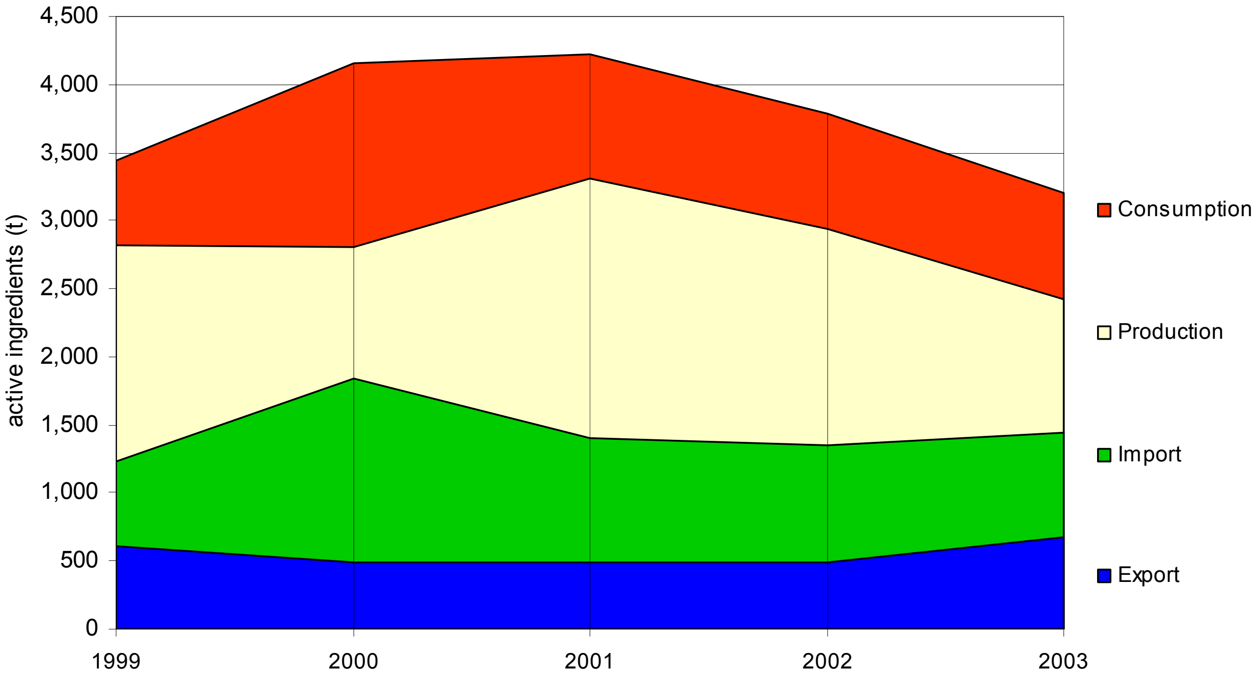


Figure 11 Pesticide production, trade balance and consumption

4.7.3 GVA from farming and FULS

Crops GM

The cropping area used for the calculation is 1052,178 ha, which comprises 25,226 ha less than the UAA of 1077,443 ha recorded by the agricultural census. This is because these 25,226 ha are reported as fallow land and thus do not result in a direct economic return. The calculated crop output is 972.56 MEUR and is made up of 750.78 MEUR generated through the revenue from the crop sale and 125.89 MEUR from subsidies (Table 11). The average crop output is 924 EUR when calculated on a per hectare basis. The intermediate consumption is 610.70 MEUR or 580 EUR per hectare. The total average gross margin generated by Croatian crop production in the period 2001-2003 was 361.86 MEUR, or 344 EUR per hectare of UAA. Nearly half (46.8 percent) was raised by fruit and grape production, while vegetables made an additional 10.7 percent. On the other hand, fruits and grapes occupied only 5.6 percent of the UAA and vegetables only 1.7 percent. The production of rye, tomatoes and potatoes made losses and contributed negatively to the overall gross margin (Table 11)..

Table 11 Crop production gross margin

Cronos	Product	Area (ha)	Yield ha^{-1} (t)	Yield ('000 t)	Price kg^{-1} (EUR)	Revenue from sale (MEUR)	Revenue from subsidies (MEUR)	Subsidy ha^{-1} (EUR)	Output (MEUR)	Output ha^{-1} (EUR)	IC (MEUR)	IC ha^{-1} (EUR)	GM (MEUR)	GM ha^{-1} (EUR)
01000	Cereals	566,517	-	2,491	-	288.40	77.5		365.9		297.2		68.72	-
01100	Wheat	182,635	3.74	682.4	0.13	88.72	34.7	190	123.4	676	85.0	465	38.43	210
01200	Rye	3,558	2.23	7.9	0.13	1.03	0.4	107	1.4	397	1.5	416	-0.07	-19
01300	Barley	48,022	2.97	142.6	0.11	15.69	5.8	120	21.4	447	19.9	414	1.59	33
01400	Oats	17,762	2.24	39.7	0.12	4.77	1.9	107	6.7	375	6.7	379	-0.06	-3
01500	Grain maize	312,240	5.15	1,608.0	0.11	176.88	34.6	111	211.5	677	183.2	587	28.29	91
01700	Others	2,300	4.39	10.1	0.13	1.31	0.2	84	1.5	654	1.0	420	0.54	234
02000	Industrial crops	123,116	-	1,122.1	-	89.25	43.3		132.5		79.7		52.77	-
02100	Oil seeds and oleaginous crops	89,348	-	191.9	-	40.75	24.2		65.0		42.3		22.72	-
02110	Rape seeds	13,299	1.99	26.5	0.22	5.82	4.4	331	10.2	769	7.1	534	3.13	235
02120	Sunflowers	25,741	2.17	55.9	0.21	11.54	8.2	318	19.7	767	13.4	520	6.35	247
02130	Soya	47,402	2.19	103.8	0.21	22.15	10.7	225	32.8	692	20.5	432	12.35	261
02190	Other oleaginous products	2,906	2.00	5.8	0.21	1.24	1.0	331	2.2	758	1.3	450	0.89	308
02200	Protein crops (incl. seeds)	3,063	1.20	3.7	0.90	3.31	0.7	223	4.0	1,303	1.5	480	2.52	823
02300	Raw tobacco	6,289	1.86	11.7	1.15	13.46	8.1	1,285	21.5	3,426	10.2	1,615	11.39	1,811
02400	Sugar beet	24,401	37.49	914.8	0.03	31.71	10.3	421	42.0	1,721	25.9	1,060	16.13	661
02900	Other industrial crops	15	1.60	0.0	0.50	0.01	0.0	0	0.0	800	0.0	490	0.00	310
03000	Forage plants	273,621	-	900.0	-	95.9	1.8		97.7		56.9		40.77	-
03100	Fodder maize	8,399	27.00	226.8	0.03	7.03	0.2	28	7.3	865	5.2	615	2.10	250
03200	Fodder root crops	2,000	33.00	66.0	0.03	2.29	0.1	28	2.3	1,172	1.6	800	0.74	372
03900	Other forage plants	263,222	-	607.3	-	86.57	1.5		88.1		50.2		37.93	
	Fodder peas and broadbeans	1,800	11.00	19.8	0.20	3.96	0.0	0	4.0	2,200	1.6	900	2.34	1,300
	Alfalfa	29,550	3.45	102.0	0.16	16.20	0.8	28	17.0	576	11.5	391	5.49	186
	Grass-clover	21,521	3.09	66.4	0.16	10.54	0.6	28	11.1	518	8.2	380	2.97	138
	Meadows	149,790	2.43	364.5	0.13	48.60	0.1	0	48.7	325	22.5	150	26.19	175
	Pastures	60,561	0.90	54.5	0.13	7.27	0.0	0	7.3	120	6.4	105	0.93	15

Crop production gross-margin (continue)

Cronos	Product	Area (ha)	Yield ha^{-1} (t)	Yield ('000 t)	Price kg^{-1} (EUR)	Revenue from sale (MEUR)	Revenue from subsidies (MEUR)	Subsidy ha^{-1} (EUR)	Output (MEUR)	Output ha^{-1} (EUR)	IC (MEUR)	IC ha^{-1} (EUR)	GM (MEUR)	GM ha^{-1} (EUR)
04000	Vegetables and hort. products	18,305		46.56	-	118.25	1.0		119.2		80.6		38.69	2,114
04110	Cauliflower	1,496	11.00	16.5	0.93	15.36	0.0	21	15.4	10,288	8.0	5,336	7.41	4,952
04120	Tomato	3,203	9.40	30.1	0.39	11.74	0.1	21	11.8	3,687	15.3	4,774	-3.48	-1,087
04190	Other fresh vegetables	11,477	-	0.0	-	41.84	0.6	-	42.4		24.2		18.26	
	Onions	2,202	7.29	16.1	0.41	6.64	0.0	21	6.7	3,034	4.1	1,859	2.59	1,176
	Cabbages	5,303	11.07	58.7	0.31	18.00	0.1	21	18.1	3,416	12.8	2,411	5.33	1,005
	Others	1,589	10.07	16.0	0.40	6.40	0.0	21	6.4	4,048	3.5	2,230	2.89	1,818
	Herbs	2,383	2.67	6.4	1.70	10.80	0.4	165	11.2	4,699	3.7	1,570	7.46	3,129
04210	Nursery plants	673	0.00	0.0	0.00	20.19	0.3	461	20.5	30,461	15.2	22,600	5.29	7,861
04220	Ornamental plants and flowers	1,456	0.00	0.0	0.00	29.12	0.0	0	29.1	20,000	17.9	12,300	11.21	7,700
05000	Potatoes	11,768	9.17	107.9	0.16	17.26	0.2	21	17.5	1,488	26.0	2,206	-8.45	-718
06000	Fruits	58,851	9.59	564	-	237.62	2.1	35	239.7	4,073	70.3	1,195	169.36	2,878
06100	Fresh fruits	27,320	-	289.1	-	105.22	0.2	-	105.4		35.9		69.53	
06110	Dessert apples	8,950	18.00	161.1	0.35	55.85	0.1	8	55.9	6,248	20.4	2,280	35.51	3,968
06120	Dessert pears	3,980	10.00	39.8	0.53	21.23	0.0	8	21.3	5,341	7.2	1,821	14.01	3,520
06130	Peaches	460	10.00	4.6	0.67	3.07	0.0	8	3.1	6,675	0.8	1,693	2.29	4,982
06190	Other fresh fruits	13,930	6.00	83.6	0.30	25.07	0.1	8	25.2	1,808	7.5	536	17.72	1,272
06200	Citrus fruits	843	20.00	16.9	0.60	10.12	0.0	8	10.1	12,008	1.7	2,069	8.38	9,939
06400	Grapes	27,688	9.00	249.2	0.47	116.29	1.5	55	117.8	4,255	31.8	1,150	85.97	3,105
06500	Olives	3,000	3.00	9.0	0.67	6.00	0.3	107	6.3	2,107	0.8	283	5.47	1,823
	Crops total	1,052,178	-	5,232	-	846.67	125.9	119.65	972.6	924	610.70	580.42	361.86	344

Livestock GM

The livestock output is 1,300.55 MEUR and is made up of 1,208.35 MEUR sale revenue and 92.20 MEUR from the received subsidies (

Table 12). The intermediate consumption is 998.96 MEUR and the gross margin is 301.59 MEUR. Exclusion of the value of newly-born animals from the milk sale revenue would result in a negative gross margin for milk production. However, as the value of these newly-born animals is again taken as an input (intermediate cost) in meat production, in the case of cattle this induced a negative gross margin.

Table 12 Livestock production gross margin

Cronos	Product	Unit	No. of units	Yield per unit (kg)	Total yield (t)	Price (EUR kg-1)	Revenue from sale (MEUR)	Subsidy per unit (EUR)	Revenue from subsidies (MEUR)	Output (MEUR)	Output per unit (EUR)	IC (MEUR)	IC per unit (EUR)	GM (MEUR)	GM per unit (EUR)
11000	Animals (meat)	head	11,478,862		483,869		809.45		28.95	838.40		700.52		137.87	
11100	Cattle	head	258,715	279.8	72,377	2.12	153.18	40.9	10.59	163.77	633	169.01	653	-5.24	-20
11200	Pigs	head	1,924,672	149.1	286,938	1.60	459.10	5.3	10.26	469.36	244	373.02	194	96.34	50
11300	Equinex	head	15,474	190.0	2,940	2.20	6.47	0.0	0.24	6.70	433	6.03	390	0.67	43
11400	Sheep and goats	head	822,319	19.3	15,832	3.00	47.50	9.3	7.68	55.17	67	47.69	58	7.48	9
11500	Poultry	head	7,994,683	13.0	103,931	1.33	138.57	0.0	0.19	138.76	17	103.93	13	34.83	4
11900	Other animals	head	463,000	4.0	1,852	2.50	4.63	0.0	0.00	4.63	10	0.83	2	3.80	8
12000	Animal products		9,207,079		618,645		398.91		63.25	462.15		298		163.72	
12100	Milk	head	339,214		614,260		269.23		61.49	330.72		222.17		108.55	
	Cow milk	head	229,931	2,632.0	605,178	0.25	252.77	260.3	59.84	312.61	1,360	214.48	933	98.14	427
	Sheep milk	head	98,632	64.0	6,312	0.73	9.96	8.4	0.82	10.78	109	6.31	64	4.47	45
	Goat milk	head	10,652	260.0	2,769	0.53	6.51	77.3	0.82	7.33	689	1.38	130	5.95	559
12200	Eggs *	bird	7,994,683	136.0	1,087	0.11	123.22	0.0	0.00	123.22	15	76.11	0	47.12	15
12910	Raw wool	head	768,182	1.6	1,229	0.20	0.25	0.0	0.00	0.25	0	0.00	0	0.25	0
12930	Honey	hives	105,000	19.7	2,068	3.00	6.20	16.7	1.76	7.96	76	0.16	2	7.80	74
13000	Animals total		20,685,941		1,102,514		1,208.35		92.20	1,300.55		998.96		301.59	

** The yield referes as to millions of eggs*

Summary GVA agriculture

Table 13 summarises the calculation on the gross value added by the Croatian farming sector in the period 2001-2003. The output equals 2,273.11 MEUR and the intermediate consumption 1,609.67 MEUR, resulting in a gross margin of 663.45 MEUR. However, when fixed costs are added (50 EUR per farm per year), the gross value added by the Croatian farming sector in the period 2001-2003 shrinks to 393.51 MEUR, the equivalent of 1.74 percent of GDP. Farming subsidies make up 55 percent of the entire farming GVA and without these Croatian farming would create only 175 MEUR added value. Livestock production makes 57 percent of the entire output and 45 percent of farming GM. The intermediate consumption is as high as 71 percent of the output.

Table 13 Croatian agricultural value-added: summary

	Value (MEUR)	Share %	Per capita (EUR yr^{-1})	Per ha UAA (EUR yr^{-1})
Crop sale	846.67	87.06	190.82	785.81
Crop subsidy	125.89	12.94	28.37	116.84
Crop output	972.56	100.00	219.19	902.66
Livestock sale	1,208.35	92.91	272.34	1,121.51
Livestock subsidy	92.20	7.09	20.78	85.57
Livestock output	1,300.55	100.00	293.12	1,207.08
Farming output	2,273.11	200.00	512.31	2,109.73
Crops intermediate consumption	610.70	37.94	137.64	566.81
Livestock intermediate consumption	998.96	62.06	225.14	927.16
Intermediate consumption farming	1,609.67	100.00	362.78	1,493.97
Gross margin crops	361.86	54.54	81.55	335.85
Gross margin livestock	301.59	45.46	67.97	279.91
Gross margin farming	663.45	100.00	149.53	615.76
Fixed costs farming	269.94	-	60.84	250.54
GVA farming	393.51	-	88.69	365.23

GVA of FULS

The FULS employ 14,410 people and generates 245.46 MEUR of GVA, representing about 1.036 percent of GDP. With about 26.51 MEUR GVA, the petroleum industry is the biggest single contributor. However, it should be noted this figure also includes gas, because nearly the entire GVA generated under the code DF 23.2 is made by the INA group, which does production and wholesale of both petroleum products and gas. As INA is registered under this code, its entire GVA related to farming and FULS had to be entered here. The second largest contributor to FULS GVA is the veterinary service. It is followed by the agricultural research organisations, wholesale sector and education. Wholesale generates a substantial GVA in comparison with retail, because a number of organisations registered under wholesale NCEA codes also deliver their goods directly to the end users. The manufacture of fertilisers and pesticides appear to be only the sixth and seventh single biggest GVA contributors in this chain.

Farming and FULS provide employment for 148,607 people and create GVA of 636.72 MEUR, or 2.84 percent of GDP. Farming accounts for 90.3 percent of the entire employment in Croatian farming and FULS. It also makes 61.45 percent of the entire GVA generated thought these sectors

Table 14 Gross-value added by farming and farm-linked sectors

NCEA code	NCEA subcode	Economic activity	No. of companies	GVA (M EUR)	No. of employees (FTE)	GVA per employee (EUR)	Revenue from HR market (%)	Agri-linked revenue (%)	No. of employees linked to HR agric. (FTE)	GVA from agri-linked HR market (MEUR)	% GDP
A		**Agriculture, hunting and forestry**									
A	01-04	Farming	-	393.51	134,966	2,916	99.4	100.0	134,196	391.27	1.743
		Subtotal	-	393.51	134,966	2,915.62	99.43	100.00	134,196	391.27	1.743
C		**Mining and quarrying**									
CA	11	Oil and gas extraction	10	100.05	3,067	32,754	42.5	7.5	109	3.61	0.016
		Subtotal	10	100.05	3,067			7.5	109	3.61	0.016
D		**Manufacturing**									
DA	15.71	Feedstuff production	45	14.36	1,122	12,782	97.3	100.0	1,093	13.98	0.062
DF	23.2	Manufacture of refined petroleum products	7	412.83	11,983	34,317	75.6	8.0	780	26.51	0.118
DG	24.15	Manufacture of fertilisers	3	29.83	2,839	10,535	47.7	95.0	1,394	14.52	0.065
DG	24.2	Manufacture of pesticides	6	12.76	517	24,739	92.0	90.0	425	10.51	0.047
DG	24.42	Manufacture of veterinary medicine	1	13.69	362	37,811	70.1	100.0	252	9.50	0.042
DK	29.3	Manufacture of agri. and forestry machinery	35	8.42	951	8,903	79.3	95.0	674	5.95	0.026
		Subtotal	97	491.90	17,773				4,619	80.97	0.361
E		**Electriciy, gas and water supply**									
E	40.1	Production and distribution of el. energy	19	371.43	14,471	25,866	99.2	1.0	158	4.72	0.021
		Subtotal	19	371.43	14,471				158	4.72	0.021
G		**Wholesale and retail trade; repair**									
	50.5	Retail of vehicle fuel	86	8.77	714	11,544	97.3	8.0	56	0.69	0.003
	51.18	Trade mediation in miscellaneous products	63	3.89	134	28,571	91.2	3.2	4	0.07	0.000
	51.19	Trade mediation in specialised products	1,408	99.76	4,447	22,202	93.2	0.3	13	0.29	0.001
	51.21	Wholesale of feeds, cereals and seeds	129	20.60	572	36,233	87.9	60.0	277	10.32	0.046
	51.46	Wholesale of pharmaceutical products	138	52.29	1,520	33,358	97.7	2.5	30	1.41	0.006
	51.51	Wholesale of fuels and liquid gas	78	17.46	820	20,484	96.2	8.0	64	1.39	0.006
	51.55	Wholesale of chemical products	128	9.34	546	17,097	89.8	20.0	60	1.71	0.008
	51.88	Wholesale of agricultural machinery	54	12.19	825	14,692	99.4	100.0	818	12.08	0.054
	51.9	Wholesale, other	10,882	721.22	66,921	11,762	94.2	3.0	633	20.38	0.091
	52.11	Retail in non-specialised shops	2,001	190.83	24,667	7,672	99.5	2.0	490	3.79	0.017
	52.12	Other retail in non-specialised shops	2,531	159.57	17,449	9,041	98.2	5.0	845	7.75	0.035
	52.48.7	Retail of other specialised goods	431	7.43	1,347	5,374	98.8	40.0	530	2.93	0.013
		Subtotal	17,929	1,303.33	119,961				3,821	62.81	0.280

Gross-value added by farming and farm-linked sectors (continued)

NCEA code	NCEA subcode	Economic activity	No. of companies	GVA (M EUR)	No. of employees (FTE)	GVA per employee (EUR)	Revenue from HR market (%)	Agri-linked revenue (%)	No. of employees linked to HR agric. (FTE)	GVA from agri-linked HR market (MEUR)	% GDP
I		**Transport, storage and communication**									
I	60.1	Railway transport	16	103.12	16,481	5,089	50.6	9.6	839	5.02	0.022
I	60.24	Road freight	1,653	114.84	7,615	14,962	78.6	7.1	537	8.29	0.037
I	60.3	Pipeline transport	4	54.78	450	116,547	73.5	7.5	22	2.92	0.013
I	61.10.2	Marine freight	43	87.96	734	121,089	29.0	7.5	16	1.95	0.009
I	61.2	River freight	4	1.17	195	7,035	74.8	10.0	17	0.09	0.000
I	63.11	Transshipment of goods	23	25.27	2,507	10,402	60.5	14.0	236	2.19	0.010
		Subtotal	1,743	387.14	27,983				1,668	20.47	0.091
K		**Real estate, renting and business activities**									
K	73.10.2	Technical and techn. research and dvlp.	16	24.79	949	26,121	95.0	100.0	902	23.68	0.105
K	74.14	Business and mngm. advisory services	16	2.81	223	16,523	100.0	100.0	170	2.39	0.011
K	74.30	Technical testing and analysis	1	0.45	33	13,325	100.0	100.0	33	0.46	0.002
		Subtotal	33	28.05	1,152				1,105	26.54	0.118
L		**Public administration, defence and social security**									
L	75.11.1	Central government	1	5.58	390	14,300	100.0	90.0	342	5.18	0.023
L	75.11.2	Regional governments (counties)	21	1.25	77	16,250	100.0	100.0	77	1.82	0.008
L	75.11.5	Local governments (municipalities)	548	1.91	147	13,000	100.0	100.0	147	2.16	0.010
		Subtotal	570	8.74	604				566	9.16	0.041
M		**Education**									
M	80.3	Higher education	5	12.76	892	14,300	100.0	100.0	892	12.76	0.057
		Subtotal	5	12.76	892				892	12.76	0.057
N		**Health and social work**									
N	85.2	Veterinary services	166	35.71	2,116	16,852	98.5	70.0	1,474	24.42	0.109
		Subtotal	166	35.71	2,116				1,474	24.42	0.109
		Total		**3,132.61**	**322,985**				**148,607**	**636.72**	**2.836**

4.8. Discussion

4.8.1 Fertiliser consumption

Fertiliser use

The fertiliser consumption data obtained in our calculations matches well with the estimates from the fertiliser industry. The difference, calculated on the basis of total fertiliser consumption is about 10-12% (Petrokemija 2004; Piršić 2004). A slightly higher difference (8-20%) occurs when this calculation is compared with that of the FAO (FAO 2005). This is most likely due to the different time series applied (agricultural vs. calendar year) and FAO's exclusion of imported fertilisers by companies other than Petrokemija.

Croatia: one of European top fertiliser consumers

Comparison of FAO statistics on fertiliser consumption in different countries (FAO 2005) ranks Croatia among the most intensive fertiliser users in Europe (Figure 12). According to this calculation, in 2001 Croatia used 269 kg nutrients per hectare of arable land (based on the census surface of 802.093 ha). This is some 25 percent higher than the EU-15 average (214 kg) and is substantially higher than in other transition countries.

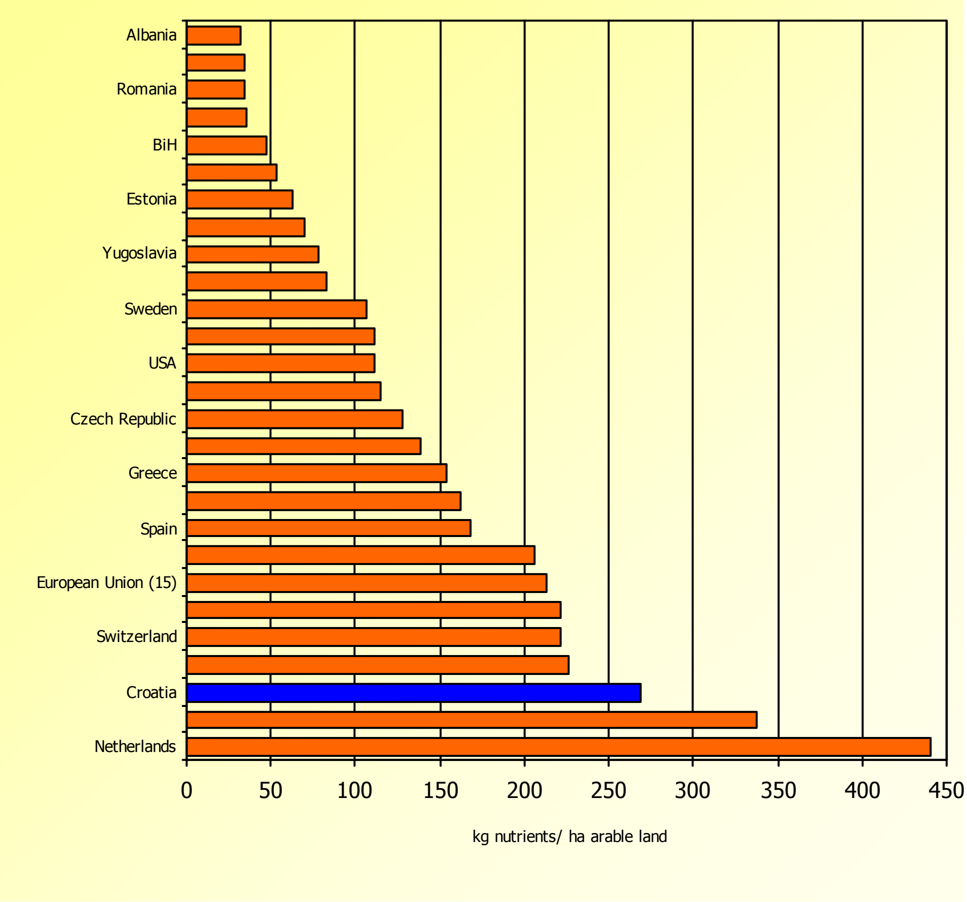


Figure 12. Fertiliser consumption in Europe and the USA in 2001

4.8.2 Pesticide consumption

Consumption above EU-15 average

As already stressed earlier, elaborated figures on pesticide consumption in Croatia hardly exist. Therefore it is difficult to compare our results with others. However they largely correspond with the general figures presented in several publications (Igrc-Barčić 2002; Igrc-Barčić 2003; MZOPU 2003). Figure 13 shows the European pesticide consumption in 1999 (the latest year with comparable information across Europe) as shown in the FAO database (FAO 2005) and EUROSTAT (EUROSTAT 2003). As in the case of fertilisers, Croatia ranks quite high.

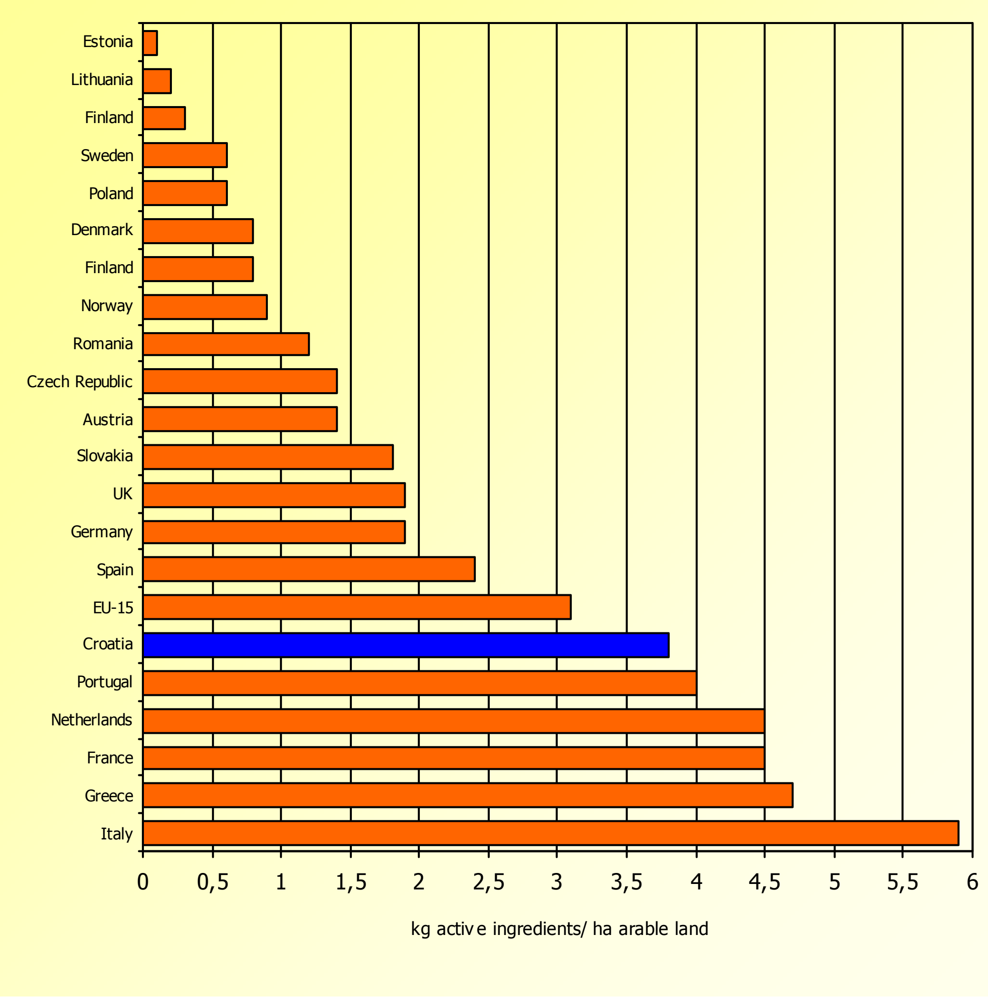


Figure 13 European pesticide consumption in 1999.

Forecast

However, in spite of the exceptionally high figures on fertiliser and pesticide use, Croatian analysts predict a further increase in their consumption. Grgić (2002), for instance, forecasts an increase in fertiliser consumption of 38% by 2010 and more than 63% by 2020. According to the same source, pesticide consumption will increase by 27% in the first ten years and approximately 61 percent in the later period.

4.8.3 Efficiency of inputs

Recommended vs. actually consumed inputs

If nutrient and pesticide per hectare rates recommended by the extension service (Mikšić, Murguić et al. 2004) are multiplied by the area under particular crops, it appears that in the period 2001-2003, Croatian farmers applied about 70 percent of the recommended fertilisers and 88 percent of recommended pesticides (Table 15). On the other hand, the yields obtained were about 50 percent lower on average than those anticipated in the extension service calculations. It is interesting to notice that the quantity of the applied nitrogen is exactly as recommended by the extension service. However, the composition of nitrogen fertilisers consumed is totally different from the recommendations. Croatian farmers seem to be fond of urea: they applied about 77 per cent more urea than needed - at the expense of CAN and nitrogen that should have been, according to the extension service, been added through NKP fertilisers. At the same time, there is an obvious deficiency of phosphorus and potassium: only about 47 percent of the recommended phosphorus and 35 percent of the recommended potassium was applied. So here, von Liebig´s "*law of the minimum*", saying that the crop yield is proportional to the scarcest input available might have paid a role. Phosphorus and potassium seem indeed to be critical nutrients in Croatian farming. Kovačević (1993) for instance obtained an increased soybean yield of 34-40 percent when P and K fertilisers were added. Krištek *et al.* (2002) report on the increased yield of sugar beet due to P and K applications higher than typically applied by Croatian farmers.

Poor nutrient management

Croatian farmers and agronomists do not seem to be sufficiently aware of the potential utilisation of nutrients in livestock manure (Moller 2003; Znaor and Karoglan Todorović 2004). Neither the application of fertilisers and manure is satisfactory, since it is often applied in inadequate formulations, quantities and time, as well as using inadequate technical equipment (Moller 2003; Sumelius, Mesić et al. 2005). The application of fertilisers is done without prior soil testing, mostly according to farmers' experience and "feeling" of what is needed (Sumelius, Mesić et al. 2005). The soil nutrient application rates recommended by the extension service often double the recommendations in Denmark for instance and this is justified by the low utilisation rate of applied nutrients, particularly due to soil acidity (Moller 2003). However, it is not clear why liming, green manure, growing of crops whose root exudates are able to mobilise less available forms of P and K, as well as drainage is not recommended instead. All these are rather efficient measures to improve soil pH and mobilise inaccessible nutrients.

Table 15 Recommended versus actual inputs

	Recommended by HZPSS			Consumption 2001-2003			Realised of recommended	
Input	t	kg UAA ha^{-1}	MEUR	t	kg UAA ha^{-1}	MEUR	% t	% MEUR
Urea	68,508	63.58	15.41	120,972	112.28	27.21	176.58	176.58
CAN	158,692	147.29	29.53	140,748	130.63	26.19	88.69	88.69
NPK	485,257	450.38	162.40	239,336	222.13	80.10	49.32	49.32
Subtotal fertilisers	712,458	661.25	207.34	501,056	465.04	133.50	70.33	64.39
Total nitrogen	118,115	109.63	57.75	119,000	110.45	58.18	100.75	100.75
Total phosphorus	39,335	36.51	59.86	18,274	16.96	20.75	46.46	34.67
Total potassim	105,177	97.62	59.86	37,102	34.43	20.75	35.28	34.67
Subtotal nutrients (N, P, K)	262,627	243.75	177.46	174,376	161.84	99.69	66.40	56.17
Pesticides	7,711	7.16	100.25	6,790	6.30	88.27	88.05	88.05
Total fertilisers and pesticides	720,170	668.41	307.58	507,846	471.34	221.77	70.52	72.10

Low efficiency of inputs leads to low yields

Exceptionally high consumption of fertilisers and pesticides on one hand and quite low yields on the other hand indicate inappropriate management practices. Nutrient and pesticide efficiency score low both from the environmental and economic point of view. Consequently, a substantial portion of these must be ending up in the environment, causing pollution and biodiversity decline. The poor yields obtained by Croatian farming could be explained as the result of the combination of one or more of the following factors:

- Inadequate crop rotation: maize and other grain occupy about 75% of the arable land. Improperly designed crop rotation enhances pest, disease and weed occurrence. It is also detrimental to soil fertility, as it can destroy the soil structure and deplete soil organic matter.
- Use of poor quality seeds
- Non-balanced use of nitrogen fertilisers: over usage of urea and under-usage of nitrogen in CAN and NPK fertilisers
- Unavailability of K and P due to their poor natural content in the soil, too little P and K applied through fertilisers and the absence of crops able to dissolve less mobile forms of P and K
- Neglected maintenance of drainage channels (Marušić 2003; Marušić 2003)
- Poor overall management skills of Croatian farmers (2002; Sumelius, Grgić et al. 2003; Sumelius, Mesić et al. 2005), inappropriate technology they apply and their limited knowledge (Franić 2003; Mesić 2003)

4.8.4 GVA calculation

Differences as compared to official figures

The methodology used to calculate gross value added from the Croatian agriculture in this study is largely in line with that of the EU (EC 2004; EUROSTAT 2004). Although about three times lower than in the official reports, the farming GVA given here is believed to be a sound indication of the size of the Croatian farming business. The methodological differences leading to a discrepancy between the official calculations and ours are explained in the previous chapters. The farming output of the official statistics is based on a (non-existent) land area nearly three times greater, while the intermediate consumption is calculated by applying a flat rate of 45 percent over the entire agricultural output. Moreover, under farming GDP various non-farming economic activities, notably food processing are also reported. On the other hand, our calculations are based on the livestock number and land area actually in use as reported in the recent agricultural census. It concerns only production of crops and livestock and does not take into account other economic activities that might have been undertaken either by the agricultural companies or family farms. Our intermediate consumption is based on the quantity of inputs actually consumed. The results obtained indicate that the intermediate consumption in the period 2001-2003 was as high as 71 percent of the output - so well above 45 percent used in the official calculations.

“Missing” 4.71 percent of GDP

Table 16 summarises the main differences between ours and the official data on the added value of Croatian farming. As already mentioned, the official statistics do not report the GVA of agriculture alone, but always together with hunting and forestry. However, from the FINA data (2005) it appears that the GVA of forestry in the studied period was 138 MEUR and of hunting 0.45 MEUR - representing only about 8.45 percent of the entire GVA reported under the NCEA code “A” (agriculture, hunting and forestry). FINA data also suggest that companies registered under NCEA codes A 01-04 generated 201.18 MEUR of GVA - from both their agricultural and non-agricultural activities. Applying GM rates for the crops and livestock obtained in our calculation to the cropland and the number of animals managed by these companies would result in a gross margin of 170.72 MEUR. Assuming an average agriculture-related fixed cost of 3,000 EUR per month per company, the value added they create though agricultural activities would be about 122.62 MEUR and not 201.18 MEUR as indicated under FINA’s codes A 01-04. Added to 1,337.19 MEUR generated by family farms this gives an amount of 1,538.37 MEUR, or 6.03 percent of GDP. Assuming that our calculation is correct, this would mean that the official statistics overestimate Croatian GDP by about 4.28 percent Table 16.

Table 16 Differences between official farming GVA and data obtained in this study.

NCEA code	Subcode	Activity	Reported to FINA	DZS figures (MEUR)	Our figures (MEUR)	Difference (MEUR)
A01	01-04	Farming and non-farming activities of agricultural companies	Yes	201.18	121.62	79.56
A01	01-04	Farming by small-scale family farms	No	1,337.19	271.89	1,065.29
A01	05	Hunting	Yes	0.41	0.00	0.41
A02	-	Forestry	Yes	138.02	0.00	138.02
		Reported as to "agriculture"		1,676.80	393.51	1,283.29
		GDP		24,185.00	22,450.00	1,735.00
		"Agriculture" as % of GDP		6.93	1.75	5.18
		Farming alone as % of GDP		6.03	1.75	4.28

5. DAMAGE TO AIR

Natural and anthropogenic air pollution

Atmospheric pollution consists of two major groups of pollutants: gases and solid particulates/aerosols. These substances change the natural composition of the atmosphere and can potentially damage human and other living organisms' health and harm the environment. Atmospheric pollution comes from two major sources: natural and anthropogenic pollution. Natural pollution occurs from volcanoes, forest fires, oceanic sea salt, dust from space, plant pollen, swamps and wetlands. However the magnitude of such pollution is usually within the carrying capacity of the atmosphere. Today, most air pollution occurs through a wide range of human activities, notably the energy and manufacturing industry, agriculture and transport. The anthropogenic pollution often exceeds the absorption capacity of the atmosphere, leading to high concentrations that can occur on a regional or local scale.

5.1. Greenhouse gases

Types of GHG

The greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), perfluorocarbons (PFCs), chlorofluorocarbons (CFCs) and hydrofluorocarbons (HFCs). These gases affect the atmosphere on a global scale and are called "greenhouse" gases, because they cause global warming.

The UNFCCC and Kyoto Protocol

The United Nations Framework Convention on Climate Change sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change (UNFCCC 2005). Its addition, the 1997 Kyoto Protocol, commits a number of countries (Annex I Parties) to individual, legally-binding targets to limit or reduce their GHG emissions. These have to cut in GHGF emissions by at least 5% from 1990 levels in the commitment period 2008-2012. Croatia is one of the few signatory countries which still has not ratified the Kyoto Protocol. Its 2001 request for the exemption from its Kyoto targets (VRH 2001) and proposal to set its 1990 emissions of 39.4 Mt CO_2 equivalent as the reference year is still pending, although its emissions in the last few years have been around 28 Mt CO_2 .

Share of agriculture

By producing about 50-75 percent of anthropogenic methane and nitrous oxide emissions and about 5 percent of anthropogenic CO_2 emissions, agriculture generates about 20 percent of the annual anthropogenic greenhouse effect globally (Cole 1996). In the period 2001-2003 agricultural activities accounted for 11.2 percent of the entire GHG emissions (CO_2 equivalent) in Croatia (MZOPUG 2004; MZOPUG 2004; EKONERG 2005).

5.2. Regional and local air pollutants

Gaseous pollutants

Pollutants like sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), ammonia (NH_3) persistent organic pollutants (POPs) and a wide range of hydrocarbons (VOCs), cause regional and local air pollution. Like most GHGs, these pollutants are mainly the product of the burning of fossil fuels. The presence of two or more of these substances in the air can be particularly harmful to human health, as these compounds can react chemically in the atmosphere, assisted by sunlight, high temperatures, and sometimes moisture, to form the secondary pollutant photochemical smog. Sulphur dioxide, nitrogen oxides and ammonia are also known as “acidic gases”, leading to the “acid rains” effect. Acid rain has an adverse effect on the environment and ecosystems and also affects human health and degrades many materials.

Particulate matter and aerosols

Particulate matter (PM) is a non-gaseous atmospheric pollutant consisting of a wide range of solid particles and liquid droplets. It can be suspended in the air for long periods of time and floating in the atmosphere as aerosols. These are the smallest size ranges of particulate matter made up of very fine particles. They pose the greatest hazard to human health and are generated by vehicles, factories, construction sites, cultivated land, unpaved roads, stone crushing and the burning of wood. The particulate matter known as PM-10 consists of particles with an aerodynamic diameter smaller than ten microns. These are responsible for most of the adverse human health effects because of their ability to reach the lower regions of the respiratory tract.

Heavy metals

Heavy metals also belong to the group of non-gaseous atmospheric pollutants.

CLRTAP Convention

The 1979 Geneva Convention on Long-range Trans-boundary Air Pollution is the overall international legally binding instrument to deal with problems of air pollution on a broad regional basis. Croatia is a signatory of this Convention and regularly reports on the pollutants which are the subject of this convention. With the emission of some

50 000 t of ammonia, agriculture makes up some 44 percent of the entire Croatian acid gases equivalent (MZOPUG 2004).

5.3. Methodology

The methodology used to determine the damage caused by GHG and regional/local air pollutants generated by faming and FULS involved two steps:

- Quantification of GHG and regional/local air pollutants generated by Croatian farming and FULS
- Valuation of the damage cost caused by the determined quantities of GHG and regional/local air pollutants.

5.3.1 Quantity of air pollutants arising from farming

Since this study has been relying on the census data regarding land-use and the number of livestock, taking data on agricultural emissions from the existing national inventories (MZOPUG 2004; MZOPUG 2004; MZOPUG 2004; EKONERG 2005; MZOPUG 2005) that are based on three times as many hectares and a different number of livestock would not be methodologically correct. Therefore, the assessment of air pollution derived from the farming sector had to be performed from scratch.

GHG from IPCC methodology

The quantity of GHG arising from Croatian agriculture has been calculated according to the IPCC methodology (2001; 2001) for the inventory of GHG. This methodology has been widely used and is one of the most recognised. Its assessment takes into account the number of livestock, housing and manure handling details, information on crop residues, biological nitrogen fixation and the use of synthetic fertilisers.

EMEP/

CORINAIR methodology

The amount of local and regional pollutants has been assessed using the EU recommended EMEP/CORINAIR methodology (EEA 2004). With the input on the data on the land use, livestock number and grazing, fertiliser and pesticide application it enables calculation of agriculture related pollutants, such as ammonia, nitrogen oxides, carbon dioxide and NMVOCs.

Both the IPCC and EPEM/CORINAIRE methodology have a set of default regional values. In same cases, these have been slightly adapted to better reflect the Croatian situation and the corrections made were largely based on the values given for Croatia by RAIN, another international model used for the assessment of air pollution (IIASA 2003; Klimont and Brink 2004).

5.3.2 Quantity of air pollutants caused by FULS

The emissions of pollutants of farm-upstream linked sectors have been quantified using data from the following sources:

Cadastre of Emissions into the Environment

Croatia has a well-established Cadastre of Emissions into the Environment. This national database was run by MZOPUG but was recently handed over to the Environmental Protection and Energy Efficiency Fund. The Cadastre contains air and wastewater emission data from point sources and data on industrial and municipal waste generation and treatment (Jurić, Burek et al. 2005; MZOPUG 2005). The primary data have been supplied by companies and other legal entities which are obliged to keep regular records and carry out annual reporting to the authorities. The Cadastre of Emissions into the Environment proved to be an important source of information, providing the type and quantity of pollutants of interest for the study from major companies. In cases of doubts and unclearness regarding the Cadastre data, additional consultations have been made with experts from MZOPUG (Kufrin 2004; Nećak 2004; Šolić-Gavranović 2004), and the Environmental Protection and Energy Efficiency Fund (Muškardin 2004; Muškardin 2005) and Agency for Environmental Protection (Kufrin 2004).

Information provided by industry

The project team contacted several companies in order to obtain additional or check already collected air pollution information. Most of these, especially agri-chemical companies have reacted positively to this request, providing various useful information: Herbos (Ivanković 2004; Smolčić 2004), Chromos (Čović 2004), Veterina (Benko Tomić 2004; Stilinović 2005) and Dalmed (Vujčić 2004). Petrokemija (Avirović 2004; Vešligaj 2004; Avirović 2005; Mesarić 2005) has submitted particularly detailed and useful environmental data.

GO reports

Governmental reports on air pollution (MZOPU 2003; CCPC 2004; MZOPUG 2004; MZOPUG 2004; MZOPUG 2005) provided plentiful useful information needed to determine the quantity of air pollutants in various sectors.

Corporate environmental reports

Corporate environmental reports, such as (HŽ 2002; Petrokemija 2002; Petrokemija 2002; HEP 2003; INA 2004; Petrokemija 2004) proved to be a particularly important source of information for the pollutants generated by oil, gas and electricity industries and railways.

Research ad consultancy organisations

Three Croatian research and consultancy organisations dealing with air pollution and involved in the preparation of the key environmental analysis for national authorities and international projects provided various additional data and clarifications needed to complete the calculations: EKONERG (Fijan Parlov 2005; Jurić 2005; Vešligaj 2005), the Hrvoje Požar Energy Institute (Vuk 2005; Vuk 2005) and the Croatian Centre for Cleaner Production (Belamarić Šaravanja 2004; Horst 2004).

The National Energy Balance for 2001-2003 (Vuk 2005), data from the energy (HEP 2003; INA 2004; VRED 2004) and industry sector (Petrokemija 2005), together with transport statistics (DZS 2005; HŽ 2005) enabled a reliable calculation of FULS-generated pollutants and their separation from sometimes aggregated figures.

5.3.3 Valuation of air-related externalities

ExternE programme

The external cost for air has been determined applying the methodology developed by the ExternE (= Externalities of Energy) project series. The ExternE project (ExternE 2005) is the biggest and most comprehensive EU programme on external costs. It was launched in 1991 with financial support from the DG Research of the European Commission and has been running since (with a total budget of over ten million EUR). The programme has involved some fifty universities and research institutes from more than twenty European countries and encompasses over twenty research projects (ExternE 2005).

***EcoSense* software**

The core of the ExternE project is the *EcoSense* software - an integrated computer tool. It provides a harmonised air quality and impact assessment models together with a comprehensive set of relevant input data for some thirty European countries (but not Croatia). Using a bottom-up environmental impact pathway approach, *EcoSense* is capable of performing a highly standardised impact assessment, allowing a site specific bottom-up impact analysis (ExternE 2005; IER 2005)

ExternE methodology

In determining the monetary value of an externality, the ExternE methodology takes into account fatal and non-fatal effects on human health; damage to crops and materials (buildings), as well as effects on global warming and ecosystems (Droste-Franke 2005; ExternE 2005). By following the entire path of an externality - from source emissions, quality changes of air, soil and water to physical impacts - the model links a 'burden' to an 'impact' and converts the impact into monetary value (IER 2004; ExternE 2005). The new generation of ExternE tools (NewExt) also analyses pollution in water and soil in addition to atmospheric pollution. The impact of heavy metals and some organic substances (e. g. dioxins), which accumulate in water and soil compartments and lead to significant exposure via the food chain are expected to be included in the ExternE model as well (ExternE 2005).

The calculation of external costs using the ExternE approach requires a well-defined reference situation regarding pollutants. This is important as the background concentration of pollutants in the reference situation has an influence on future (scenario) released pollutants with non-linear chemistry or non-linear dose-response functions (Droste-Franke 2005; ExternE 2005). The ExternE approach estimates the difference in air quality between the reference situation and a situation simulated through a scenario. The difference in the simulated air quality situation between the case and the reference situation is combined with exposure response functions to derive differences in physical impacts on public health, crops, buildings, global warming and ecosystems. Finally, the physical impacts are evaluated and converted in monetary terms applying concepts of welfare economics. For impacts on crops and materials market prices are used to evaluate the damages. However, for non-market goods (especially damage to human health), the damage is assessed on the basis of the willingness-to-pay or willingness-to-accept approach. The monetary values recommended in ExternE have been derived on the basis of informal meta-analysis (in the case of mortality values) and most recent robust estimates from welfare-based valuation studies (ExternE 2005). In cases of high uncertainties (e.g. for ecosystem damage resulting from acidification and eutrophication, or damage caused by global warming), avoidance costs are calculated. This approach deviates from the pure welfare economic paradigm followed by ExternE, but it allows a more complete estimation of damage caused by the same pollutants already included in the calculation on public health, materials and crops.

The ExternE model takes into account both local and transboundary impacts because air pollutants are transformed and transported over long distances, causing considerable damage hundreds of kilometres away form the source (ExternE 2005). Extensive information on the methodological framework used in ExternE and *EcoSense* can be obtained from the several sources (EC 1995; EC 1999; Friedrich and Bickel 2001; EC 2003; IER 2004; ExternE 2005).

The ExternE model actually does take into account positive effect of CO_2 and other "pollutants" on crops. Nitrous gases and SO_2 can sometimes be beneficial as they act as fertilisers. In the ExternE model, the positive externality effect is then deducted from the negative ones (Droste-Franke 2005).

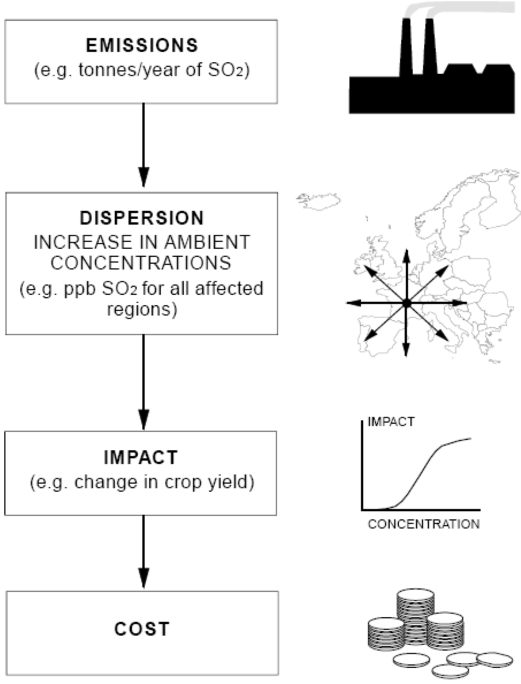


Figure 14 The main steps of the impact pathways methodology applied to the consequences of pollutant emissions (IER 2004)

Damage factors for Croatia

Croatia is one of the very few European countries for which the ExternE model does not provide ready monetary values (damage factors) for the key air pollutants. In order to obtain these, help was requested from the ExternE experts who have, following this request, computed calculations for Croatia applying standard ExternE methodology (Droste-Franke 2005)

The damage factors for Croatia have been derived by using the Windrose Trajectory Model used in *EcoSense* software on the quantity of emissions in Croatia. The Windrose Trajectory Model is a user-configurable trajectory model based on the windrose approach of the Harwell Trajectory Model developed at Harwell Laboratory, UK (Derwent, Dollard et al. 1998). The Windrose Trajectory Model is used to estimate the concentration and deposition of acid species on a European wide scale (IER 2004) and can be fed by a set of site specific meteorological data. The emission data for Croatia have been taken from the UNECE/EMEP activity data and emission database (UNECE/EPEM 2005) for the year 2000. These have been incorporated in the *EcoSense* software version 4.01 containing an extended grid and gridded emission data (spatial resolution of 50x50 km^2) for the whole of Europe. In order to correct UNECE/EMEP emission figures from 2000 for the emission levels in the period 2001-2003 a ten percent increment for each analysed substance was applied. This is because the official reports on air quality for the period 2001-2003 indicate an increase in pollutants as compared with the situation in 2000 (MZOPU 2003; MZOPUG 2004; MZOPUG 2004; MZOPUG 2004; EKONERG 2005; MZOPUG 2005). The ExternE methodology also distinguished between emissions deriving from high sources (above 100 metres) and low sources (emission height above the ground of less than 100 metres). The separation between low and high sources in *EcoSense* version 4.01 is made on the basis of the 1998 emission scenario (Droste-Franke and Friedrich 2003) and includes some uncertainties, especially for the substances that tend to be involved in chemical reactions, such as SO_2, NO_X, NH_3, and NMVOC. Their impact changes substantially with the background emission levels (Droste-Franke 2005).

Health exposure-response functions

The health exposure-response functions have been calculated following the methodology described in EC (1999) and applying the adoptions recommended in Hurley (2004) and Searl (2002). This calculation takes into account impact categories such as bronchodilator usage, (chronic) cough and bronchitis, lower respiratory symptoms (wheeze), asthma attacks, congestive heart failure, restricted activity days, chronic and acute mortality, respiratory and cerebrovascular hospital admissions, etc. for various receptor categories (e.g. children, adults, elderly 65+, population with chronic respiratory diseases, etc. This enables calculation of exposure-response slopes (morbidity and mortality) for each impact and receptor category as described in the studies considered (Whittemore and Korn 1980; Ostro 1987; Dockery, Speizer et al. 1989; Ostro and Rothschild 1989; Krupnick, Harrington et al. 1990; Pope and Dockery 1992; Roemer, Hoek et al. 1993; Abbey, Lebowitz et al. 1995; Dusseldorp, Kruize et al. 1995; Schwartz and Morris 1995; Anderson, Ponce de Leon et al. 1996; Dab, Quenel et al. 1996; Ponce de Leon, Anderson et al. 1996; Sunyer, Castellsague et al. 1996; Touloumi, Samoli et al. 1996; Wordley, Walters et al. 1997; Pope, Burnett et al. 2002). Concentrations of SO_2, PM_{10}, sulphates and nitrates were based on annual mean concentration and ozone concentrations as a seasonal six hour average. The slope factor derived from Pope et al. (2002) was used to derive the Years of Life Lost (YOLL) per increase of $1\mu g/m^3$ pollutant concentration. For unspecified primary particles (PM_{10}) and sulphates a factor of 39 YOLL per 100,000 persons and per increase of $1\mu g/m^3$ was used according to Hurley (2004). As for all other human health effects, for nitrates half of the factor of PM_{10} was taken. The calculated slope functions were applied to different risk groups of population, taking into account the share of population representing the risk group for the different health effects. The monetary values used for the economic valuation of particular impact categories (diseases, hospital admissions, etc.) were taken from Friedrich and Bickel (2001). Table 17 gives the damage factors for Croatia. These take into account only the damage to human health (morbidity and mortality). The pollutants' impact on crops, materials and ecosystems was not possible to calculate due to the lack of reliable data necessary to perform such calculations. However, results from other European countries indicate that the impact on human health accounts for 80 percent or more of the entire damage cost (Droste-Franke and Friedrich 2003; Droste-Franke 2005; Droste-Franke 2005). Thus the current figures used for Croatia present only a portion of the external cost and are likely to be underestimated by up to 20 percent. However, they should be accurate enough to derive an order of magnitude for the damage costs caused by air pollutants from Croatia.

Table 17 Damage factors (M EUR kt^{-1}) for air pollutants originating from Croatia (Droste-Franke 2005)

	Human Health Morbidity	Human Health Mortality	Human Health Total
Total (incl. effects in Croatia)			
SO_2 high	1.71	3.54	5.25
SO_2 low	1.65	3.43	5.08
NO_X (as NO_2) high	2.09	3.57	5.66
NO_X (as NO_2) low	2.07	3.52	5.58
Primary PM_{10} high	3.11	6.23	9.34
Primary PM_{10} low	3.40	6.80	10.20
NH_3	1.96	3.93	5.89
NMVOC	0.30	0.06	0.35
In Croatia			
SO_2 high	0.17	0.37	0.54
SO_2 low	0.16	0.36	0.52
NO_X (as NO_2) high	0.21	0.38	0.59
NO_X (as NO_2) low	0.17	0.30	0.47
Primary PM_{10} high	0.80	1.59	2.39
Primary PM_{10} low	0.85	1.70	2.54
NH_3	0.42	0.84	1.26
NMVOC	0.01	0.00	0.02

PM_{10} calculation

Particular attention should be paid to primary PM_{10}, as regional models underestimate the local effect around the source. Therefore, correction factors for the local environment (0 to 50 km or 20 km around the source in case of transport) were derived from earlier calculations using air quality models incorporated in ExternE. Depending on the emission heights, local correction factors should be added to the regional (Croatian) damage factors for primary emissions of PM_{10}. For the Croatian industrial sources below 100 metres this is 2.3 M EUR kt^{-1}, and for those above 100 metres 0.4 M EUR kt^{-1}. The transport correction factor for primary emissions of PM10 in Croatia is 14.2 M EUR kt^{-1} and for other low sources 10.9 M EUR kt^{-1} (Droste-Franke 2005). It should be stressed that these factors are average estimates and might be inappropriate for some site-specific conditions (e.g. when the emission source is in a densely populated urban area or in a poorly-populated rural area).

GHG damage factor same as elsewhere

Table 17 gives damage factors for air pollutants only. The external costs (damage factors) for GHG were not specifically calculated for Croatia. These were taken from the existing values suggested by *EcoSense LE* software package (IER 2005). Namely, in the present ExternE methodology, there is only one damage factor for GHG, because the damage associated with GHG are made on a global, rather than an individual country basis (Droste-Franke 2005; IER 2005). The current ExternE damage factors per tonne of GHG are: 19 EUR for CO_2, 437 EUR for CH_4 and 5,620 EUR for N_2O (IER 2005). The ExternE CO_2 abatement cost of 19 EUR per tonne of CO_2 is a central estimate of the range of values required to meet the EU-15 Kyoto targets in 2010. It is based on the work of Capros and Mantzos (2000) and Fahl *et al.* (1999). It assumes fully operating international market for carbon dioxide trade and reduction of CO_2 emissions in a cost effective way. The later implies that reduction targets are not set per sector, but that the cheapest measures are implemented, no matter in which sector (ExternE 2005).

Final cost determination

The monetary value of the damage to air caused by Croatian farming and FULS is obtained by multiplying the quantities of particular pollutants with the corresponding damage factors for Croatia (Table 17). The obtained figure is further corrected per economic activity for the percentage that reflects its linkage to the domestic market (e.g. percentage of total fertiliser production sold on the domestic market) and agriculture and FULS (e.g. these consume only 1.3 percent of the national production of electrical energy). Finally, the distinction between the damage occurring in Croatia and elsewhere is made based on the factors presented in Table 17.

5.4. Results

Agriculture causes biggest damage

Croatian farming and FULS have in the period 2001-2003 emitted 13.61 Mt CO_2 equivalents (Table 18). The total damage of Croatian farming and FULS to the atmosphere is assessed at 413.98 MEUR (Table 21). Only 36.18 per cent of it is the damage taking place in Croatia. Agriculture accounts for 86.63 per cent of the entire damage to the atmosphere and is followed by manufacture of fertilisers which makes an additional 7.48 per cent. In comparison with the contribution of these two (94.12 percent), the impact of all other sectors is insignificant. Ammonia emissions alone make up 58.56 per cent of the entire damage to air. Livestock (manure) accounts for 58.29 of ammonia costs and 34.14 per cent of the entire damage to air caused by farming and FULS.

Table 18 Quantity of regional/local pollutants and GHG

NCEA code	NCEA subcode	Economic activity	POLLUTANTS (t)						GHG (t)			
			SO_2	NO_x	NH_3	CO	NMVOC	PM10	CO_2	CH_4	N_2O	eq-CO_2
A.		Agriculture, hunting and forestry										
A	01-04	Farming										
		Enteric fermentation	0	0	0	0	0	0	0	35,563	0	746,827
		Manure management	0	0	23,995	0	0	0	0	7,423	577	334,701
		Soil management	0	1,780	14,060	347	9	0	1,053	0	7,050	2,186,476
		Residue burning	0	0	39	499	0	0	0	0	3	930
		Mobile	1,115	7,939	0	6,616	1,323	0	506,744	33	4	508,657
		Stationary	309	125	0	50	8	4	105,023	7	1	105,400
		Subtotal A	1,424	9,845	38,093	7,512	1,340	4	612,821	43,026	7,634	3,882,991
C.		Mining and quarrying										
CA	11	Oil and gas extraction										
		Oil extraction	0	233	0	0	0	0	191,333	248	0	196,534
		Gas extraction	0	0	0	0	7,633	0	671,000	32,667	0	1,357,000
		Subtotal C	0	233	0	0	7,633	0	862,333	32,914	0	1,553,534
D.		Manufacturing										
DA	15.71	Feedstuff production	4	0	0	0	0	0	60	0	0	60
DF	23.2	Manufacture of refined petroleum prod.	15,333	4,267	0	1,300	2,967	267	873,333	217	0	877,883
DG	24.15	Manufacture of fertilisers	1,835	2,279	3,070	23,877	0	486	1,010,981	0	2,229	1,702,074
DG	24.2	Manufacture of pesticides	18	0	0	37	0	0	47	0	0	47
DG	24.42	Manufacture of veterinary medicine	39	0	0	0	0	0	3,124	0	0	3,124
DK	29.3	Manufacture of agri. and forestry mach.	0	0	0	0	0	0	49	0	0	49
		Subtotal D	17,229	6,546	3,070	25,214	2,967	753	1,887,593	217	2,229	2,583,237
E.		Electricity, gas and water supply										
E	40.1	Production of electrical energy	20,627	10,779	0	493	0	1,269	4,578,000	0	0	4,578,000
		Subtotal E	20,627	10,779	0	493	0	1,269	4,578,000	0	0	4,578,000
I.		Transport, storage and communic.										
I	60.1	Railway transport	54	1,553	0	1,330	287	0	87,833	6	1	88,269
I	60.24	Road freight	192	1,126	0	726	217	57	83,373	6	3	84,540
I	60.3	Pipeline transport	25	4	0	366	0	0	5,433	0	0	5,433
I	61.10-20	National navigation	0	1,972	0	1,333	287	0	108,667	7	1	109,117
I	63.11	Transshipment of goods	0	0	0	0	0	0	350	0	0	350
		Subtotal I	271	4,655	0	3,755	790	57	285,657	19	5	287,709
G-N		Trade, administration, education and vet. services	2,350	883	0	633	91	0	743,000	90	5	746,330
		Total (A-M)	41,902	32,942	41,163	37,607	12,821	2,083	8,969,404	76,266	9,874	13,631,800

Table 19 Externalities arising from air pollution: total and in Croatia only

NCEA code	NCEA subcode	Economic activity	Pollutants (M EUR)										
			SO_2	HR SO_2	NO_x	HR NO_x	NH_3	HR NH_3	CO	NMVOC	HR NMVOC	PM10	HR PM10
A.		Agriculture, hunting and forestry											
A	01-04	Farming											
		Enteric fermentation	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
		Manure management	0,00	0,00	0,00	0,00	141,33	30,01	0,00	0,00	0,00	0,00	0,00
		Soil management	0,00	0,00	10,07	0,90	82,81	17,59	0,00	0,00	0,00	0,00	0,00
		Residue burning	0,00	0,00	0,00	0,00	0,23	0,05	0,00	0,00	0,00	0,00	0,00
		Mobile	5,86	0,60	44,94	4,01	0,00	0,00	0,00	0,46	0,01	0,00	0,00
		Stationary	1,62	0,16	0,71	0,06	0,00	0,00	0,00	0,00	0,00	0,04	0,01
		Subtotal A	7,48	0,76	55,72	4,98	224,37	47,65	0,00	0,47	0,01	0,04	0,01
C.		Mining and quarrying											
CA	11	Oil and gas extraction											
		Oil extraction	0,00	0,00	1,32	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00
		Gas extraction	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2,67	0,01	0,00	0,00
		Subtotal C	0,00	0,00	1,32	0,01	0,00	0,00	0,00	2,67	0,01	0,00	0,00
D.		Manufacturing											
DA	15.71	Feedstuff production	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
DF	23.2	Manufacture of refined petroleum prod.	80,50	0,54	24,15	0,14	0,00	0,00	0,00	1,04	0,00	2,60	0,04
DG	24.15	Manufacture of fertilisers	9,63	0,40	12,90	0,47	18,08	1,55	0,00	0,00	0,00	4,73	0,48
DG	24.2	Manufacture of pesticides	0,09	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
DG	24.42	Manufacture of veterinary medicine	0,20	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
DK	29.3	Manufacture of agri. and forestry mach.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
		Subtotal D	90,45	0,96	37,05	0,61	18,08	1,55	0,00	1,04	0,00	7,33	0,52
E.		Electricity, gas and water supply											
E	40.1	Production of electrical energy	108,29	0,14	61,01	0,07	0,00	0,00	0,00	0,00	0,00	12,36	0,04
		Subtotal E	108,29	0,14	61,01	0,07	0,00	0,00	0,00	0,00	0,00	12,36	0,04
I.		Transport, storage and communic.											
I	60.1	Railway transport	0,28	0,00	8,79	0,00	0,00	0,00	0,00	0,10	0,00	0,00	0,00
I	60.24	Road freight *	1,01	0,10	6,38	0,57	0,00	0,00	0,00	0,08	0,00	0,56	0,14
I	60.3	Pipeline transport	0,13	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
I	61.10-20	National navigation	0,00	0,00	11,16	0,03	0,00	0,00	0,00	0,10	0,00	0,00	0,00
I	63.11	Transshipment of goods	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
		Subtotal I	1,42	0,10	26,35	0,60	0,00	0,00	0,00	0,28	0,00	0,56	0,14
G-N Trade, administration, education and vet. services			12,34	0,01	5,00	0,00	0,00	0,00	0,00	0,03	0,00	0,00	0,00
		Total (A-M)	219,98	1,97	186,45	6,26	242,45	49,20	0,00	4,49	0,02	20,29	0,71

Table 20 Externalities resulting from GHG

NCEA code	NCEA subcode	Economic activity	GHG (M EUR)						
			CO_2	HR CO_2	CH_4	HR CH_4	N_2O	HR N_2O	eq-CO2
A.		Agriculture, hunting and forestry							
A	01-04	Farming							
		Enteric fermentation	0,00	0,00	15,54	15,42	0,00	0,00	15,54
		Manure management	0,00	0,00	3,24	3,22	3,24	3,22	6,49
		Soil management	0,02	0,02	0,00	0,00	39,62	39,31	39,64
		Residue burning	0,00	0,00	0,00	0,00	0,02	0,02	0,02
		Mobile	9,63	9,55	0,01	0,01	0,02	0,02	9,66
		Stationary	2,00	1,98	0,00	0,00	0,00	0,00	2,00
		Subtotal A	11,64	11,55	18,80	18,66	42,90	42,57	73,35
C.		Mining and quarrying							
CA	11	Oil and gas extraction							
		Oil extraction	3,64	0,24	0,11	0,01	0,00	0,00	3,74
		Gas extraction	12,75	0,86	14,28	0,96	0,00	0,00	27,02
		Subtotal C	16,38	1,10	14,38	0,97	0,00	0,00	30,77
D.		Manufacturing							
DA	15.71	Feedstuff production	0,00	0,00	0,00	0,00	0,00	0,00	0,00
DF	23.2	Manufacture of refined petroleum prod.	16,59	1,09	0,09	0,01	0,00	0,00	16,69
DG	24.15	Manufacture of fertilisers	19,21	7,72	0,00	0,00	12,53	5,03	31,74
DG	24.2	Manufacture of pesticides	0,00	0,00	0,00	0,00	0,00	0,00	0,00
DG	24.42	Manufacture of veterinary medicine	0,06	0,04	0,00	0,00	0,00	0,00	0,06
DK	29.3	Manufacture of agri. and forestry mach.	0,00	0,00	0,00	0,00	0,00	0,00	0,00
		Subtotal D	35,86	8,86	0,09	0,01	12,53	5,03	48,49
E.		Electricity, gas and water supply							
E	40.1	Production of electrical energy	86,98	1,08	0,00	0,00	0,00	0,00	86,98
		Subtotal E	86,98	1,08	0,00	0,00	0,00	0,00	86,98
I.		Transport, storage and communic.							
I	60.1	Railway transport	1,67	0,00	0,00	0,00	0,01	0,00	1,68
I	60.24	Road freight *	1,58	1,58	0,00	0,00	0,02	0,02	1,61
I	60.3	Pipeline transport	0,10	0,01	0,00	0,00	0,00	0,00	0,10
I	61.10-20	National navigation	2,06	0,05	0,00	0,00	0,01	0,00	2,07
I	63.11	Transshipment of goods	0,01	0,00	0,00	0,00	0,00	0,00	0,01
		Subtotal I	5,43	1,64	0,01	0,00	0,03	0,02	5,47
G-N Trade, administration, education and vet. services			14,12	0,09	0,04	0,00	0,03	0,00	14,18
		Total (A-M)	170,42	24,32	33,33	19,63	55,49	47,63	259,24

Table 21 Externalities from air pollutants and GHG: total and in Croatia only

NCEA code	NCEA subcode	Economic activity	Total (M EUR)	HR market-linked	Agri-linked (%)	Total (M EUR)	In HR (M EUR)
A.		Agriculture, hunting and forestry					
A	01-04	Farming					
		Enteric fermentation	15,54	99,23	100,00	15,42	15,42
		Manure management	147,82	99,23	100,00	146,68	36,45
		Soil management	132,53	99,23	100,00	131,51	57,82
		Residue burning	0,24	99,23	100,00	0,24	0,07
		Mobile	60,92	99,23	100,00	60,45	14,21
		Stationary	4,38	99,23	100,00	4,35	2,23
		Subtotal A	361,43			358,65	126,19
C.		Mining and quarrying					
CA	11	Oil and gas extraction					
		Oil extraction	5,06	74,00	8,90	0,33	0,25
		Gas extraction	29,70	85,00	7,90	1,99	1,82
		Subtotal C	34,76			2,33	2,07
D.		Manufacturing					
DA	15.71	Feedstuff production	0,02	100,00	100,00	0,02	0,00
DF	23.2	Manufacture of refined petroleum prod.	124,97	74,00	8,90	8,23	1,83
DG	24.15	Manufacture of fertilisers	77,08	42,30	95,0	30,98	15,65
DG	24.2	Manufacture of pesticides	0,10	79,70	90,0	0,07	0,01
DG	24.42	Manufacture of veterinary medicine	0,26	69,59	100,0	0,18	0,06
DK	29.3	Manufacture of agri. and forestry mach.	0,00	74,29	95,0	0,00	0,00
		Subtotal D	202,44			39,48	17,55
E.		Electricity, gas and water supply					
E	40.1	Production of electrical energy	268,65	95,70	1,30	3,34	1,33
		Subtotal E	268,65			3,34	1,33
I.		Transport, storage and communic.					
I	60.1	Railway transport	10,85	53,53	0,091	0,01	0,00
I	60.24	Road freight *	9,62	100,00	100,00	9,62	2,43
I	60.3	Pipeline transport	0,26	56,29	8,70	0,01	0,01
I	61.10-20	National navigation	13,33	33,00	7,70	0,34	0,08
I	63.11	Transshipment of goods	0,01	61,71	15,00	0,00	0,00
		Subtotal I	34,07			9,98	2,51
G-N		Trade, administration, education and vet. services	31,55	99,00	0,66	0,21	0,10
		Total (A-M)	932,90			413,98	149,76

5.5. Discussion

Quantities of pollutants

The quantities of individual pollutants per sector correspond with those reported in the sources indicated in the chapter on methodology, because they've either directly taken the figures from those sources or derived figures from aggregated figures presented in them. However, this is not the case with the farming sectors. Pollutants from farming sector calculated here differ somewhat from the quantities reported in national inventories (MZOPUG 2004; MZOPUG 2004; MZOPUG 2004; EKONERG 2005; MZOPUG 2005). This is not surprising because these reports did not use the census data for the land-use and livestock reference and did not have such exact figures on fertiliser consumption (Fijan Parlov 2005). Besides, our calculation has adapted some standard IPCC and EMEP/CORINAIR factors with those from the RAIN model. In spite of all these differences, the ammonia emission (the biggest single cost) calculated here is only 22.5 per cent lower than in other official reports (MZOPUG 2004; MZOPUG 2005).

CO_2 price debate

The price level attached to carbon dioxide is decisive in all monetary assessments of its damage. However, a "fair" external price of carbon dioxide (as well as all other pollutants) is difficult to determine. The price level seems to be depending primarily on the approach to sustainability. The assessment of CO_2 damage value is much higher under the "strong" sustainability, than the "weak" and "intermediate" sustainability scenarios (EC 2003). From this table it appears that the external cost of CO_2 used in this study is far below the central estimate under the weak sustainability approach. However, the 19 EUR external price for a tonne of emitted CO_2 applied in this study corresponds well with the estimates presented in other reports (Pearce, Cline et al. 1996; Eyre, Downing et al. 1997; Smith, Powlson et al. 1998; Holland, Forster et al. 1999; Holland and Watkiss 2002). It is also worthwhile to note that the carbon emission tradable permits have been traded on the international market at about 20 EUR t CO_2^{-1} in the second half of 2005 (Point Carbon 2005).

The IPCC recognises that the estimates on the marginal damage values of CO_2 emissions range between 18 EUR and 457 EUR per tonne of carbon emitted now (IPCC 2005). The UNEP estimates the CO_2 marginal cost of meeting Kyoto targets at 15-550 EUR t CO_2^{-1}, with emission trading and at 70-2,200 EUR t CO_2^{-1} without emission trading (Halsnaes 2004). The ExternE CO_2 cost of 19 EUR per tonne of CO_2 assumes fully a operating international market for the carbon dioxide trade. In the case that the EU-15 were prohibited from trading CO_2 emissions with non EU countries, the abatement costs would be 38 EUR per tonne of CO_2 avoided (Capros and Mantzos 2000). Davidson *et al.* (2002) based on the environmental policy goals of the Netherlands government, set CO_2 price at 50 EUR t^{-1}, CH_4 at 1.0 EUR kg^{-1} and N_2O at 15,5 EUR kg^{-1}.

Table 22 Costs associated with climate change impacts and mitigation (EC 2003)

Type	Description	Value (EUR t CO_2^{-1})
Weak sustainability	Marginal damage of climate change	29.28
Intermediate sustainability	Limit carbon dioxide concentrations to 550 ppm	179.34
Strong sustainability	Limit carbon dioxide concentrations to 450 ppm; zero emissions by 2020	1,811.40

The external price of carbon dioxide used in this study is substantially lower than the values used in the UK studies on agricultural externalities: Hartridge and Pearce (2001) used 157 95 EUR t CO_2^{-1}, while Pretty *et al.* (2000), largely relying at the ExternE estimates at the time, applied a value of 95 EUR t CO_2^{-1}. In a study on agricultural influences on carbon emission and sequestrations Pretty and Ball (Pretty, Ball et al. 2002), applying the central carbon value of the carbon exchange and trading systems of the time, applied a value similar to thee present ExternE value: 18 EUR t CO_2^{-1}. A study from Tegtmeier and Duffy (2004) is a good example illustrating the magnitude of difference resulting from opting for one external price for carbon dioxide instead of another. In doubt whether to assign a cost of $20-50 per tonne of carbon dioxide equivalents as suggested by Titus (1992) or $0.98, which was the final market price for 2003 carbon dioxide equivalents at the Chicago Climate Exchange, they opted for the latter. By applying the lowest of Titus's values instead (which is also more in line with the CO_2 value calculated by other sources), the total external cost of US agriculture would be increased by 52-257 percent as compared to the cost estimated in their paper.

It is also interesting to notice that the European Climate Change Programme envisages payments for carbon-friendly farming (ECCP 2001). Farmers could be paid 20 EUR for the reduction of 1 t of CO_2 (73 EUR per t C). Assuming an annual absorption potential of 0.3 t C ha^{-1}, some 22 EUR could be paid for per hectare of such managed agricultural land (Freibauer, Rounsevell et al. 2004).

NH_3 price decisive

The ammonia cost in our calculation represents more than half of the entire damage to air. Thus, assigning the “right” level of its external price is even more crucial than for carbon dioxide. The external cost for ammonia of 5.89 EUR kg NH_3^{-1} we used corresponds quite well with the estimate of Davidson *et al.* (2002) for the Netherlands (6.4 EUR kg NH_3^{-1}). But it is important to notice that due to some new evidence and refined calculations, the new ExternE price for ammonia is about twenty times higher than originally estimated (Droste-Franke 2005). Applying this revised ammonia price for the UK for instance (Droste-Franke and Friedrich 2003) results in about 1.7 billion EUR damage, while Pretty *et. al.* (2000) estimated it at about 70 MEUR and Hartridge and Pearce (2001) did not consider it at all. This dramatic increase of the external price of ammonia in the ExternE programme best illustrates how uncertain these calculations are and how vulnerable they are against the price change of a pollutant.

Croatian charges for air pollutants

Current Croatian charges for the emission of air pollutants (N.N. 2004) are generally below those applied in other European counties in 2000, as seen in Table 23, which is based of the figures presented by the REC (2001). Their level is just some 1-7 percent of the value of air pollutant tradable permits currently traded on the international market (Evomarkets 2005; Point Carbon 2005).

Table 23 Emission taxes/charges for selected countries (in EUR)

Country	Year	CO_2	SO_2	NOx
Poland	2000	0.05	85.0	85.0
Lithuania	2000	5.50	56.3	105.5
Latvia	2000	12.62	17.9	17.9
Czech Republic	2000	26.69	28.0	22.0
Slovakia	2000	36.74	46.7	35.0
Denmark	2000	N/A	1,340.0	N/A
France	2000	N/A	27.4	22.9
Italy	2000	N/A	53.2	105.0
Norway	2000	N/A	2,100.0	N/A
Spain (Galicia only)	2000	N/A	33.0	33.0
Sweden	2000	N/A	6,940.0	4,630.0
Croatia, maximum	2005	1.60	25.6	25.6
Croatia "discounted"	2005	1.00	15.9	15.9

Last but not least - it is worthwhile to mention that the damage factors for air pollutants used in our study are some 30-50% lower than the damage factors used by the Croatian institute EKONERG in a recent feasibility study on Croatian public heating plants (Vešligaj 2005).

6. DAMAGE TO WATER

6.1. Water and agriculture

Agriculture as threat to water

Agriculture consumes about 70% of fresh water used worldwide (Postel 2001; Pimentel, Berger et al. 2004). Agricultural operations, such as soil tillage, manuring, grazing, spraying and irrigation, pose a serious threat to water quality and water habitats (Pretty, Mason et al. 2003) and agriculture is the largest single source of nutrients in the waters of many countries (ECE 1992; Quiang 1992; Rekolainen and Kauppi 1993; RIVM 1993; Haskoning 1994; Znaor and Bošnjaković 1998; Znaor 1999; Yin, Yang et al. 2001; EPA 2002; Stalnacke, Vandsemb et al. 2004; Granlund, Raike et al. 2005; Kronvang, Jeppesen et al. 2005; Norse 2005; Oenema, van Liere et al. 2005). As well as agricultural practices, the agri-chemical industry that serves agriculture also causes significant levels of pollution. In Romania, for instance, a single fertiliser producer contributes 14 percent to the total Romanian phosphate discharge into the Danube river (Toma 1999).

Agriculture as water victim

Unlike other economic sectors, notably industry, agriculture is not only a source of water pollution and over-usage - it is also a victim of such pollution. Water availability and water quality are among the most essential factors in the cultivation of plants and the rearing of livestock (Znaor 1999). Environmental problems related to water pollution are amplified by consumption patterns particularly the increase of animal protein consumption (Haskoning 1994; Vollenbroek and Csikós 1995). The quantity of water required to produce one kg of dry yield ranges from about 300 to 2,000 L per kg dry crop yield (Pimentel, Berger et al. 2004), while beef production requires up to 16,000 L (Chapagain and Hoekstra 2003; Hoekstra 2003) and sheep up to 50,000 L per kilogram (Pimentel 2005).

6.2. Pathways of entering water and type of pollutants

Pathways

Agricultural pollutants (fertilizers, pesticides, silage effluent, organic manures and other farm wastes) enter the water through runoff, erosion, leaching, base-flow and direct inputs such as manure discharge and pesticide drift (Haskoning 1994; Wit, Posma et al. 1999; Znaor 1999; Delgado 2002; Kronvang, Grant et al. 2002).

Type of pollutants

The most important water pollutants that originate in agriculture are: nutrients, pesticides, pathogens, heavy metals, oxygen-demanding (depleting) substances, fats and oil, radioactive substances and GMOs (Haskoning 1994; Vollenbroek and Csikós 1995; Znaor and Bošnjaković 1998).

6.2.1 Nitrogen balance and losses to water

Nitrogen efficiency in agriculture

Nitrogen is dynamic and mobile. Its fate and transport in agricultural systems is affected by management and unpredictable events. The average global efficiency of nitrogen use has been reported to be about 50 percent and even as low as 33 percent for cereals. (Delgado 2002; Delgado, Dillon et al. 2004). Similar nitrogen efficiency rates have been reported by other authors too (SOS 2002; Leach, Allingham et al. 2004).

The nitrogen cost, defined as the ratio between fertilizer N-input (including animal manure) and the nitrogen in products, is around 3 for wheat, 14 for dairy products and 21 for meat (Bleken and Bakken 1997).

National and regional N surpluses

The nitrogen surplus is the difference between the sum of nitrogen supplied to agricultural land (fertilisers, livestock manures, biological N fixation, atmospheric deposition) and nitrogen withdrawn by harvested crops and animal production (OECD 2001). The nitrogen surplus indicates the nitrogen pollution potential. A negative balance over time can cause soil fertility loss, while a large surplus indicates a potential environmental risk due to nutrient loss to water and the atmosphere. The average nitrogen surplus in the period 1995-97 for the OECD countries was 23 kg N ha^{-1}, for the USA 31 kg N ha^{-1} and for the EU 58 kg N ha^{-1} of agricultural land (OECD 2001). According to Brouwer, et *al*. (1999) the nitrogen surplus remains below 50 kg N ha^{-1} on almost 50% of the agricultural land in the EU. It exceeds 100 kg N ha^{-1} on a further 22%, and is in excess of 200 kg N ha^{-1} on only 2% of agricultural land. According to Terres (2002) the average nitrogen surplus in the EU is 60 kg N ha^{-1}, but the distribution of the balances shows high surplus amounts in regions of intensive livestock farming (Flanders, the Netherlands and Brittany), and low or deficit values in the central areas of Spain, France and Italy. The national annual nitrogen balance of agriculture in the Netherlands shows a surplus of 213 kg N ha^{-1}, while the surplus of Luxemburg is 121 kg N ha^{-1} (EEA 2000) The Swedish Bureau of Statistics (SOS 2002) reported an agricultural annual nitrogen budget of 70 kg N ha^{-1}, while the N balance of the Baltic States in the mid nineties was 5-75 kg N ha^{-1} (Vagstad, Stalnacke et al. 2004). The annual agricultural nitrogen balance of Slovenia is estimated at 73.6 kg N ha^{-1} and for Serbia & Montenegro at 11.9 kg N ha^{-1} (Redman 2003).

Stringent (agri)environmental policy in the EU countries has caused considerable changes in agricultural practices, leading to a reduction of the net N-surpluses. In Denmark for instance, the annual N surplus decreased from 136 to 88 kg N ha^{-1} (41 percent reduction) and the net P-surplus from 19 to 11 kg P ha^{-1} (42 percent reduction) during the period 1985-2002. (Kronvang, Jeppesen et al. 2005).

Even the UK

N balance questionable

The UK figures on nitrogen balance of agriculture are a good example of the questionable reliability of data on national agricultural nitrogen balances loss pathways even in the countries with well-organised statistics. These data are often scarce, old and remain arbitrary. The nitrogen balance for the UK in the mid nineties varies from source to source. According to the UK Ministry of Agriculture (MAAF 2000) nitrate losses to water in the mid nineties were approximately 35 kg N ha^{-1}. The OECD indicates that the total UK agricultural nitrogen balance (N inputs minus N plant uptake) in the period 1994-95 was 35 kg N ha^{-1} (Parris 1999), in 93 kg N ha^{-1} in 1994 (OECD 2000) and 86 kg N ha^{-1} in the period 1995-1997 (OECD 2001). However, according to Lord et *al.* (Lord, Anthony et al. 2002), the agricultural nitrogen balance for the UK in 1995 was 115 kg N ha^{-1}, while a national inventory of the mass nitrogen balance suggests that the UK nitrogen surplus from agriculture in 1998 was 166 kg N ha^{-1} (HRI 2002). These differences are not surprising, taking into account that some of the basic input data for such calculations are also controversial. DEFRA (2002) for instance estimates that UK figures for the production of manure "*range from 90 to 170 million tonnes/year, around 90% of all organic 'waste' production*", while in another document (DEFRA 2002) it says that British farmers "*every year spread about 80 million tonnes of animal manures onto the land as fertiliser*". A national nitrogen balance for the UK that is more recent than 1995-1998 doesn't seem to exist.

Problems with nutrient balances calculations

In spite of the several calculation models that are available, the reliability of nitrogen budgeting still remains arbitrary. Watson and Atkinson (1999) compared three approaches to nitrogen budgeting. Depending on the complexity of the method and calculation objectives, the three approaches resulted in a nitrogen surplus of 188, 212 and 285 kg N ha^{-1} $year^{-1}$.

Nutrient efficiency, defined as the percentage of outgoing over incoming nutrients, ranged from 11% (N) and 21% (P) on cattle and sheep farms in less favoured areas to 54% (both N and P) on cereal farms. The contribution from cropping versus livestock farming in the total efficiency varied widely between farm types. On the catchment scale the surplus associated with grassland and livestock (225 and 37 kg ha-1 of N and P) clearly exceeded that associated with arable crops (44 and 19 kg ha-1 of N and P) (Domburg, Edwards et al. 2000).

Losses depend on numerous factors

Nitrogen loss depends on several factors among which soil type and climate seem to dominate (SUM 2000). These determine precipitation and thus influence drainage and percolation, while temperature greatly influences plant growth, soil ecology, nitrogen utilization and atmospheric processes. In addition, management practices such as the type, timing and method of nutrient application also play an important role in nutrient losses (Goulding 2004).

N loss pathways

The excess nitrogen, or surplus, is washed out into groundwater in the form of nitrate, eliminated through microbial denitrification and degassing of ammonia or stored in the organic soil fraction until a new balance is reached between nitrogen mineralisation and organic nitrogen input (OECD 2001; Schweigert and van der Ploeg 2002; Watson, Bengtsson et al. 2002). Duxbury *et al*. (1993) made an attempt to describe a typical nitrogen pathway once it has been applied in the form of fertiliser. Fifty percent is harvested in the crop and the other 50 percent is lost by a combination of leaching (25 percent), surface runoff (5 percent) and gaseous loss (20 percent), primarily denitrification. According to Layers (2001) for every 100 kg of fertilizer N applied 50 kg is taken up by the crop, leaving 50 kg to go elsewhere. Typically, 20 kg remains in soil organic matter, 10 kg is lost to drainage water and 20 kg is lost to the atmosphere. Other authors, however, report on different patterns of N loss pathways. The nitrogen balance for Sweden for instance indicates that 15.5 percent of the nitrogen surplus remains in the soil, while in the case of Germany this is as high as 28 percent (Isermann 1990; Isermann 1994).

Average leaching 10-50 percent of N applied

Nitrate leaching is notoriously difficult to estimate and losses can vary from zero to 60 percent of the applied nitrogen. The losses from common grain-production systems would range from 10% to 30% of N added through fertilisers and manure (Gast, Nelson et al. 1978; McNeil and Pratt 1978; Legg and Meisinger 1982; Pratt 1984; Randall and

Iragavarapo 1995; Delgado 2002; Meisinger and Delgado 2002; Maene 2004). According to Mosier *et al.* (1998) some 30 percent of the nitrogen applied to agricultural fields is lost through leaching and runoff, of which about 2.5 percent is converted to N_2O in aquatic systems. Some authors, however, report on slightly higher (30-50 percent) average nitrogen leaching losses (Bouwer 1987; Goderya, Dahab et al. 1996; Shamrukh, Corapcioglu et al. 2001). In an experiment during a wet season Allingham *et al.* (2003) reported N leaching of 70% of N applied on grass ley, 80% on forage maize and 380% on stubble turnips. Nitrogen loss is difficult to reduce without drastic reductions in fertiliser inputs or stocking rates (Leach, Allingham et al. 2004). Nitrogen loss to water can be greatly reduced through judicious feeding (type of feeds and ratio change), an improved utilization of manure and good balance between grassland and arable area. Following this policy Dutch experimental farms managed to reduce nitrate concentration in the upper groundwater from 200 to 50 mg NO_3 L^{-1} within a few years (Aarts, Habekotté et al. 2000).

National estimates on N ending in water depend on calculation method

Silgram *et al.* (2001) made a comparison between the standard IPCC model for calculating national nitrate leaching, and two other approaches, a modified IPCC and NEAP-N, a UK simulation model. Their results showed large differences between the estimates for total leaching, ranging between 39 and 88 kg N ha^{-1}. In the case of the UK, this would mean that the total annual nitrogen loss to water could be in the range between 455,064 and 1,026,810 tonnes of nitrogen (HRI 2002). Lord *et al.* (2002) omitted nitrogen input through aerial deposition in their calculation, but in spite of this arrived at a higher figure. According to them some 1,341,855 tonnes of nitrogen derived from UK agriculture enters water resources. The OECD estimates that nitrogen loss to water in the UK is approximately 40 percent of the surplus (OECD 2000). A similar figure (32-44 percent) has been reported also for Denmark (Kronvang, Grant et al. 2002).

6.3. Environmental problems

Pollution from agriculture causes serious environmental problems especially because aquifers have a slow rate of renewal (a long time is needed to restore the previous quality level) (OECD 1986; Pimentel, Berger et al. 2004).

Pesticides in water

Pesticides exceeding the maximum admissible concentrations are found in numerous ground water supplies in the EU (OECD 1986; Znaor and Bošnjaković 1998; Pretty and Hine 2005) causing a threat to human health and water ecosystems.

Sedimentation

Agriculture-induced sedimentation takes place when wind, water, gravity or ice, transports soil particles and organic material from agricultural land to streams or lakes. Excessive sedimentation clouds the water reducing the amount of sunlight reaching aquatic plants; covering fish spawning areas and food supplies; and clogging the gills of fish (Brusven, Walker et al. 1995; Znaor 1999). The soil particles that enter water bodies in this way also carry nutrients (particularly phosphorus), pathogens, and heavy metals. Solids deposited in water bodies can accelerate eutrophication through the release of nutrients over extended periods of time, and decrease not only the overall productivity of waters but have a negative effect on their other functions (e.g recreational uses) as well (Pretty, Mason et al. 2003). In the US sediment forming (siltation) was found to be the most important environmental problem associated with rivers and streams and agriculture was responsible for almost 50% of the total sediment load (EPA 1998). Eroded soil particles have a negative impact on dams and other hydraulic structures and decrease the retention volume of water-bodies (Znaor 1999).

Eutrophication

Eutrophication causes serious implications for the ecological balance in rivers, lakes and coastal water and can seriously affect drinking water quality. It results in excessive aquatic weed growth and algae bloom, reducing swimming and boating opportunities, and disrupting ecosystem equilibrium (ECE 1992; Vollenbroek and Csikós 1995; Pretty, Mason et al. 2003). High nutrient concentrations deplete oxygen and cause toxicity to aquatic fauna, and foul taste and odour in drinking water (Znaor 1999).

Wider problems

In addition, water pollution generated by agriculture raises a number of additional concerns because:

- the migration period for nitrates (also other nutrients) and pesticides to be washed out of the topsoil and leached into groundwater amounts to 10-20 years. This means that the groundwater pollution measured now reflects the grade of pollution which existed 10-20 years ago (RIVM/RIZA 1991);
- pesticide metabolites and "cocktails" may be more hazardous, more persistent or more toxic than the use of a single pesticide. Most of the sprays used in today agriculture are pesticide "cocktails" (Evans, Jevel et al. 1992)
- impurities in pesticides are usually not controlled and monitored and are often a greater hazard than that of the pesticides themselves (OECD 1986)
- existing analytical methods can detect only about half the active ingredients in pesticides today and monitoring programmes in many countries are limited or non-existent (RIVM/RIZA 1991).
- use of phosphorus fertilisers raises the radioactivity of soils and water (Barišić, Lulić et al. 1992; Znaor 1999)
- only a few countries have regulations with regard to the use and disposal of *Baciloviruses* and genetically modified organisms. Most of the regulations don't allow these organisms to be used in water catchments, although sometimes inactivated formulations (unable to multiply) are allowed (Znaor 1999).

6.4. Impact on human health

6.4.1 Pesticides

Global problem

Pesticides cause various public health problems, although their effects are not widely recognised and their true extent remains unknown (Kishi 2005; Pretty, Heffron et al. 2005; Pretty and Waibel 2005). Globally, pesticides are estimated to cause 26 million human poisonings and 220,000 deaths each year (Richter 2002).

Cause a range of health problems

Pesticides are associated with cancer, neurological and reproductive effects, respiratory and skin disorders and impaired immune functions (Keifer 1997; Kreiger 2001; Kishi 2005). Many of the pesticide-related health problems are linked with water containing pesticides above the admissible levels. Exposure to pesticides raises the risk of cancer (Ejaz, Akram et al. 2004) and is associated with Parkinson's disease (Seidler, Hellenbrand et al. 1996; Priyadarshi, Khuder et al. 2000; Priyadarshi, Khuder et al. 2001). Pesticides are found to activate human androgen receptors (Lemaire, Terouanne et al. 2004), and disturb metabolic processes in the blood (Ledirac, Antherieu et al. 2005). A study from Croatia suggests that 2,4-dichlorophenoxyacetic acid pesticides cause an increase in chromatid and chromosome breaks, a number of micronuclei and number of nuclear buds (Željezić and Garaj-Vrhovac 2004)

Herbicides

Nitroaromatic herbicides (e.g., dinitrophenol, dinoseb, dinitrocresol formulations) affect cellular metabolism and have been associated with hyperthermia (high body temperature), rapid breathing, dehydration, liver and kidney degeneration, and neutropenia (low numbers of immune system cells called neutrophils) following overexposure (Morgan 1989). Atrazine has been known to have adverse environmental and health impacts. It is categorised as a high environmental risk to ground water, a medium risk to surface water, aquatic species, acute and chronic health, and a low-risk to birds, mammals and non-target organisms (Mullen, Norton et al. 1997; Brethour and Weersink 2001). Atrazine present at low concentrations was found to be a strong inducer of homologous recombination (Besplug, Filkowski et al. 2004) and to contribute to dopaminergic system disorders (Rodriguez, Thiruchelvam et al. 2005). The herbicide, 2,4,5-T is believed to develop a skin condition called chloracne, resulting from low level contamination of this product with tetrachlorodibenzodioxin (TCDD, called dioxin) (Kimbrough 1990). Paraquat has resulted in fatal pulmonary edema following intentional and accidental overexposure (Klaassen, Amdur et al. 1986; Morgan 1989).

A number of fungicides are believed to cause respiratory and dermal irritation and/or sensitization (Morgan 1989).

Pesticides also cause endocrine disruption in wildlife (Gies 2003).

Croatian authorities consider organochlorinated pesticides, DDT and lindane as compounds of "*high toxicity and proven tetragenic and carcinogenic properties*" (Hrvatske vode 2002).

6.4.2 Nitrates

Associated with numerous health problems

Higher nitrate concentrations in water are associated with a risk of coronary heart disease (Cerhan, Weyer et al. 2001) and cancer mortality (Criss and Davisson 2004). Nitrates are found to have a positive correlation with the development of various forms of cancer, such as: gastric cancer (Sandor, Kiss et al. 2001), esophageal cancer (Zhang, Zhang et al. 2003), urothelial cancer (Volkmer, Ernst et al. 2005), bladder and ovarian cancer (Weyer, Cerhan et al. 2001), non-Hodgkin lymphoma and colorectal cancer (Gulis, Czompolyova et al. 2002), as well as childhood brain tumours (Mueller, Nielsen et al. 2004). Nitrates impair thyroid function (Follett and Follett 2001; Eskiocak, Dundar et al. 2005) and are believed to cause intrauterine growth restriction and prematurity (Bukowski, Somers et al. 2001), as well as respiratory infection (Follett and Follett 2001). Nitrates and nitrites react with secondary amines in food, forming nitrosamines- compounds that have been demonstrated to cause a variety of adverse effects when administered to laboratory animals in high doses. These effects include liver and lung damage, convulsions, birth defects, and cancer (NRC 1981; EPA 1987).

Can cause mortality of infants

The use of nitrate-contaminated drinking water to prepare infant formula causes a potentially fatal methemoglobinemia. This disorder is better known as the “blue baby syndrome”, deriving its name from skin colour. It develops as a result of nitrate conversion to nitrite, resulting in the compromised ability of haemoglobin to reversibly interact with oxygen, thus depriving tissues of oxygen. Nitrate-nitrogen concentrations as low as 30 mg L^{-1} have been found to cause methemoglobinemia (Knobeloch, Salna et al. 2000), which can be developed by children up to 8 years of age (Gupta, Gupta et al. 2000). Besides babies and children, people who receive kidney dialysis treatment are also very susceptible to methemoglobinemia (Follett and Follett 2001).

... and animals

Studies from Campagnolo et al (2002) and Belilage *et al.*, (2002) demonstrate that higher nitrate concentrations in drinking water can cause health problems and mortality by livestock. Water high in nitrate can also have detrimental effects on the health of farm animals, resulting in weight loss and poor feed conversion (Carter and Sneed 1987).

However, the level at which nitrate becomes toxic for humans and livestock remains a matter of harsh debate between scientists advocating the precautionary principle and scientists challenging the epidemiological evidence for direct relationships between nitrate and health (Boink and Speijers 2001; L’Hirondel and L’Hirondel 2002; Schroder, Scholefield et al. 2004).

6.4.3 Other water pollutants

Pathogens (viruses and bacteria) as well as heavy metals (Cd, Cu, Zn) deriving from agricultural inputs and operations can also cause water pollution and consequently severe health problems for humans, livestock and wildlife

6.5. Water valuation methods

No standard valuation method available

Although the studies on water valuation and water externalities date from as early as the mid eighties (Radford 1983) no uniformed approach has been developed yet. Instead a variety of methods are employed. Methodological difficulties, lack of data and a high degree of uncertainly have been reported as key difficulties in assessing water-related externalities (Forster, Watkiss et al. 2003; Pretty, Mason et al. 2003; von Blottnitz, Rabl et al. 2004). A comprehensive overview on water functions and water valuation methods is given in (FAO 2004).

Water externality features

Pretty *et. al*. (2003) stress that externalities in the water sector have four features:

- their costs are often neglected
- they often occur with a time lag
- they often damage groups whose interests are not well represented
- the identity of the source of the externality is not always known.

Difficulties and limitations

According to van Beukering *et al.* (1998) in the water sector many effects cannot be estimated in monetary terms and it is necessary to estimate certain externalities using non-monetary evaluation methods. Poe (1999) stresses that water-related externalities (costs and benefits) are large, concurrent and widely varying by location and affected population. Agriculture's contribution to the pollution of surface water and contamination of groundwater is particularly difficult as the share of this sector in the degradation of water quality is difficult to determine and quantify (Ongley 1996). A particular problem is the valuation of nitrates and pesticides impacts. These are very difficult to quantify, because both pollutants are largely controlled through drinking water regulations (Forster, Watkiss et al. 2003).

Water pollution benefits

Although water pollution is primarily associated with costs, Pretty *at al*. (2003) stress that there also might be some benefits of water pollution. In the case of eutrophication the benefits include:

- Increased productivity of some fisheries
- Positive fertilisation effect on farmland through the use of nutrient-enriched irrigation water
- Improved sources of food for some wild birds.

In order to obtain the true cost of pollution these benefits should be assessed against the costs.

Cost categories

Pretty et *al.* (2003) distinguish between two main cost categories and several sub-cost categories relating to water nutrient enrichment:

1. Damage (or value loss) costs arising from reductions in the value of clean or non-nutrient enriched water. These are further subdivided into:
    a. Use values: private benefits gained from ecosystem services. These include private uses (e.g. agriculture, industry), recreation benefits (e.g. fishing, water sports, bird watching), education benefits, general amenity benefits, and option values (the desire of an individual to maintain the choice to use an ecosystem's services in the future).

   b. Non-use values comprise existence values (preservation of an asset, even though individuals do not envisage using it) and bequest values (attached to preservation so that a future generation has an option for use.

2. Policy costs incurred in responding to eutrophication damage plus the costs of changing practices to meet legal obligations

Figure 15 outlines the key cost categories as used in some recent studies on water valuation and water externalities.

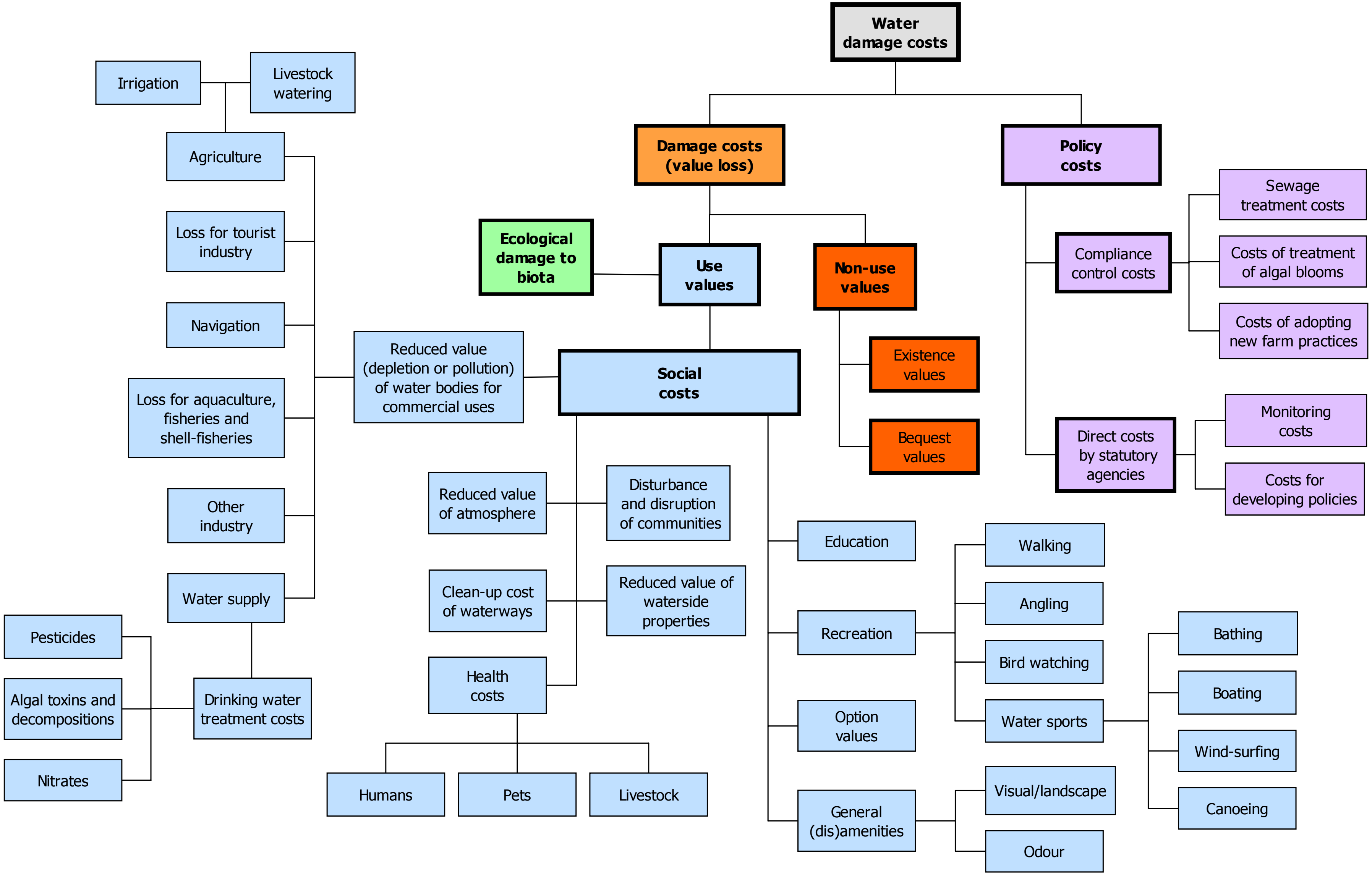


Figure 15 Cost categories relevant for water externalities, based on (van Beukering, van Drunen et al. 1998; Forster, Watkiss et al. 2003; Pretty, Mason et al. 2003)

Below is an attempt to outline some of the methods used in assessing the true price of water and/or related externalities.

Efforts at the EU level

The European Commission (EC 2001) identifies the following ‘priority impacts’ for the water pollution impact category:

1. Impacts of eutrophication on ecosystems;
2. Human health effects of nitrates;
3. Impacts of organic pollution on ecosystems;
4. Impacts of pesticides upon ecosystems;
5. Human health effects of pesticides.

However, the Commission does not seem to have made an attempt to quantify water externalities outside of the efforts made by the ExternE programme. Thus the valuation of water externalities at the EU level remains in the realm of the unknown.

ExternE assessment

Due to the site-specific dependence of water pollution, the ExternE programme is unable to use the standard impact pathway approach in the same way as for the air pollution (University of Bath 2005). Figure 16 illustrates the impact assessment and valuation stages used in the ExternE project. The ExternE project estimates welfare measures of water pollution impacts in monetary terms, as well as the avoidance costs associated with sustainability paths (Forster, Watkiss et al. 2003). Only freshwater costs are estimated and no assessment of pollution of estuarine, marine and coastal systems has been made. Besides, the ExternE calculation on water externalities comprises only some case studies and no overall EU assessment exists yet.

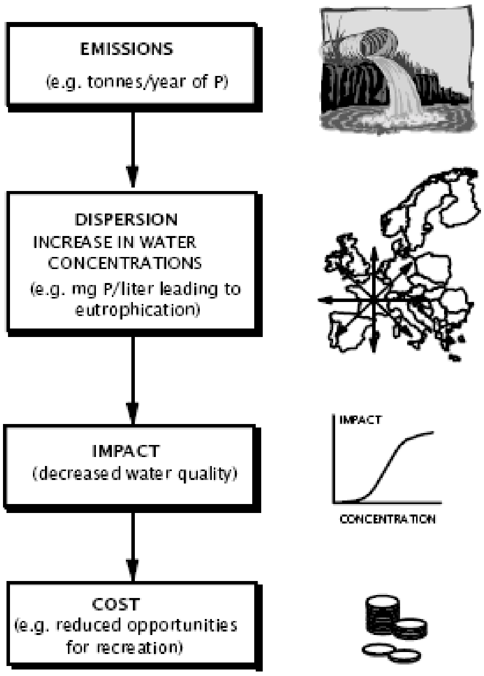


Figure 17 Impact assessment and water valuation stages in the ExternE assessment (Dorland, Jansen et al. 1997)

6.5.1 Contingent valuation

Widely used

Contingent valuation measuring citizens' WTP for an improvement in water quality has widely been used to value water and related externalities (Bockstael, Hanemann et al. 1987; Bockstael, McConnell et al. 1989; Choe, Whittington et al. 1994; Zylicz, Bateman et al. 1995; Brouwer, Langford et al. 1997; Bockstael, Freeman et al. 2000). Depending on the region and the extent of the problem, households seem to be willing to pay monthly 3.8 EUR in Greece (Kontogianni, Langford et al. 2003), 5.3 EUR in Latvia (Ready, Malzubris et al. 2002) and 7.8-9.7 EUR in the USA (Kramer and Eisen-Hecht 2002; Mathews, Homans et al. 2002) for the water cleanup programmes. Besides WTP for the cleanup operations, residents are also willing to contribute in non-monetary ways (mainly their time), which can represent 60% of the total value for the non-marketed benefits (Alam and Marinova 2003). Another contingent valuation method is willingness to accept (WTA) compensation to tolerate environmental damage. This method has also widely been used to assess external costs of pollution (Carson 2000; Pretty, Mason et al. 2003; Perman 2004).

However, the applicability of the contingent valuation method in assessing water pollution caused by adverse agricultural practices seems to be limited as hardy any of such studies seemed to have used this method.

6.5.2 Pollution abatement and shadow prices method

N shadow price similar in several studies

A shadow price derived from the pollution abatement costs is another known method to valuate water pollution. This method is mostly used to assess the cost of water pollution generated through the excessive use of nitrogen. Studies on the costs involved in abating nitrogen entering water exist in several countries. Although these studies do not necessarily apply the same theoretical framework and calculation methods, a number of them have obtained similar value ranges for nitrogen shadow prices.

Table 24 outlines the results of some of these studies. In order to make a better comparison between the studies, the nitrogen shadow price from the reference year has been updated to the 2005 value by applying an annual price increase of 5%. The average 2005 nitrogen shadow price based on these studies would be 3.1 EUR per kg of nitrogen.

Table 24 Nitrogen shadow price as obtained by different studies.

Country/region	Author	Reference year	Average nitrogen shadow price	
			Ref. year	2005
The Netherlands	(Bleijenberg, Davidson et al. 1998)	1997	1.6	2.4
	(Reinhard 1999)	1998	1.4	2.0
	(Davidson, Hof et al. 2002)	2002	3.8	4.4
Italy	(Tiezzi 1999)	1991	0.3	0.6
Germany	(Piot-Lepetit, Brümmer et al. 2002)	1998	2.5	3.5
Denmark	(Schou, Skop et al. 2000)	1999	1.6	2.1
	(Berentsen, Giesen et al. 1998)	2002	4.5	5.2
Norway	(Vatn, Bakken et al. 1999)	1997	1.8	2.7
Sweden	(Bystrom 1998)	1997	3.0	4.4
Finland	(Lankoski and Ollikainen 1999)	1998	5.4	7.6
France	(Piot-Lepetit and Vermersch 1998)	1997	1.8	2.7
	(Piot-Lepetit, Brümmer et al. 2002)	1998	1.4	1.9
EU-15	(Brouwer, Hellegers et al. 1999)	1999	2.0	2.6
USA	(Shaik, Helmers et al. 2002)	1997	2.4	3.6
Danube basin	(Wit, Posma et al. 1999)	1997	1.0	1.5
	(Gren, Groth et al. 1995)	1994	2.2	3.7
Croatia	(Sumelius, Mesić et al. 2005)	2002	1.4	1.6
	Average above studies	-	2.2	3.1

An exceptionally high nitrogen shadow price has been reported for Switzerland. The social benefit of avoided nitrogen emissions are estimated at 14 EUR per kilogram of nitrogen (Lehmann, Haefliger et al. 1997).

N shadow price in organic farming

Since nitrogen is a scarce resource on organic farms, Dabbert (1990) argues that its shadow price is thus also higher than in conventional farming and sets it in the range 0.4-2.3 EUR per kg of nitrogen (value in 1990). In a later study, Dabbert and Priorr (1998) suggest that the internal nitrogen value in organic farming is 6-7 times higher than the costs of mineral fertiliser and its application.

N shadow price for Croatia

The nitrogen shadow price for Croatia could be extrapolated from the study of Sumelius *et al.* (2003; 2005). Following surprisingly high N inputs in the Lonjsko Polje nature park (206-236 kg N per hectare of maize and wheat), they've developed a mathematical model to assess the relationship between N input and N leaching (Figure 18). Similar N-dose response behaviour between the nitrogen response curve and corresponding leaching losses are well known and have been reported in other studies too (Goulding 2000).

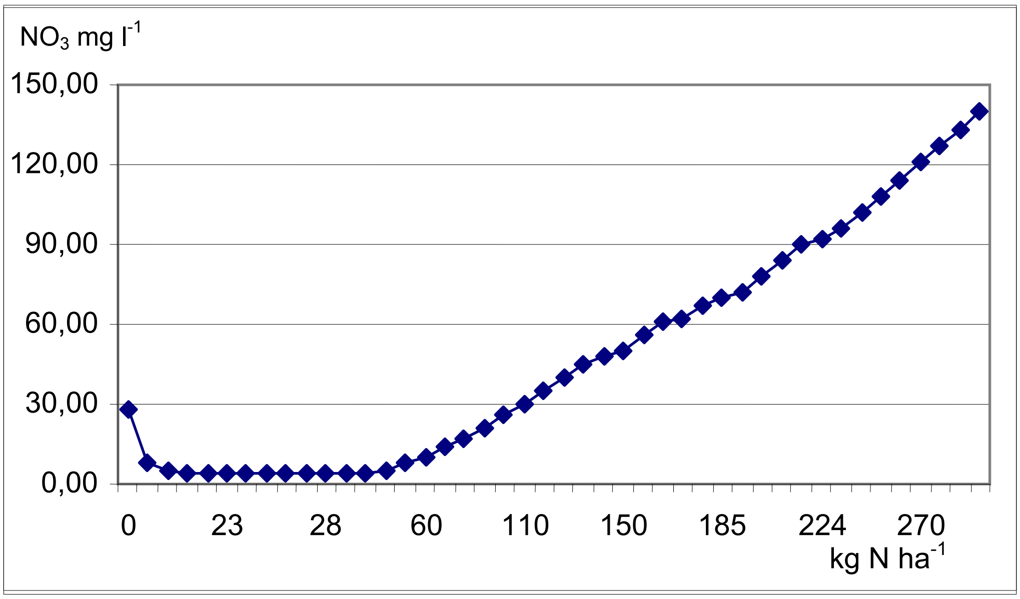


Figure 18 Leaching response to nitrogen input, modified after (Sumelius, Grgić et al. 2003; Sumelius, Mesić et al. 2005)

The average N use of 218 kg N ha^{-1} in Lonjsko Polje park results in an average leaching of 89 mg NO_3 L^{-1}. From the graph above it seems that the N inputs higher than about 145 kg N ha^{-1} lead to nitrate concentrations above 50 mg NO_3 L^{-1}, which is the MAC for nitrates prescribed by the EU Nitrates Directive. In the case of Lonjsko Polje, a reduction of some 73 kg N (from 218 to 145 kg N ha^{-1}) is required, resulting in a reduction of 39 mg NO_3 L^{-1} (from 89 to 50 mg NO_3 L^{-1}). The study reports that the marginal cost per mg NO_3 L^{-1} is 2.49. If this marginal cost is multiplied with the reduced concentration of 39 mg NO_3 L^{-1} and divided by 73 reduced kg N, it results in a shadow price of 1.33 EUR per kg of nitrogen.

However, the calculation of Sumelius *et al*. (2003; 2005) takes into account only the farm level cost of reduced nitrogen leaching and does not include monitoring and other social costs.

Pesticide externalities difficult to assess

Studies estimating the marginal damage from pesticides released into the environment are scarce because little is known about the individual toxicity levels of pesticides and about how pesticides interact with each other, and with other chemicals (Hartridge and Pearce 2001). A study from Foster *et al*. (Foster, Mourato et al. 1998) estimated the WTP to avoid pesticide residues in food at 17.5 EUR per kg of pesticides and in 2001 was the only European study of this type (Hartridge and Pearce 2001).

6.5.3 Pressure-state-response method

Assesses actual water externalities

Both the contingent valuation and shadow price methods are rather hypothetical as they measure the cost of an imaginary clean-up technology or policy programmes reducing/avoiding pollution. These methods do not assess the actual costs occurring at the time of assessment. A pressure-state-response method developed by Pretty *et al.* (2000) offers a framework for assessing the actual (in-progress) social and ecological water damage costs, as well as policy response costs. This method has also been adopted by other authors (Hartridge and Pearce 2001; EA 2002).

Assessments of the UK water externalities

Using the pressure-state-response method, Pretty *et al.* (Pretty, Ball et al. 2005) assessed the damage to water caused by UK agriculture at 333 million EUR for 1996 and 500 million EUR for 2000 (Table 25). The cost items include externalities related to pesticides, nitrate, phosphate, soil and Cryptosporidium in water; eutrophication of surface water and monitoring of water systems and advice.

Table 25 External costs of UK agriculture to water (Pretty, Brett et al. 2000; Pretty, Ball et al. 2005)

	1996	2000
	MEUR	MEUR
Pesticides in water	173	206
N, P, soil and *Cryptosporidium* in water	135	161
Eutrophication of surface water	9	114
Monitoring of water systems and advice	16	19
Total	333	500

In another study, Pretty *et al.* (2003) estimated the damage costs of freshwater eutrophication in England and Wales to be in the range of 108-164 million EUR per year. Seven cost categories have been found to dominate the eutrophication damage costs:

1. Reduced value of waterfront dwellings
2. Drinking water treatment costs for nitrogen removal
3. Reduced recreational and amenity value of water bodies
4. Drinking water treatment costs for removal of algal toxins and decomposition products
5. Reduced value of non-polluted atmosphere
6. Negative ecological effects on biota, and
7. Net economic losses from the tourist industry.

The accompanying eutrophication policy response cost makes an additional 79 million EUR, bringing the total costs of freshwater eutrophication in England and Wales at 187-243 million EUR. The eutrophication cost of the US Madison’s Lake Mendota has been estimated to be about 45 million EUR in lost recreation and property alone (Carpenter 2002).

Using the results from Pretty *et al*. (2003), von Blottnitz *et al*. (2004) have made an attempt to assign the external costs of mineral fertiliser nitrogen in relation to eutrophication, suggesting that this lies in the range of 0.01 - 0.065 EUR kgN^{-1}, with a central value of 0.03 EUR kgN^{-1} applied in the UK. This value, however, also includes externalities associated with nitrogen fertiliser manufacture.

Damage to the Danube basin

The damage to the priority functions (drinking water, recreation, fisheries, ecosystem and hydraulic structures) of ground and surface water in the Danube basin and part of the north-western shelf of the Black Sea is estimated to be about 4 billion EUR per year (excluding the loss of topsoil) (Haskoning 1994; Vollenbroek and Csikós 1995). Agriculture is believed to contribute to more than fifty percent of these costs.

Comparison of pesticide damages

A study from the 15-million-inhabitant Mekong Delta in Vietnam (Phuong and Gopalakrishnan 2003) assessed the degradation of the rural water system due to pesticide application for rice production at some 220 million EUR in 2003. This study assesses the damage caused by a single crop to a single watershed and when compared to the pesticide damage of 206 million EUR caused by the entire UK agriculture (Pretty, Ball et al. 2005) it appears to be pretty high - or the other way around. A study on pesticide reduction from agricultural practices in Ontario (Brethour and Weersink 2001) calculated that the average annual citizens' willingness to reduce pesticide risk in Ontario between 1983 and 1998 was some 12.5 EUR per household. If the UK pesticide damage to water (Pretty, Ball et al. 2005) is divided between 25.6 million UK households, the corresponding cost for pesticides in water is 6.7 EUR for 1996 and 8.0 EUR for 2000.

6.5.4 Water purification costs

Removal methods

The methods used to remove water pollutants from drinking water include water treatment with bacteria, ozone, powdered or granular activated carbon; nanofiltration; catalytic removal; use of reverse osmosis membranes, etc.

Efficiency of pesticide removal methods

The removal efficiency of pesticides from water largely depends on the membranes used and on the pesticides that have to be removed. The efficiency removals are generally low (40%-80%) (Haist-Gulde, Baldauf et al. 1993; Montovay, Assenmacherd et al. 1996) and can go up to 90%-95% if more expensive membrane systems are used (Kiso, Nishimura et al. 2000; Van der Bruggen and Vandecasteele 2003). Košutić *et al*. (2005) found that nanofiltration gives satisfactory results in drinking water treatment in Slavonia, a Croatian region that is known for intensive agriculture. However, the investment and operating costs of this action are not specified.

Removal costs

Nitrogen and pesticide removal costs vary according to the raw water quality, removal method and filters used, as well as the nature and initial concentration of the pollutants (Haist-Gulde, Baldauf et al. 1993). Water companies have been facing increasing yearly costs for water treatments (Pretty, Mason et al. 2003; Knapp 2005). Table 26 indicates typical costs for such treatments in several countries.

Table 26 Costs of nitrogen and pesticide removals from water

Country	Author	Pollutant	Removal method	Average price per cubic meter (EUR)
Austria	(Lughofer and Kratochvil 1997)	Nitrates	Various	0.33
	(Lughofer and Kratochvil 1997)	Atrazine	Various	0.12
Germany	(Gorenflo, Velazquez-Padron et al. 2003)	Pesticides	Nanofiltration	0.23
	(Horold, Tacke et al. 1993)	Nitrates	Catalitic	0.25
	(Rutten and Schnoor 1992)		Autotrophic bacteria	0.24
France	(Rapinat 1993)	Nitrates	Ion exchange, Biological	0.38
W. Europe	(Van der Bruggen and Vandecasteele 2003)	Pesticides	Nanofiltration	0.26
Turkey	(Koyuncu, Topacik et al. 2001)	Ammonium	Reverse osmosis membranes	0.75
	(Eroglu, Sarikaya et al. 2001)	Nutrients	Not specified	0.80

Prevention cheaper than removal

Generally speaking, the prevention of pesticide and nitrate pollution of groundwater is more cost-effective than treatment (Smit and Laeven 1998). Purification plants are effective tools to clean water but their construction and maintenance is expensive and most countries require loans for such operations (Znaor 1999). Investing in prevention of pollution at source is cheaper than investing in water-purification plants, notably in agriculture, which is the sector with the most favourable cost:benefit ratio in prevention of water pollution (Haskoning 1994).

German water companies pay for organic farming

Several German companies have been supporting organic farming in their water harvesting regions. In 1998, out of 1,300 water companies in Germany, 26 had programmes for supporting organic farming, while an additional 98 were considering starting such a programme (AGÖL/BUND 1997; Hermanowski and A 1997; Krug 1997). The investment in organic farming programmes per cubic metre of water has been found to be about seven times cheaper than the cost of nitrogen removal (Schirmer and Fleischer 1995; Kratochvil 2002). The support water companies offer to organic farmers include economic and informative instruments such as area payments, land lease, marketing promotion, extension, demonstration and information services (Kratochvil, Lindenthal et al. 1999; Kratochvil 2002).

6.6. Quality of Croatian water resources

6.6.1 General

Public water supply system

In Croatia only 75 per cent of the population is connected to the public water supply system and the average water use per inhabitant is 120-150 litres per day (MZOPU 2003). Some 85% of water for the public water supply system is obtained from groundwater reserves (CCPC 2004). Due to its unsatisfactory microbiological and chemical properties, the harmful quality of drinking water affects the health of 10-15 percent of those connected to public water supply system (CCPC 2004).

Inconsistent and poor data

While the quality of fresh water is monitored to a degree by state-owned company Croatian Waters, there is no systematic monitoring of the costal water - only some basic testing is being practiced for the region of Dalmatia (Hrvatske vode 2002; Hrvatske vode 2004). A comprehensive database of information on nitrogen levels in lakes is not yet available and systematic groundwater monitoring exists only in the city of Zagreb (Hrvatske vode 2003; Hrvatske vode 2004).

The National Environmental Protection Review (MZOPU 2003) stresses that the number of monitoring points in the major Croatian catchments (Sava, Drava, Danube) is insufficient for getting reliable information on pesticide concentrations. Along the 510 km of the Sava river - the longest Croatian river passing through the fertile plains with intensive agricultural production - there are only 4 pesticide measuring points - one every 128 km on average!

Both Croatian surface and drinking water quality is being assessed using fewer parameters than recommended by the World Health Organization or signed conventions (Vitale, Rajčić et al. 2002).

6.6.2 Nutrients

National Environmental Protection review

The National Environmental Protection Review points at various water quality problems, notably those related to increased nutrient content (MZOPU 2003). The nitrogen content of the major rivers of the Danube basin, which is also Croatia's most intensive agricultural area, fails to meet the prescribed quality for the rivers (II category). The eutrophication process has been enhanced in most Croatian lakes and their phosphorus content is far above the prescribed parameters for the second water category, ranging from category III-V. In 2000 only 30% of the Croatian spring water (largely reflecting the quality of the ground water) met prescribed nutrient content standards (MZOPU 2003).

Croatian Waters P.l.c. surveys

Croatian Waters, the public company responsible for water management, produces annual reports on the quality of water resources in Croatia. Water quality monitoring on nutrient contents is carried out at around 250 locations throughout the country (Hrvatske vode 2002; Hrvatske vode 2002; Hrvatske vode 2003; Hrvatske vode 2004). In the period 2000-2003, at the vast majority (in the range of 64% - 74%) of the monitored locations the water exceeded the prescribed nutrient content for the given water category (Figure 19). A particular concern is the situation with the first category water. This includes all groundwater, as well as spring and surface water that should be drinkable in its natural state or after disinfection. In the period 2000-2003, more than 80% (range 82% - 95%) of locations containing such water exceeded the MAC for nutrients.

Hardly any Croatian water company seems to be practising nutrient removal from drinking water and in case of excessive nitrates the most common practice is to drill a new water supply source (Šobot 2004;

Devčić 2005; Međimurske vode 2005; Miler 2005; Pnjak 2005; Valek 2005; Zagorski vodovod 2005).

As long as the new sources can be found locally, this practice seems to be more economically viable than the introduction of nutrient removal technologies (Šobot 2004; Pnjak 2005).

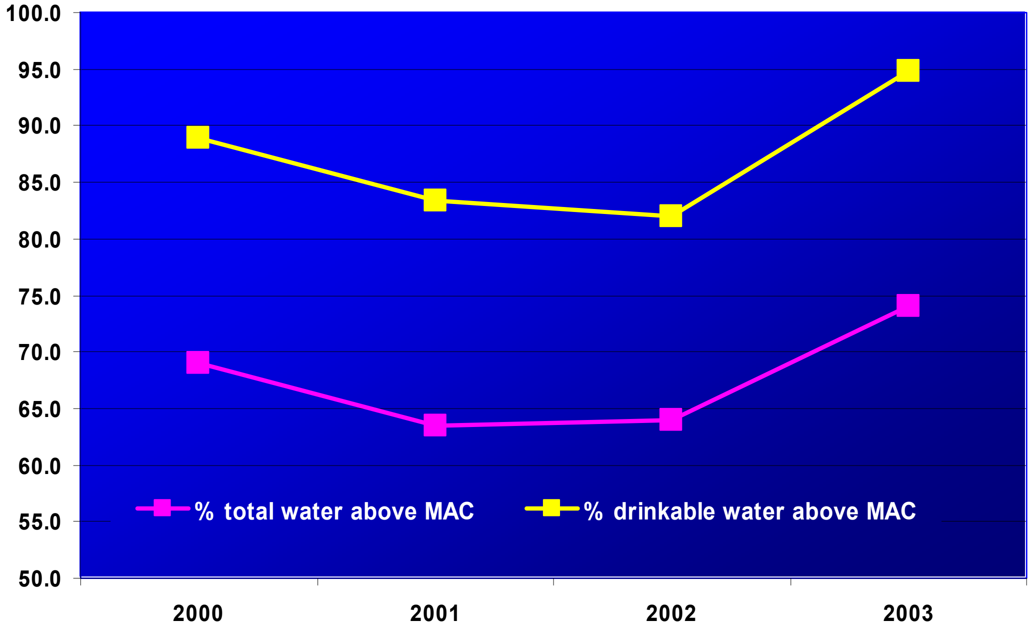


Figure 19 Percentage of total and drinkable water exceeding the MAC for nutrients (after Hrvatske vode (2002; 2002; 2003; 2004).

Although very unlikely, theoretically it is possible that the inhabitants have been supplied exclusively with drinking water from the tiny portion (5% - 12%) of locations complying with the MAC for nutrients, or other high-quality water sources, notably ground water, not included in the monitoring scheme of the Croatian Waters. However, taking into account the aforementioned figures from the locations throughout the country, it is very unlikely that the quality of non-monitored drinking water sources would be substantially better. But even if this was to be the case, the existing data from the national water quality surveys suggest that Croatian water resources contain ample nutrients whose impact is most likely to have long-term consequences.

Public health authority reports

According to the figures of the Croatian National Institute of Public Health (HZJZ 2002; HZJZ 2003; HZJZ 2004), 7.1 percent of the analysed water samples from the public water supply was "*chemically unsafe*" for drinking in the period 2001-2003. High percentages of chemically unsafe water can particularly be found in some typical agricultural areas (Table 27). The report states that "*the most common reasons causing chemically unsafe water are its physical properties, the presence of nitrogen salts, iron and manganese, as well as excessive organic matter content*".

Table 27 Number of samples and percentage of chemically unsafe water in the period 2001-2002 (after (HZJZ 2002; HZJZ 2003; HZJZ 2004).

	2001		2002		2003	
	n	% chemically unsafe	n	% chemically unsafe	n	% chemically unsafe
Brodsko-posavska	492	38.8	277	29.6	229	35.8
Varaždinska	523	24.9	248	33.9	697	28.5
Vukovarsko-srijemska	223	1.3	960	44.8	340	14.1
Bjelovarsko-bilogorska	838	8.6	941	13.5	815	8.7
Požeško-slavonska	383	26.9	458	13.8	429	6.1
Osječko-baranjska	2,504	6.7	1,956	12.7	2,285	11.3
Sisačko-moslavačka	1,253	3.3	1,391	1.4	1,475	9.4
Total Croatia	**23,287**	**7.2**	**22,791**	**8.1**	**25,010**	**6.1**

Unfortunately, the exact percentage of chemically unsafe water due to excessive concentrations of nitrogen compounds, phosphorus and pesticides is virtually impossible to obtain. This is because the central national register receives from the county offices only figures on total chemically unsafe water, without further details regarding the causes and frequency of their occurrence (Šobot 2004). The latest systematic information on the nitrate content in drinking water at the national level seems to be from the mid seventies (HZJZ 2005). Experts from the Croatian National Institute of Public Health estimate that currently 1%-2% of the entire water from the public water supply system contains nitrates above the MAC (Šobot 2004; Valek 2005). However, the percentage of the population exposed to an excessive concentration of nitrates in water is substantially higher. Namely, 25 percent of the Croatian population is supplied by drinking water from private wells and other non-public water supply sources, and this percentage is even higher (32%) in the Danube basin, the most intensive agricultural area (MZOPU 2003). The majority of these non-public water supply systems face severe problems with nitrates and concentrations often exceed the MAC (Šobot 2004; Devčić 2005; Valek 2005), as shown on Figure 20.

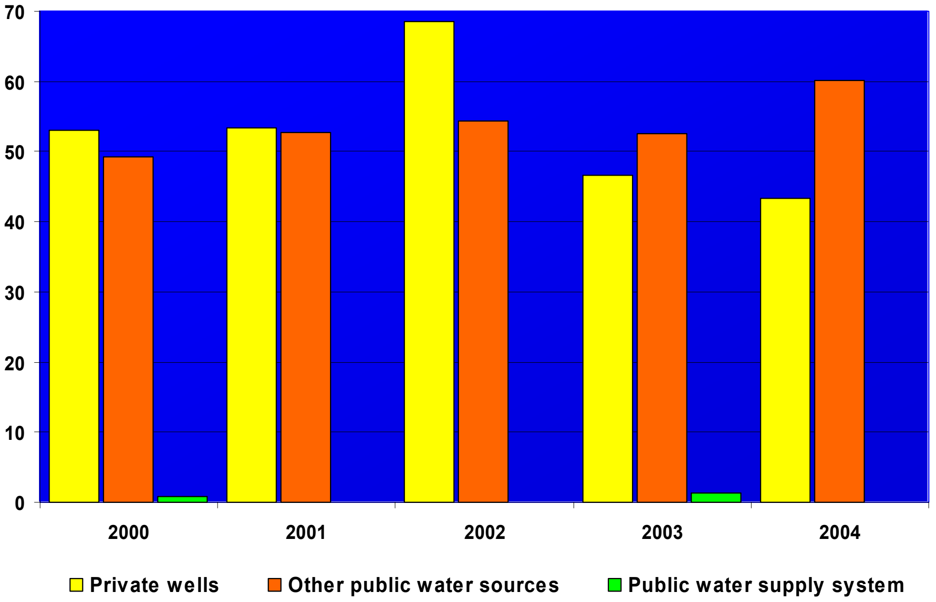


Figure 20. Percentage of water supply sources with excessive nitrates in Bjelovarsko-Bilogorska County, after (Devčić 2005)

Vitale *et al*. (2002) have performed a detailed survey of the existing water quality analysis for the Drava river in the period 1992-2000. Both nitrates and nitrites have been increasing over the time, with nitrates often exceeding the guideline values.

Algal bloom

Algal bloom in Croatia is a severe problem, particularly in the northern part of the Adriatic Sea, a very popular tourist destination (IRB 2004; IRB 2004; IRB 2004). Algal blooms, red tides, and fish and bottom fauna mortality have been reported with concentration levels of 1.6-59 µM NO_3 and 0.6a-2.9 µM PO_4 (EEA 1999). The algal bloom causes economic damage to fisheries and the tourist industry (IRB 2004; Ured Turističke zajednice grada Poreča 2004).

N balance of the Croatian part of the Danube basin

A nitrogen budget of Croatian agriculture still does not exist. However, within the framework of two recent regional studies on the protection of the Danube River (2003; Redman 2003; Schreiber, Behrendt et al. 2003; Schreiber, Behrendt et al. 2003; Zessner, Gabriel et al. 2005), the nitrogen balance and load to water was also calculated for the Croatian part of the Danube basin. The nitrogen balance was calculated using standard OECD soil surface nitrogen balance methodology (OECD 2001). Data on nitrogen inputs, outputs and emissions were derived by GIS-analysis, from digital maps of land use, elevation, soil types and hydrogeology, figures on point source pollution, FAOSTAT and information provided by national consultants. The estimated total annual nitrogen loss to water resources of the Croatian part of the Danube basin is about 35,000 tonnes of nitrogen (Schreiber, Behrendt et al. 2003), similar to the previous estimates of Mesić *et al*. (1994). Some 42.5 percent (14,886 t N) of this loss is due to diffuse pollution (agriculture), resulting in a nitrogen surplus of 39.2 kg N ha^{-1} of agricultural land and nitrogen loss of 8.3 kg N ha^{-1} of agricultural land

(Redman 2003). An earlier report from the World Bank (1992), similarly to Zessner (2005), points out that 51 per cent of the nitrogen loss to the surface water of the Danube Basin area of Croatia is derived from agriculture,.

Agriculture makes >90% of the total N load

According to the Croatian Water Resources Management Plan, the nitrogen load from Croatian settlements, industry, and the tourism sector is approximately 20,000 tonnes of nitrogen per year (2003). From the calculation presented in this study, agriculture contributes an additional load of 215,416 tonnes, representing 91.5 percent of the total national nitrogen load and consequently most likely also a similar share of the total nitrogen losses to water resources.

P loss is not a problem

Most of the nutrient problems in waters are associated with excessive concentrations of nitrogen. Phosphorus is believed not to be a significant water pollutant in Croatia. It is far less mobile than nitrogen, the majority of Croatian soils have poor phosphorus content and figures on phosphorus fertiliser use suggest that its application is in quantities below the crop requirements.

6.6.1.2 Nitrates deriving from Croatian agriculture

Agriculture: main source of nitrogen load

Data from the Croatian Water Resources Management Plan indicate that agriculture accounts for more than 90% of the total nitrogen pressure on Croatian water resources(1999; 2000; 2001; 2001; 2002; 2002; 2003; 2003; 2003; 2003; 2003; 2005).

Three major experimental sites

The relationship between agricultural practices and nitrogen concentration in water has been subject to several experiments in Croatia. However, nearly all relevant data from the last 15-20 years seem to be derived from the three experimental sites in central Croatia: Popovača, Karašica and Kutina. Too few data seems to exist for the karst region. This area covers some 50 percent of Croatian territory and due to its hydro-geological structure it is particularly prone to nitrate leaching.

Popovača site experiments

A five-year experiment on nitrate leaching was carried out at the experimental field in Popovača in the period 1996-2000. Its results have been widely reported in various publications by Mesić *et. al.* (2002; 2003; 2005) and Sumelius *et al*. (2002; 2003; 2005). The experiment involved ten variants receiving different applications of nitrogen, from zero to 300 kg N ha^{-1}. Depending on the year and the amount of nitrogen applied, the experiment recorded a leaching range from 7.1 kg NO_3-N ha^{-1} for plots receiving no nitrogen, up to 64.2 kg NO_3-N ha^{-1} at the input level of 300 kg N ha^{-1}. The later leaching corresponds to 21.3 percent of the nitrogen amount applied by fertilisers. Treatments with nitrogen input up to 150 kg N ha^{-1} basically recorded nitrogen concentrations below the admissible level of 10 mg NO_3-N L^{-1}, while other treatments exhibited much higher nitrogen concentrations - up to 28.7 mg NO_3-N L^{-1}. The loss of ammonia nitrogen in all treatments was found to be negligible, below 1 kg N ha^{-1}.

... also used for mathematic models

Based on the results from the Popovača experiments, Sumelius *et al.* (2002; 2003; 2005) have developed a mathematical model which enabled them to determine nitrogen leaching for the family farms in Lonjsko Polje nature park. These have been found to be applying 206-230 kg N ha^{-1} (fertilisers plus manure) on maize and 234-236 kg N ha^{-1} on wheat. The corresponding leaching levels as determined by the mathematic model were in the range 82-96 mg NO_3-N L^{-1}, some 1.6-1.9 times higher than the critical maximum level defined by the EU Nitrate Directive (50 mg NO_3 L^{-1}).

Kutina site experiments

Šimunić *et al.* (1996; 1998; 1998; 2002; 2002; 2002; 2003) have performed a ten year experiment (1991-2000) in the vicinity of Petrokemija fertiliser plant. The crop rotation included maize and winter wheat (a common crop rotation in Croatia) and received fertiliser application of 145-200 kg N ha^{-1}. The average NO_3-N concentration in drainage water was found to be 12.7 mg NO_3-N L^{-1}, which is above the maximum allowable concentration of 10 mg NO_3-N L^{-1}. Similar results were also reported by Klačić *et al.* (Klačić, Petošić et al. 1998). The average ammonia nitrogen levels at the Kutina experiments were also above the MAC, typically ranging from 0.7-1.9 mg NH_4-N L^{-1}. The highest leaching recorded was 20 kg N ha^{-1}, corresponding to 10 percent of the fertiliser nitrogen applied.

Karašica site experiments

In the Karašica and Vučica catchment Vidaček *et al.* (1999; 2002; 2003) ran a seven year experiment measuring the environmental impact of different fertilisation levels. The crops included were maize (173 kg N ha^{-1}), winter wheat (199 kg N ha^{-1}), winter barley (110 kg N ha^{-1}) and oilseed rape (128 kg N ha^{-1}). In spite of these - by the standards of Croatian farming - modest nitrogen levels, typical nitrate concentrations in ground water were in the range of 12.0-97.9 mg NO_3 L^{-1}, sometimes reaching levels up to 147 mg NO_3 L^{-1} in ground water and 171 mg NO_3 L^{-1} in drainage water.

Other findings

Excessive nitrate concentrations found in Croatian drainage and groundwater have also been reported by several other authors (Romić, Romić et al. 1997; Tomić, Šimunić et al. 1997; Grgić, Mesić et al. 2002).

N balance and losses

So far Croatia does not have any calculation on the national nitrogen balance for agriculture.

6.6.3 Pesticides

Data from Croatian Waters P.l.c.

Croatia does not have systematic monitoring of pesticide presence in water. Croatian Waters measures the presence of DDT and lindane but does hardly any herbicide monitoring. DDT has been found (Hrvatske vode 2002; Hrvatske vode 2002): Of the water samples tested in 2000, 41 percent contained DDT and 12 percent lindane in higher than allowed concentrations, while other organochlorinated pesticides remained within the prescribed limits (Hrvatske vode 2002). The situation in 2001 was much better: DDT was found in 14 percent of samples and lindane in only 5 percent of samples, most probably due to its ban in mid 2001. The reports for 2002 and 2003 do mention problems with both DDT and lindane, but unfortunately do not present aggregated data at the national level (Hrvatske vode 2003; Hrvatske vode 2004).

Other data

The National Environmental Protection Review (MZOPU 2003) stresses the problems with lindane and DDT concentrations in surface water, notably in those of the Mura and Drava catchments.

The Croatian National Institute of Public Health does not have systematic monitoring of pesticides in drinking water (Šobot 2004). Some county offices do not practice this analysis at all (Devčić 2005), while others do it occasionally (Šobot 2004; Valek 2005).

6.6.1.3 Excessive herbicide concentrations in water

Studies investigating the link between agricultural use of pesticides and their impact on water were mainly performed at the above-mentioned experimental sites in Kutina and Karašica.

Herbicides at Kutina and Karašica experiments

Results from the experiments in Kutina (Šimunić, Tomić et al. 1999; Šimunić 2002; Šimunić, Tomić et al. 2002; Šimunić, Tomić et al. 2002; Šimunić 2003) indicate high leaching and excessive presence of herbicides in water. Atrazine levels in nearly all drainage water samples were higher than 100 ŋg L^{-1}, reaching levels up to 478 ŋg L^{-1}, while chlortoluron reached levels up to 486 ŋg $L^{-}1$. These results suggest that some 0.05% of the initially applied herbicide quantities were leached. Excessive concentrations (up to 332 ŋg L^{-1}) of atrazine and chlortoluron were also occasionally found in the experiments at Karašica (Vidaček, Sraka et al. 1999; Vidaček, Racz et al. 2003).

Mass use of atrazine

Atrazine is routinely applied on Croatian maize fields and 87-100 percent of maize fields seem to be receiving atrazine treatment (Neumeister 2003). This poses a severe treat for water resources since maize occupies some 37 percent of Croatian arable land in use. Application of fertilizers, especially on soil with low clay and low organic matter content was found to enhance the mobility of some herbicides (Horvat, Kaštelan-Macan et al. 2003).

Other data on atrazine

At three out of the five monitoring stations on the Sava river, atrazine was found in concentrations higher than the MAC (Hrvatske vode 2004). High levels of atrazine and simazine have also been reported by Stipčević *et al*. (2002). According to Šarić (1996), in the period 1992-1995, atrazine concentrations in waters of many parts of Croatia were above the MAC. In a review of the Croatian research on pesticide content in water prepared by Igrc-Barčić, (2002) the findings of several other studies have been discussed. Many of these also point at increased content (often above the MAC) of pesticides in Croatian water resources, with atrazine again being the main problem.

Atrazine: 30% of all pesticides

The environmental concerns relate not only to the quantity, but also to the type of pesticides used in Croatia. Atrazine seems to account for as much as 30% of all pesticide consumption in Croatia (Znaor and Karoglan Todorović 2004). This environmentally unfriendly herbicide has been banned in most EU countries. Officially, the use of atrazine has been restricted to certain crops and geographical areas, but in practice, there is virtually no control over the (im)proper use of atrazine and other pesticides(Znaor 2002). Igrc (Igrc-Barčić 2002) gives an overview of results from studies that have measured atrazine concentration in Croatian water. From this inventory it is visible that the excessive concentration of atrazine in water is more the rule than exception (atrazine was found in concentrations up to 390 times above the maximum allowed quantities). According to the same source (Igrc-Barčić 2002) the use of atrazine is widespread in Croatia and this herbicide is applied on nearly all Croatian maize fields.

Restrictions in karst region

Its use is forbidden in water harvesting zones and karst water storage fields (areas) and should not be applied at least 20 meters from the water bodies. The use of atrazine is also banned in vineyards, orchards (apples and pears) and on light soils and slopes and should not be used on the same filed and crop for more than two subsequent years.

Nearly 30% drinking water with atrazine above MAC

Drevenkar *et al*. (2002; 2004) measured the presence of triazine herbicides atrazine and simazine in 477 samples of surface, ground, drinking and rain/snow waters collected in the 1992-2001 period. Atrazine was detected in 77 percent and simazine in 8.4 percent of samples. The study found no great differences in atrazine concentrations in drinking waters from rural and urban areas. The atrazine concentration exceeded the MAC of 0.1 microgram per litre in 29% of drinking water samples, reflecting the contamination of ground waters serving as drinking water supply.

In Osječko-Baranjska County, atrazine above the MAC has been found in drinking water samples: 4 percent in 2003 and 15 percent in 2004 (Valek 2005). High concentrations of atrazine in drinking water have also been recorded both in rural areas and in the vicinity of big cities (ZJZGZ 2004).

A study assessing organic pollutants in sediment samples (Francisković-Bilinski, Bilinski et al. 2005) of the Kupa basin found that 52 percent of samples contained phenols and 16 percent of samples contained polychlorinated biphenyls (PCBs) above toxic levels.

Some Croatian bottled waters also fail to meet requirements for drinking water (ZJZGZ 2004).

6.6.4 Heavy metals and radioactivity

Low concentrations of heavy metals

Cadmium, as well as most other heavy metals have been reported to be mostly below the MAC for soil and water and thus do not seem to pose an environmental problem (Čoga, Vidaček et al. 1998; Šimunić, Tomić et al. 2002). The low cadmium content of the raw phosphates used by Petrokemija contributes positively to this trend.

Possible radioactivity problems

A study from the Kanovci area in Eastern Slavonia (Barišić, Lulić et al. 1992) found high concentrations of radioactive elements 226Ra, 228Ra, 235U, 238U and 137Cs in the surface, shallow ground and water from drainage channels. This effect has been attributed to phosphate fertiliser application. More recent information on this topic is not available since no new studies of this kind have been performed (Barišić 2005).

6.6.5 Conclusions

From the aforementioned section, the following conclusions can be drawn as to regard to the quality of Croatian water resources:

National leaching likely higher than in experiments

Most nitrate and pesticide leaching studies have been performed on three experimental sites in Central Croatia, on gley and pseudogley soils which are known for their limited water permeability. Experiments on pesticide and nitrate leaching in the Croatian karst regions hardly exist. The karst area covers some fifty percent of Croatian territory and its soils are known as problematic in terms of leaching. The data obtained by the experiments in Central Croatia therefore cannot be representative for the entire country and the average national leaching both for pesticides and nitrates is most likely to be higher due to leaching in karst areas.

Poor pollutants monitoring

The present national monitoring of nitrates and pesticides in water resources is poor. Analysis of the coastal water doesn't exist, while the quality of the ground water is sufficiently monitored only in Zagreb. Surface water is hardly analysed for herbicides and there are no data on the nutrient status of lakes. The extent of nitrate presence in drinking water from the public water supply system is not precisely known and this water is only occasionally analysed for herbicides.

Nitrates and atrazine: key pollutants

Croatian agriculture threatens water resources primarily through the use of atrazine and nitrogen applications above 150 kg N ha^{-1}. Both atrazine and nitrates are regularly found in excessive concentrations in Croatian water resources. The national nitrogen balance from agriculture is not available.

No pesticide and nitrate removal

Very few Croatian water companies seem to be removing pesticides and nitrates from drinking water. In case of excessive concentrations, most companies simply drill new wells. Thus no removal cost for pesticides and nitrates can be obtained.

Authorities not worried

In spite of quite dramatic figures with regard to the presence of nutrients and pesticides, the Croatian authorities do not seem to be worried about the current situation. Ćosić-Flajsig and Lukšić (2003) for instance declare that surface and spring water quality in Croatia is in "*good or reasonably good state*" and a similar attitude prevails in the annual reports of Croatian Waters (Hrvatske vode 2002; Hrvatske vode 2002; Hrvatske vode 2003; Hrvatske vode 2004). Franić (2003), also stresses that the State Water Directorate, at the time the highest national authority, did not recognise agriculture as a significant source of water pollution.

6.7. Water valuation methodology for Croatia

No standard method that can be applied

As already mentioned earlier, there is still no standard methodology that could be applied to assess externalities of water resources. The existing studies used mostly contingent valuation and the pressure-state-response method has also been emerging. Unfortunately, studies on willingness to pay for water quality improvement in Croatia, as well as figures needed to quantify the actual social costs and ecological damage do not exist. On the other hand, from the data on water quality it is evident that Croatian water resources and subsequently Croatian society suffer from the excessive nitrogen and pesticides in water. The following steps have been undertaken to assess these costs in monetary terms:

6.7.1 Agricultural nitrogen balance calculation

OECD soil surface N balance

The nitrogen balance has been calculated following the OECD methodology of the soil surface nitrogen balance (OECD 2001). It is the difference between the total annual quantity of nitrogen inputs entering the soil and the quantity of nitrogen outputs leaving the soil Figure 21.

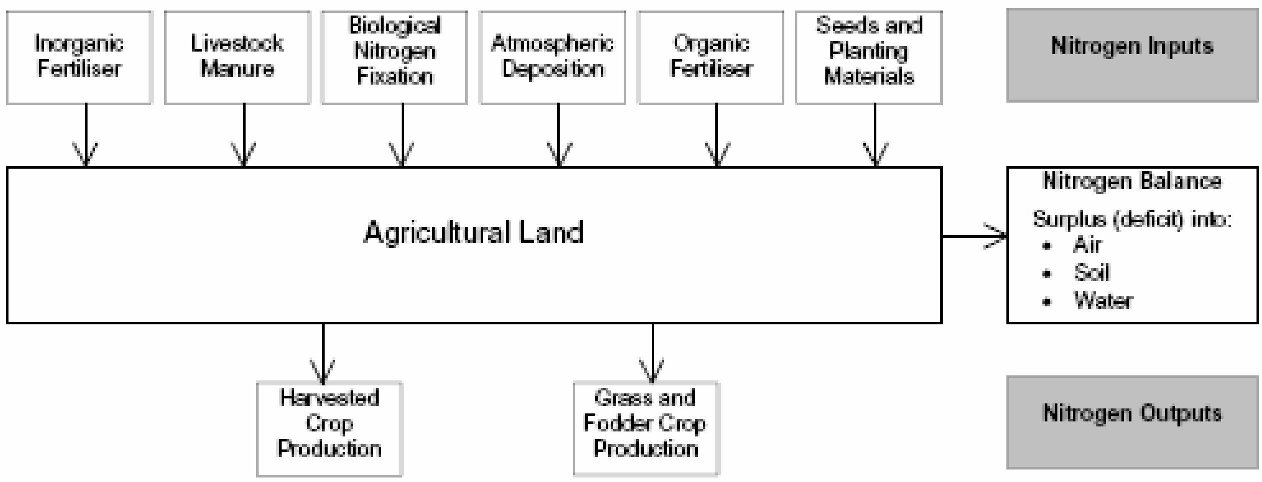


Figure 21 Soil surface nitrogen balance (OECD 2001)

N input data

The amount of nitrogen in fertilisers is taken from the previous calculations on fertiliser consumption, while the nitrogen content in livestock manure is taken from the calculations of the greenhouse gases. Biological nitrogen fixation from the nitrogen-fixing free-living micro-organisms is assumed to be 4 kg N ha^{-1} for all crops. In addition, for N-fixing crops the following N fixation is assumed: soya bean 120 kg N ha^{-1}, beans 90 kg N ha^{-1}, other pulses 110 kg N ha^{-1}, alfalfa 20 kg N ha^{-1}, grass-clover 170 kg N ha^{-1} and for meadows and pastures 40 kg N ha^{-1}. The acreage under legume crops is taken from the DZS (2002; 2003; 2004) and reduced by 25 percent. This is because the area of the arable land in use from these reports is some 25 percent greater than the arable land reported by the agricultural census. The latter has been used as the agricultural area reference through this report. Although the arable land area has been decreased by 25 percent, the cropping pattern (share of individual crops on the total arable land) is assumed to be correct as presented in DZS (2002; 2003; 2004). The figure on the acreage under meadows and pastures is taken directly from the agricultural census data (DZS 2003). The average atmospheric deposition is assumed to be 13 kg N ha^{-1}, and is based on the atmospheric deposition data for several Croatian regions reported by the DZS (2003; 2004). As Croatian farmers hardly ever apply commercial organic fertilisers, nitrogen input from this material is not taken into consideration. The nitrogen content of seeds and planting material has been calculated using the standard seeding rates reported by the state extension service (Mikšić, Murguić et al. 2004) and applying the seed nitrogen content reported in Habets (1999).

N output data

The per hectare output data for individual crops have been taken from DZS (DZS 2002; DZS 2003; DZS 2004) and multiplied by the UAA reported in the agricultural census (DZS 2003). The nitrogen content of crops has been taken from the OECD Nitrogen Balance Database (OECD 2005). Since Croatia is not included in this database and lacks its own statistics on the issue, the nitrogen content of crops has been calculated from the database figures for Austria, Italy and Hungary. This was necessary because figures on the nitrogen content of crops differ substantially from one country to another. Taking the average from the three nearby countries is believed to give more representative values. The nitrogen content of crops from Habets (1999) was used as an additional reference in case of doubts.

6.7.2 Calculation of N loss to water

Portions lost into water, soil and retained in soil

The OECD soil surface nitrogen balance gives only an indication of the nitrogen balance/surplus. It still does not give an answer to the amount of nitrogen lost into the water. In order to determine this, the surface nitrogen balance was further split to the fractions lost to the atmosphere and water and retained in the soil. The quantity of nitrogen lost to atmosphere is taken from the previous calculation on the atmospheric pollution and GHG. The amount of nitrogen retained in soil is calculated according to the nitrogen mineralization rates for organic matter presented in van der Werff (1992) and Janssen (1984). It is assumed that the average mineralization rate of nitrogen contained in the livestock manure is 35 percent and 65 percent for crop residues. The nitrogen added by fertilisers is in easily soluble forms and for this reason we assumed that no nitrogen added by fertilisers is retained in the soil. The difference between nitrogen lost in the atmosphere and nitrogen retained in the soil gives the quantity of nitrogen lost into water.

N loss to water from other sectors

Of the economic sectors considered in this study, it appears that only the fertiliser industry discharges substantial quantities of nitrogen. The environmental performance data provided by Petrokemija (2005) indicate an average annual nitrogen discharge (ammonium and nitrate nitrogen) of approximately 171 t N for the period 2001-2003. However, applying EFMA BAT (EFMA 2001) figures for the nitrogen released into water by the ammonia, urea, CAN and NPK plants results in an average annual emission of 401 t N. As this quantity is trivial in comparison with the nitrogen derived from farming (less than 1 percent), it has not been considered in the calculation.

6.7.3 Costing the damage

The human health and ecological damage arising from the use of nitrates and pesticides in the Croatian agricultural sector is notoriously difficult to determine. There are too few systematic data on the presence of these substances in water, notably the drinking water.

All water in Croatia is enriched by excessive N

Numerous aforementioned Croatian studies and official statistics point at high concentrations of nutrients, notably nitrates, in water. The nitrogen balance obtained in our study also indicates that the agricultural nitrogen input in Croatia is above the level of 140-150 kg N ha^{-1}, which is believed to be the upper input level ensuring nitrate concentration below the MAC in Central Croatia (Mesić, Bašić et al. 2003; Sumelius, Grgić et al. 2003;

Mesić, Bašić et al. 2005; Sumelius, Mesić et al. 2005). Taking into account that about half of the Croatian territory is in the karst area which is highly susceptible to leaching, the average national nitrogen input leading to nitrate concentration below the MAC is certainly much lower than 140-150 kg N ha^{-1}. From our calculation it appears that the average nitrogen input in the period 2001-2003 was 200 kg N ha^{-1} UAA^{-1}. For this reason we assume that all the country's water resources are enriched by nitrogen derived from agricultural practices above the MAC.

N damage

Externalities resulting from the excessive nitrogen concentration in water are calculated in two ways: by applying a shadow price to nitrogen causing the concentration of nitrates above the MAC and by calculating water treatment costs ensuring nitrogen removal from the drinking water.

1. Shadow price method

In the absence of reliable statistics and assessment methods, we assume that the external cost caused by the excessive concentration of nitrogen in water is equal to the shadow price of 1 EUR per kilogram of nitrogen causing the increase of concentration above the MAC. Similar methodology has been advocated by Hanley (1991). The shadow price of 1 EUR kg N^{-1} applied is some three times lower than the average shadow price extrapolated from the studies for other countries (Table XY). It is also some ten times lower than the marginal damage estimated for the discharge of nitrogen by Hartridge and Pearce (2001). Finally, the shadow price of 1 EUR kg N^{-1} is also some 35 percent below the shadow price for Croatia that can be extrapolated from the work of Sumelius *et al.* (2003; 2005). This approach ensures a conservative estimate of the damage. The nitrogen dose-response curve for Croatia (Sumelius, Grgić et al. 2003; Sumelius, Mesić et al. 2005) indicates that the nitrogen loss above MAC appears at N inputs higher than 145 kg N ha^{-1}. Our N balance calculation shows that the average N input per ha of UAA in Croatia is 200 kg N. Theoretically a reduction of 55 kg N ha^{-1} (27.5 percent of the N input) would be needed to ensure that the MAC for nitrogen in drinking water is not exceeded. Applying this rule to the nitrogen input across the entire UAA (215,417 t N), the required reduction is equal to 59,162 t of nitrogen.

2. Nitrate removal method

In order to get an indication of the cost of nitrogen and pesticide removal under Croatian circumstances a survey has been made among nearly eighty Croatian water companies. Only five of these have replied, stating that they do not have any significant problem with these substances and/or do not practice their removal. Therefore a hypothetical nitrate removal cost had to be derived from data from other countries.

The typical nitrate removal costs in Austria, Germany and France range from 0.25 to 0.38 EUR per cubic metre of water (Lughofer and Kratochvil 1997; Gorenflo, Velazquez-Padron et al. 2003; Van der Bruggen and Vandecasteele 2003). The average nitrate removal cost per cubic metre of water from these reports appears to be 0.32 EUR and this value has been taken for Croatia too. The average daily consumption of water in Croatia is 135 l per capita (MZOPU 2003). The multiplication of the annual water consumption per capita with the number or inhabitants (DZS 2003) results in an annual consumption of 218,633 million litres of water for the entire Croatian population. A further multiplication with the nitrate treatment cost per cubic metre gives the indication of the hypothetical external cost. A further adjustment is made for the share of agriculture in the total N load to the Croatian water resources (91.5 percent).

The mean value of the damages obtained by these two methods has been taken as the final damage caused by the excessive nitrogen in water.

In addition to this, another external nitrogen-related cost has been added. It is the cost of the lost nitrogen resources from the farming system. In the period 2001-2003 on average some 49.1 Mt of nitrogen was washed into water annually. This lost nitrogen represents inefficient resource use. If farmers had to purchase this nitrogen and apply it, it would cost them additional money. One could however, argue that this is neither an environmental nor a social cost because the nitrogen inefficiency has already been included in the price of the agricultural produce. However, it is a cost of insufficient resource use leading to environmental pollution. For this reason we consider it as an externality. Each kilogram of nitrogen washed into water is multiplied by 0.5 EUR. This was its average commercial value in the studied period (Mikšić, Murguić et al. 2004). The same source indicates the application cost of 0.01 EUR per kg N per hectare.

Pesticides damage

The pesticide damage is assessed by applying a flat rate of 0.2 EUR for the treatment of one cubic metre of water and represents the average treatment costs reported for Austria, Germany and the EU-15 (Rapinat 1993; Lughofer and Kratochvil 1997; Van der Bruggen and Vandecasteele 2003). This cost is multiplied with the annual use of drinking water by the population and as in the case of nitrogen, is assumed to be equal to the damage.

Fluoride from fertiliser production

In the period 2001-2003, Petrokemija annually released on average 16.93 tonnes of fluorides into the water (Petrokemija 2005). This is a highly toxic substance and the new water permit issued in 2004 requires Petrokemija to reduce the emission of fluoride beyond levels that seem to be possible to reach with its present technology (Vešligaj 2004). The literature on the shadow price of fluoride is scarce. However, the Netherlands Ministry of the Environment (VROM 1999) and the Centre for Energy and Technology from the Netherlands (Davidson, Hof et al. 2002) set a shadow price per kilogram of discharged fluoride at 1.840 EUR in 1999. Updating this value by a 5 percent compounded rate annually would result in 2.348 EUR per kilogram of fluoride value in 2005. However, because of the high uncertainty we applied half the price of the Netherlands 1999 value. This allows for a more conservative estimate and possibility that the shadow price of fluoride under Croatian circumstances is cheaper than in the Netherlands (although it might be also the other way around).

6.8. Results

Nitrogen budget and losses

Nitrogen budgeting and nitrogen losses from Croatian agriculture are presented in Table 28. The majority of nitrogen input (55.2 percent) comes from mineral fertilisers. Livestock manure (47 percent) is the second largest source of nitrogen, followed by biological fixation (13 percent). Table 29 shows nitrogen consumption by Croatian counties. Assuming that low-external input agriculture under European conditions is all agriculture up to 50 kg of N fertiliser input (Kieft 1999), these figures suggest that only 4 percent of the Croatian UAA qualifies for this status.

Table 28 Nitrogen budget for Croatia

				Average 2001 - 2003			
	2001 (t)	2002 (t)	2003 (t)	t	%	kg N ha UAA^{-1}	kg N ha arable land^{-1}
N inputs							
Inorganic fertilisers	124,341	122,151	110,509	119,000	55.2	110.5	148.4
Livestock manure	47,604	47,385	57,751	50,913	23.6	47.3	63.5
Biological nitrogen fixation	30,410	28,002	25,905	28,106	13.0	26.1	35.0
Atmospheric deposition	14,006	16,161	10,774	13,647	6.3	12.7	17.0
Seeds and planting material	3,850	3,650	3,750	3,750	1.7	3.5	4.7
Organic fertilisers	0	0	0	0	0.0	0.0	0.0
Total	220,212	217,349	208,689	215,417	100.0	199.9	268.6
N outputs							0.0
Harvested crops	72,726	81,662	53,417	69,268	76.1	64.3	86.4
Harvested grass forage crops	22,496	25,485	17,352	21,778	23.9	20.2	27.2
Total	95,222	107,147	70,769	91,046	100.0	84.5	113.5
N efficiency %	43	49	34	42	-	-	-
N surplus							
Total	124,989	110,202	137,920	124,371	57.7	115.4	155.1
Losses							
Loss to atmosphere	32,558	34,289	34,280	33,709	27.1	31.3	42.0
Loss to water	52,365	36,713	58,331	49,136	39.5	45.6	61.3
Retained in soil	40,066	39,201	45,310	41,525	33.4	38.5	51.8

Table 29 Consumption of nutrients in Croatian counties in the period 2001-2003.

Region	TOTAL LU	UAA (ha)	% from UAA	LU per UAA	Organic N (t)	Organic N per ha UAA (kg)	Fertiliser N (t)	Fertiliser N per ha UAA (kg)	Total N (t)	Total N per ha UAA (kg)
REPUBLIKA HRVATSKA	744,109	1,077,403	100.0	0.7	58,041	54	119,008	110.5	177,049	164
Zagrebačka županija	77,083	77,819	7.2	1.0	6,012	77	12,134	155.9	18,146	233
Krapinsko-zagorska županija	31,636	27,784	2.6	1.1	2,468	89	2,781	100.1	5,249	189
Sisačko-moslavačka županija	49,205	62,722	5.8	0.8	3,838	61	4,337	69.1	8,175	130
Karlovačka županija	27,108	34,045	3.2	0.8	2,114	62	2,080	61.1	4,195	123
Varaždinska županija	44,619	38,513	3.6	1.2	3,480	90	3,489	90.6	6,969	181
Koprivničko-križevačka županija	85,228	76,232	7.1	1.1	6,648	87	9,478	124.3	16,126	212
Bjelovarsko-bilogorska županija	86,941	91,449	8.5	1.0	6,781	74	6,145	67.2	12,927	141
Primorsko-goranska županija	7,765	17,742	1.6	0.4	606	34	451	25.4	1,057	60
Ličko-senjska županija	19,815	24,444	2.3	0.8	1,546	63	773	31.6	2,318	95
Virovitičko-podravska županija	30,755	83,752	7.8	0.4	2,399	29	6,341	75.7	8,740	104
Požeško-slavonska županija	21,131	42,548	3.9	0.5	1,648	39	15,467	363.5	17,116	402
Brodsko-posavska županija	33,372	62,316	5.8	0.5	2,603	42	4,553	73.1	7,156	115
Zadarska županija	16,219	21,030	2.0	0.8	1,265	60	1,495	71.1	2,760	131
Osječko-baranjska županija	77,093	184,094	17.1	0.4	6,013	33	17,719	96.3	23,733	129
Šibensko-kninska županija	12,519	11,198	1.0	1.1	976	87	907	81.0	1,883	168
Vukovarsko-srijemska županija	47,047	121,078	11.2	0.4	3,670	30	19,234	158.9	22,904	189
Splitsko-dalmatinska županija	20,312	20,738	1.9	1.0	1,584	76	2,589	124.8	4,173	201
Istarska županija	13,316	24,643	2.3	0.5	1,039	42	2,579	104.7	3,618	147
Dubrovačko-neretvanska županija	3,417	7,244	0.7	0.5	267	37	603	83.3	870	120
Međimurska županija	28,946	33,520	3.1	0.9	2,258	67	2,910	86.8	5,167	154
Grad Zagreb	10,580	14,494	1.3	0.7	825	57	2,940	202.9	3,766	260

N damage

The shadow price method of N damage results in a cost of 59.16 MEUR, while the nitrate removal calculation results in a similar cost - 59.74 MEUR. The pesticide damage results in a cost of 41.26 MEUR. Table 30 outlines these costs per capita and per hectare of UAA.

Table 30 Cost of nitrates and pesticides removal

	Price (EUR/m^3)	Water consumption (ML yr^{-1})	Removal cost (MEUR yr^{-1})	Farming share (%)	Damage from farming (MEUR)	Cost per capita (EUR yr^{-1})	Cost per ha UAA (EUR yr^{-1})
Nitrates	0.32	218,633	69.96	92.00	64.37	14.51	59.74
Pesticides	0.20	218,633	44.46	100.00	44.46	10.02	41.26
Total	0.52	218,633	114.42	192.00	108.82	24.53	101.00

The nitrogen resource inefficiency cost reflects the commercial value of the lost nitrogen and the cost of its application results in an additional cost of 25.06 MEUR Table 31).

Table 31 Farming value of nitrogen

Cost/value category	Quantity (t N)	Price (EUR kg N^{-1})	Total (MEUR)
Commercial N value	49,136	0.50	24.57
Cost of N application	49,136	0.01	0.49
Total	49,136	0.51	25.06

The damage caused by fluoride is 15.50 MEUR. The total damage to water arising from Croatian agricultural practices is assessed at 131.19 MEUR Table 32 The cost category shadow/ removal value is the average of the costs obtained by the shadow price and nitrate removal approaches.

Table 32 Damage to air: summary

Pollutant	Damage (MEUR)	Share %	Cost per capita (EUR yr^{-1})	Cost per ha UAA (EUR yr^{-1})
Nitrates				
farming value	25.06	17.73	5.65	23.26
shadow/removal value	59.45	42.06	13.40	55.18
Pesticides	41.26	29.19	9.30	38.29
Fluoride	15.58	11.02	3.51	14.46
Total	141.35	100.00	31.86	131.19

6.9. Discussion

N balance

From the calculations of this study it appears that the Croatian nitrogen balance is higher than the nitrogen balance of the EU-15 (Brouwer, Hellegers et al. 1999; Terres 2002) and substantially higher than in other Danube basin countries (Redman 2003). Consequently, nitrogen losses to water are also higher than in many other countries.

N efficiency

The nitrogen recovery by crops (efficiency) of 42 percent is within the typical ranges of 30-40 percent reported in other studies (Delgado 2002; 2002; SOS 2002; Delgado, Dillon et al. 2004; Leach, Allingham et al. 2004). Coincidentally, it is exactly the same as the nitrogen efficiency for the UK as reported by HRI (2002).

N losses

Results on nitrogen losses that are similar to those obtained here have been reported by Kolbe (1990) for intensive conventional arable farming in Germany. The nitrogen input was 234 kg N-1, while the surplus was 112 kg N ha-1, of which 60 kg N has been leached, resulting in nitrogen concentration of 79 mg NO_3 mg L^{-1}. The share of nitrogen lost into the atmosphere, water and stored in soil is also very similar to those reported by Isermann (2003).

Nitrogen washed into water has been determined as the difference between nitrogen lost in the atmosphere and nitrogen retained in the soil. Instead, we could have also used the methodology suggested by the IPCC (2001; 2001). It recommends a 30 percent flat rate to be applied over the nitrogen amount added in the form of fertilisers and livestock manure in order to determine nitrogen leaching. But this simplified approach does not take into account nitrogen inputs through biological fixation, atmospheric deposition and seeds and planting material. Interestingly, the nitrogen loss to water obtained through both calculation methods differs only by some two percent. The IPCC method would result in an average nitrogen loss to water of 50,250 t N for the period 2001-2003, while our approach gives a loss of 49,136 t N.

N losses differ from the Danube basin studies

The nitrogen surplus and nitrogen loss to water per hectare of UAA presented in this study is substantially higher than those presented by Redman (2003) and Schreiber *et al*. (2003) for the Croatian part of the Danube basin (surplus of 39.2 kg N ha^{-1} and nitrogen loss of 8.3 kg N ha^{-1} of agricultural land). But this is easy to explain. Their calculation is based on a much greater agricultural area than is in use. Their estimate is that the farmland of the Croatian Danube basin is 1.8 million hectares, while the UAA of the entire country is some 1.1 million hectares as explained in the earlier chapters of this study. This huge gap in land use area leads to crucial differences in their calculation and the one provided in this study. Besides, the nitrogen fertiliser consumption data by Redman (2003) and Schreiber *et al*. are taken from the FAOSTAT and Croatian experts. These do not take into account imported fertilisers, resulting in a lower nitrogen load to farmland. Redman (2005) has also assumed N inputs of 100-120 kg N ha^{-1} for wheat, which is some 50 percent lower than the application rates found by Sumelius *et al*. (2003; 2003; 2005) and the average per hectare N input obtained in this study. Some of these problems have been recognised by Schreiber *et al*. (Schreiber, Behrendt et al. 2003) who clearly stress that their nitrogen balance and nitrogen loss data for Croatia should be treated with caution due to insufficient information on land use, erosion and hydroecology.

Correlation with some other Croatian data

The per hectare amount of nitrogen loss to water calculated here corresponds quite well with the results obtained by the simulation model applied by Sumelius *et al*. (Sumelius, Grgić et al. 2003; Sumelius, Mesić et al. 2005). Their quadratic form variant calculation resulted in a leaching of 48 kg NO_3-N ha^{-1} with a nitrogen input of 185 kg N ha^{-1}. Our nitrogen balance shows a comparable nitrogen loss to water (45.6 kg N ha^{-1}) at a slightly higher nitrogen input level (199.9 kg N ha^{-1}).

Many damage cost items not covered

Due to the lack of sound assessment methodology and/or the lack of reliable data, a number of water-related external costs have not been possible to quantify in this study Table 33).

Table 33. Water-related externalities not covered by the study

Cost item
Loss for tourist industry (particularly due to algal bloom)
Loss to navigation [a]
Loss for aquaculture, fisheries and shell-fisheries
Loss to other industries [b]
Consumers' avoidance cost (e.g. increased consumption of mineral water)
Disturbance, disruption of coherence of communities
Reduced value of waterside properties
Education and recreation values
Avoidance costs of consumers due to increased consumption of mineral water
Option and general (dis)amenities values

[a] Nutrient enriched waters stimulate development of biomass of aquatic algae and macrophytes, resulting in impeded navigation (TISUP 2005)

[b] In Croatia, particular damage might be made to the beer and beverage industries, which make up some 1.5-2.0 percent of GVA.

Comparison with the UK results

Compared with the similar UK water-related external costs (Pretty, Brett et al. 2000; Hartridge and Pearce 2001; Pretty, Mason et al. 2003; Pretty, Ball et al. 2005), the results obtained for Croatia appear to be substantially higher (approximately three times), both per capita and per hectare of UAA. This discrepancy is most probably due to the use of different methodological frameworks and pollutant costing. However, the level of the UK water-related externalities appears to be lower also when compared with the WTP for the cleanup programmes in other countries. From the calculation of Pretty *et al.* (2005), the monthly water pollution costing caused by agriculture appears to be 1 EUR per UK household. The households' monthly WTP for cleaner water in Greece is 3.8 EUR (Kontogianni, Langford et al. 2003), 5.3 EUR in Latvia (Ready, Malzubris et al. 2002) and 7.8-9.7 EUR in the USA (Kramer and Eisen-Hecht 2002; Mathews, Homans et al. 2002). Although this WTP is not entirely linked to agriculture, from these papers it appears that the majority of water pollution problems considered are linked to agriculture. The UK studies also largely rely on the actual water pollution incidents, which seem to be rare, while in the case of Croatia, it has been assumed that the majority of water does not meet water quality standards for nitrates and pesticides.

Nitrate concentrations in the UK drinking water above 50 mg NO_3 L^{-1} are infrequent and Hartridge and Pearce (2001) were not able to assess damage to water caused by excessive nitrogen in UK water. However, from the work of Pretty *et al.* (2000; 2005) the damage to UK water attributed to nitrogen seems to be about 108 MEUR. However, the nitrogen removal cost of the UK water companies remains modest, some 28 million EUR per year (Pretty, Mason et al. 2003), corresponding to 0.5 EUR per capita. On the other hand, the average nitrate removal cost in the EU countries is reported to be in the range of 0.25 to 0.38 EUR per cubic metre of water (Lughofer and Kratochvil 1997; Gorenflo, Velazquez-Padron et al. 2003; Van der Bruggen and Vandecasteele 2003). Assuming that all drinking water in the UK would have to be treated under this cost, the present UK nitrate removal expenditure would suffice for 13 days only. Relatively high nitrogen damage in Croatia can also be defended from the impact on health point of view. The agricultural nitrogen input is 200 kg N ha^{-1} of UAA, i.e. some 30 per cent above the nitrate levels ensuring nitrate-safe drinking water in Central Croatia. However, about half of the Croatian territory lies in nitrogen-leaching-prone karst regions. This means that the population is already or will soon be exposed to an excessive concentration of nitrates in water. As only few (or no) water companies seem to be practicing nitrate removal, it is logical that the UK nitrate prevention (removal) cost per capita is much cheaper than the health damage occurring in Croatia due to the lack of nitrate removal.

The UK uses some 25,000 t of pesticides per year (Hartridge and Pearce 2001), which divided between 18.5 million hectares of UAA (DEFRA 2005) gives a consumption rate of 1.4 kg pesticides per hectare. The calculation from this study shows that Croatia uses six times more pesticides - 8.1 kg per hectare. Thus it is no wonder that water-related pesticide costs per capita and per ha of UAA is higher in Croatia. Besides, the most pronounced problem with pesticides in Croatia relates to the excessive presence of triazine herbicides in water. However, in the UK, both atrazine and simazine have been banned since 1993 (Hartridge and Pearce 2001) and thus do not pose a threat as in the case of Croatia. The per capita pesticide costs reported in the UK studies are also substantially lower than elsewhere in Europe (Foster, Mourato et al. 1998), the USA (Brethour and Weersink 2001) and Vietnam (Phuong and Gopalakrishnan 2003). Charging a rate of 17.5 EUR per kg of pesticide applied, as done by Hartridge and Pearce (2001) for the UK, would result in a damage cost of 117,3 MEUR. However, our calculation results in a cost some three times lower. This is not surprising, because Hartridge and Pearce's (2001) pesticide cost estimate derives from the research of Foster *et al.* (1998). Their estimates do not relate to the pesticide discharge in water, but to the WTP to avoid pesticide residues in food, and besides the concern for human health also included concern for the safety of birds.

7. DAMAGE TO SOIL

7.1. Soil-related external costs and valuation methods

Estimates on soil damage costs

Soil related externalities, notably those of erosion, have been the subject of debate for some time (Conway and Pretty 1991; Pimentel, Harvey et al. 1995; Pretty 1995; Znaor 1995; Pretty 1998; Volker 1998; Knowler 2004). Estimates of soil-related external costs exist for several countries and are usually part of the overall assessment of agricultural externalities (Pretty, Brett et al. 2000; Hartridge and Pearce 2001; Tegtmeier and Duffy 2004). According to the European Conservation Agriculture Federation, soil erosion increases EU-15 annual agricultural production costs by about 53 EUR per hectare, representing some 25 per cent of the direct production costs (ECAF 2000). Further, if on-site and off-site costs are combined, the total annual cost of erosion from EU agriculture can be estimated at about 85.5 EUR per hectare (Pimentel, Harvey et al. 1995; ECAF 2000). The off-site soil erosion economic damage is nearly 40 percent of the total cost of the erosion (Pimentel, Harvey et al. 1995). The cost of erosion, evaluated as the cost of the operations necessary to redistribute the sediment/soil over the field and to repair the hillside ditches, equal some 5 per cent of the farm income in Spain (Martinez-Casasnovas, Ramos et al. 2005). The on-site soil erosion highly depends on the rotation and in some parts of the USA ranges from 3-20 EUR ha^{-1} (Brusven, Walker et al. 1995). The World Bank (1992) has calculated the total off-site costs of soil erosion in the United States to be approximately 17 billion EUR per year. According to these estimates, the off-site damage and on-site costs of soil erosion together cost the United States some 44 billion EUR every year, resulting in about 26 EUR ha^{-1} of cropland. However, these calculations do not include offsite costs such as reservoir infilling, river sedimentation, damage to irrigation systems, etc. (Holland and Watkiss 2002). A comprehensive assessment of the damage to soil in the USA has been made by Tegtmeier and Duffy (Tegtmeier and Duffy 2004), resulting in a cost of 13-80 EUR per hectare of cropland. The soil damage from UK agriculture (off-site soil erosions and organic matter loses) is estimated at 85 MEUR (Pretty, Brett et al. 2000). The exact figures for the so-called developing world are not available, but the estimates from eight countries indicate that the cost of soil erosion is 0.9-17.4% of the GNP with an average of 8.33% (Barbier and Bishop 1995). However, the World Bank (1992) reported that extrapolation from test-plots of impacts of soil loss on agricultural productivity, results in a 0.5-1.5% loss of GDP annually for countries such as Costa Rica, Malawi, Mali and Mexico.

On-site protection most effective

Soil conservation measures taken in fields are effective means in reducing on-site soil loss and in drastically reducing sediment yield. Off-site sediment control measures appear to be much less effective (Verstraeten, Van Oost et al. 2002). Knowler (2004) compiled data from 67 studies of the financial attractiveness of conservation technologies and found that 64 percent of these can provide positive net returns at the farm level.

7.1.1 Soil carbon

Soil carbon sequestration potential

Due to international concerns about greenhouse gas emissions and global climate change, the international community has increasingly been placing emphasis on the need to sequester carbon from atmospheric carbon dioxide into soil organic matter (Lal 2003; Smith 2004; Machado 2005). A reduction in CO_2-carbon emissions and sink growth will be key to meeting Europe's Kyoto targets and agricultural practices will play an important role in this process (Smith, Powlson et al. 1997; Smith, Powlson et al. 2000; Pretty and Ball 2001; Smith 2004). The carbon sink capacity of the world's agricultural and degraded soils is 50 to 65 percent of the historic carbon loss of 42 to 78 GT of carbon (Lal 2004). Agricultural soils in the EU-15 are believed to be able to sequester up to 16-19 Mt C year^{-1} during the first Kyoto commitment period (2008-2012), representing less than one fifth of the theoretical potential and equivalent to 2% of European anthropogenic emissions (Freibauer, Rounsevell et al. 2004). As agriculture is capable of reducing greenhouse-gas emissions and increasing carbon sinks, the carbon mitigation potential of the so called less developed countries might yield a financially interesting reward (Pretty, Ball et al. 2002) and trading mitigation gains due to “carbon faming” might in the near future represent a substantial share of the national income of these counties (Smith, Mulongoy et al. 2000; Pretty and Ball 2001; Znaor 2005).

Importance of SOM

Carbon makes some fifty percent of the SOM on average (Bauder 1999; Pretty, Brett et al. 2000). The building up of carbon stocks in the soil is enhanced by the increased input of organic matter to the soil, and/or decreased rate of soil organic matter decomposition (Smith, Powlson et al. 1997; Smith, Powlson et al. 2000; Renwick, Ball et al. 2002; Smith 2004). SOM has a stabilising effect on soil structure, increases water and air holding capacity, protects soil against erosion and enhances soil biological activity (Grandy, Porter et al. 2002; Mäder, Fliessbach et al. 2002; Pulleman, Jongmans et al. 2003; Mäder 2004; Six, Bossuyt et al. 2004). SOM content is determined by a variety of factors, such as soil moisture, temperature, oxygen supply, drainage, soil acidity, nutrient supply, clay content and mineralogy (Pretty and Ball 2001).

Carbon losses

Most of the today’s agricultural practices result in a loss of soil carbon. Expert opinions indicate that in about 20-50 years of intense tillage most European agricultural soils lost 50-65 percent of soil carbon (Davidson and I.L. Ackerman 1993; González-Fernández 1997; Matson, Parton et al. 1997; EEA 1998; ECAF 2000). This is undesirable not only from the climate change point of view but also from the soil fertility point of view, because 45-58 percent of stable soil organic matter is carbon, while nitrogen makes up 4-5 percent (Bauder 1999).

Rate of carbon sequestration

There are only few studies estimating the agricultural soil carbon sequestration potential for Europe (Freibauer, Rounsevell et al. 2004). The average carbon content in European arable soils is about 53 t C ha^{-1} at 30 cm depth (Smith, Smith et al. 2001). However, there are great regional variations, depending on the climatic conditions and soil types. The average carbon content of the UK soils is for instance much higher than the European average: 162 t C ha^{-1} for arable soils, 207 t C ha^{-1} for permanent pastures and 350 t C ha^{-1} for soils under semi-natural vegetation (Pretty, Brett et al. 2000). A mineral soil with 4 percent organic matter contains as much as 90 t of organic matter per hectare at a depth of 0-15 cm; 36-47 t of carbon, and 468 t of nitrogen per hectare (Bauder 1999). Intensive soil cultivation and notably conversion of grassland into arable land enhances mineralisation, leading to the loss of SOM and soil carbon (Znaor 1995; Pretty and Ball 2001). The efficiency of conversion of residue carbon to soil organic matter is 10-18 percent, depending on the crop rotation and fertilisation level (Campbell, Zentner et al. 2000; Gregorich, Drury et al. 2001). The sequestration rates of soil organic carbon depend on soil texture and structure, rainfall, temperature, farming system, and soil management (Lal 2004; Lal 2004). Zero tillage with mixed rotations and cover crops can accumulate 0.66-1.3 t C ha^{-1} year^{-1} (Pretty and Ball 2001) or maximum up to 0.8 t C ha^{-1} year^{-1} under European conditions (Freibauer, Rounsevell et al. 2004). However, the uncertainties regarding the contribution of different farming practices to the increase of soil carbon stocks in European agricultural soils are still great, as well as the potential of the annual sequestration rates per hectare (Freibauer, Rounsevell et al. 2004). The sequestration effect of the application of the added soil organic matter under European conditions is still a matter of debate (Freibauer, Rounsevell et al. 2004). Vleeshouwers and Verhagen (2002) for instance estimate that the incorporation of 10 tonnes fresh matter of farmyard manure results in an increase of 1.5 t C ha^{-1}, while the calculation from Smith *et al.* (2000; 2000; 2001), using the same amount of manure and similar humification rates results in a gain of only 0.4 t C ha^{-1}. Other authors (Jenkinson, Bradbury et al. 1994; Powlson 1994) argue that the application of manure can double soil carbon (or nitrogen) levels in about forty years. An extensive study on carbon sequestration in Europe (Freibauer, Rounsevell et al. 2004) concludes that the application of organic matter (crop residues, cover crops, farmyard-manure, compost, etc.) on arable land leads to a sequestration rate of 0.3-0.8 t C ha^{-1}. An increase of one ton of soil carbon may increase crop yields by 20-40 kg ha^{-1} for wheat, 10-20 kg ha^{-1} for maize and 0.5 to 1 kg ha^{-1} for cowpeas (Lal 2004).

Soil carbon value

The estimates for the value of the soil carbon range from some 5 EUR t^{-1} (Pretty, Ball et al. 2002) to 10 EUR t^{-1} (Niles, Brown et al. 2002), up to some 70 EUR t^{-1} (Smith, Powlson et al. 1998; IER 2004; IER 2004; IER 2005).

7.1.2 Soil erosion

Soil erosion impacts

Soil erosion moves soil particles and associated agricultural pollutants into watercourses, resulting in the sedimentation of watercourses and dams and leading to decreased retention volume of water-bodies and more likely flooding (Znaor 1999). Erosion silts hydraulic structures and damages irrigation systems, disrupts the ecosystems of lakes and contaminates drinking water. Roadside ditches and irrigation channels clogged with eroded soil require sediment removal and maintenance to prevent local flooding (Tegtmeier and Duffy 2004). Runoff of soil particles from the land increases water turbidity, smothering the bed of rivers and lakes. Particles also carry phosphorus, pesticides, faecal pathogens and other pollutants into surface waters. Fine particles clog coarse river gravels, reducing water flow and aeration of the river bed, reducing the survival of fish eggs and fry, invertebrates and plants such as water crowfoot (Znaor 1999). In addition to productivity losses, soil erosion causes damages to field structures, such as conservation structures, roads, bunds, and fences.

On-site soil erosion costs

Soil-related externalities basically concern on-site and off site soil erosion costs and the loss of soil carbon. The on-site cost of soil erosion is defined as the value of lost future productivity due to current cultivation (Burt 1981; Gunatilake and Vieth 2000). These costs are imposed on farmers themselves and comprise (Pretty, Brett et al. 2000):

- the loss of organic matter, leading to decreased water holding capacity of soils and increased run-off
- reduced yields because crops germinate and develop more slowly due to the loss of organic matter-rich soils
- loss of nutrients and crops themselves in water and wind erosion.

Off-site soil erosion costs

The off-site soil erosion costs relate to public and private expenditure arising from blockage of roads and ditches, damage to property, induction of traffic accidents, increased risk of flooding and water pollution (Pretty, Brett et al. 2000).

Soil erosion rates

Average soil erosion rates at national and regional levels are rare and contradictory. Pimentel suggests the average soil erosion for Europe to be 17 t ha^{-1}, (Pimentel, Harvey et al. 1995), although the method by which this figure was derived was later challenged by some authors (Crosson 1997; Boardman 1998; Trimble and Crosson 2000). Seven year plot data from central Italy indicate an average annual soil erosion of 5.6 t ha^{-1} for wheat, 18.7 ha^{-1} for maize and 2.2 t ha^{-1} for pastures (Zanchi 1988).

Problems with assessing soil erosion at national levels

A common problem associated with valuing the cost of soil erosion is the assessment of the national soil erosion. Too few countries seem to have reliable data on this. Soil erosion on a national scale is difficult to assess and extrapolation from field data does not give accurate results, particularly because the scale factor is poorly understood. Calibration and validation of spatially distributed soil erosion models is associated with difficulties and is subject to errors (Jetten, Govers et al. 2003). In twenty one catchments in central Belgium, for instance, the mean error on computed sediment yield, using sediment deposits in small ponds, was estimated to range between 40 and 50 per cent (Verstraeten and Poesen 2002). A paper from Boardman (Boardman 1998) discusses at length the limits and pitfalls regarding calculations of the soil erosion rates and their extrapolations for various objectives, stressing that converting plot experiments is a poor basis for regional or national determination of soil erosion.

7.2. State of Croatian soils

Poor data on soil damage

Data on the soil damages in Croatia are incomplete, not well organized and not systematised in a database enabling sound damage assessments (Kisić, Bašić et al. 2001; Kisić, Bašić et al. 2002). Soil testing and monitoring is inadequate and insufficient too (Bašić 2002;

Vidaček, Bogunović et al. 2005). Water sediment testing is unsystematic and is done at nine sites only (Music, Pojatina Basta et al. 2003).

Soil pollution

Data on soil pollution with pesticides is scarce, while heavy metals are reported to be within tolerable limits (Čoga, Vidaček et al. 1998).

National soil erosion estimates

More than 90 percent of Croatian soils are subject to various degrees of erosion (UN-ECE, 1999; Grgić et al., 1999). Although there seems to be a national consensus about this high figure, several authors stress that on approximately 70 percent of the area this process is still within "tolerable limits" (Petraš, Bašić et al. 1994). The most critical situation is in the region of central Istria where erosion rates as high as 100-200 tonnes of soil per hectare of agricultural land have been recorded (UN-ECE 1999). Several studies have assessed potential and actual risk of soil erosion in Croatia and sophisticated maps indicating these risks exist (Husnjak, Bogunović et al. 2000; Husnjak, Bogunović et al. 2000). However, these studies just analyse the soil erosion risks and do not quantify the national soil erosion from agricultural land. The improved digital soil mapping information doesn't give this answer either (Husnjak 2005). However, Kisić *et al.* (Kisić, Bašić et al. 2003) have estimated the soil erosion from agricultural land in Croatia at 3.8 million tonnes, and the average soil erosion rate at 1.21 t ha^{-1}.

Soil erosion trials

Recent soil erosion trials in Croatia have been undertaken at four sites in different regions: Butoniga (Istria), Mali Vrh (Hrvatsko Zagorje), Klačine (Dalmatia) and Daruvar (Slavonia). The results from the latter trial have been widely published (Bašić, Kisić et al. 2000; Bašić, Kisić et al. 2002; Bašić, Kisić et al. 2002; Bašić, Kisić et al. 2002; Kisić, Bašić et al. 2002; Kisić, Bašić et al. 2002; Kisić, Bašić et al. 2003; Kisić, Bašić et al. 2003; Kisić, Bašić et al. 2003; Bašić, Kisić et al. 2004; Kisić, Bašić et al. 2004; Kisić, Bašić et al. 2004) and used to assess the soil erosion at the national scale (Kisić, Bašić et al. 2003). The experiment was run from 1995-1999 on stagnic luvisols soil and included maize (*Zea mays* L.), soybean (*Glycine hyspida* L.), winter wheat (*Triticum aestivum* L.), oil-seed rape (*Brassica napus* var. *oleifera* L.), spring barley (*Hordeum vulgare* L.), double-cropped soybean/spring barley and black fallow. Several tillage treatments including across, up and down-slope tillage as well as the no-tillage method were tested. The no-tillage system was found to be superior over the others and reduced soil erosion in maize and soybean 40-65 percent compared to ploughing up and downhill. A standard depth of ploughing across a slope (the most common practice in Croatia) resulted in average erosion rates of 11.7 t ha^{-1} for maize, 5.4 t ha^{-1} for soybean; 0.1 t ha^{-1} for winter wheat and oil-seed rape; and 0.2 t for ha^{-1} spring barley and double cropping barley-soybean. The eroded soil was found to be richer in organic matter and contain more available phosphorus and potassium than the plot soil.

SOM losses

There has been no systematic monitoring of soil organic matter loss at the national level. Thus the available estimates are based on expert opinion, rather than on the actual national measurements over a period of time. The most fertile Croatian soil types (chernozem and eutric brown soil) have in the last hundred years of cultivation lost 50-70 percent of SOM and the humus content has dropped from 4-6 percent to 1-2 percent on average (Vidaček, Bogunović et al. 2005). The soil organic matter loss of various types of Croatian soil has also been reported by

Martinović (1997) and these analyses suggest that the most important Croatian agricultural soils have lost 2.1-2.8 percent of soil organic matter in the last 50 years. Reclaimed soils have in the period of about 20 years lost humus levels from 6-10 percent to 4-5 percent and most Croatian agricultural soils currently have a humus level of 1.5-2.5 per cent. (Vidaček, Bogunović et al. 2005).

CO_2 emissions

The carbon dioxide emitted by the Croatian agricultural sector (livestock, fertilisers, manure and residues burning) in the mid nineties has been estimated at 723,00 t CO_2 equivalent per year (Mesić *et al.* 2000). However, according to Bašić (2002), 723,00 t CO_2 derives from agricultural soils alone. If divided on 3.15 m ha taken as the agricultural area in use, it corresponds to 63 kg C ha^{-1}. The same source estimates that approximately 225,000 t of carbon is stored in Croatian agricultural soils in the form of stable humus, corresponding to 0.2 t C ha^{-1}.

Soil compaction

Soil compaction is another pronounced problem in Croatian soils and the reported loss of air/water porosity is in the range of 3-9 percent (Vidaček, Bogunović et al. 2005).

Damage due to neglected channels maintenance

So far there has been no attempt to assess soil damage costs in Croatia. However, Marušić (2003; 2003) has highlighted the economic loss due to neglected drainage, irrigation and other channels on agricultural land. The maintenance cost of these hydraulic systems costs some 54 MEUR. However, an additional cost relates to the yield reduction of agricultural crops. According to Marušić's hypothetical calculations, the yields on the agricultural land along neglected channels are dramatically lower: 60-66 percent for maize and 57-60 percent for wheat. Wheat grown on this land is calculated to be lower by 1.7-2.3 t ha^{-1}, resulting in a revenue loss of 200-300 EUR ha^{-1} or some 100 MEUR for maize and wheat alone.

7.3. Methodology

Soil erosion estimate

The soil erosion has been calculated using the following estimates and assumptions:

- the cropping pattern is taken from DZS (2002; 2003; 2004) and adjusted to the total UAA reported by the agricultural census (DZS 2003).
- soil erosion rates for individual crops are taken from the results for standard depth ploughing across the hill from the Daruvar experiments (Kisić, Bašić et al. 2002; Bašić, Kisić et al. 2004) and adjusted for some crops to the rates that are believed to better reflect the national average.
- the average soil organic matter content is assumed to be 1.8 percent based on the estimates by Vidaček *et al.* (2005)
- the average carbon content in the SOM is assumed to be 50 percent and is based on Bauder (1999) and Pretty *et al.* (Pretty, Brett et al. 2000)
- the average content of nitrogen, phosphorus and potassium in Croatian soils is estimated from the data of Martinović (1997).

Valuation of soil damage

The price for carbon is taken from the ExternE programme (IER 2004; IER 2004; IER 2005). The average ExternE price for carbon dioxide is 19 EUR, which is an equivalent of 69.54 EUR per tonne of carbon. The carbon price is multiplied by the tonnes of estimated carbon losses. Nitrogen has been priced similarly as for water resources: a shadow price of 1 EUR kg N^{-1} plus 0.51 kg N^{-1} for the commercial price of nitrogen fertiliser and its application to land. The phosphorus shadow price for the Netherlands set at 28 EUR kg P^{-1} (Davidson, Hof et al. 2002) is the only reference of this kind we were able to find. In order to allow a more conservative estimate for Croatia, we have applied a price of 15 EUR kg P^{-1}. As the “nature” (mode of action) of potassium stands between nitrogen and phosphorus (van der Werff 1992; Znaor 1995), its pollution effect is also assumed to be between the two. Therefore a shadow price that is the average of the price used for nitrogen and potassium is applied to potassium (8.25 EUR kg K^{-1}).

The per hectare yield reduction due to carbon losses for maize and wheat are based on the average figures indicated in Lal (Lal 2004), while for all other crops this loss is assumed to be 0.3 percent of the average yield (lowest losses:yield ratio from Lal’s figures). The yield loss factors are multiplied with the area under individual crops and the average prices for the period 2001-2003 derived from the reports of the Croatian state extension service (HZPSS 2003; Mikšić, Murguić et al. 2004) and the TISUP database (TISUP 2005). A fixed rate of 5 EUR per hectare is assumed to be the average price Croatian farmers pay for the redistribution of eroded soil and for repairing fence and ditch damage caused by eroded soil. This estimate includes both the cost of material and labour.

SOM losses from mineralization

The soil organic matter loss is calculated following the methodology described by Pretty *et al.* (Pretty, Brett et al. 2000). Based on the indications on the soil organic matter losses presented in Vidaček *et al.* (Vidaček, Bogunović et al. 2005) and Martinović (Martinović 1997), we estimate a loss of 2.5 percent of the SOM over the last thirty years. The soil depth considered is 20 cm, with the assumption that a typical dry soil bulk density is 1.25 g per cm^3 (Pretty, Brett et al. 2000).

7.4. Results

The results show that the on-site soil erosion damage is 7.87 MEUR. The reduced crop yields due to the total soil carbon losses results in a reduced crop value of 2.49 MEUR (Table 34), while the costs of the soil erosion restoration is 5.39. Loss of soil carbon resulting from mineralization of the SOM is by far the highest of all soil damage costs: 54.14 MEUR (Table 35). The off-site erosion is 13.19 MEUR, with nitrogen losses accounting nearly for a half of it. The total soil damage is 75.21 MER, which represents 16.95 EUR per capita and 69.80 EUR per ha of UAA (Table 36).

Table 34 On-site erosion damage

Crop	**Lost C erosion (t)**	**SOM miner. C losses (t)**	**Lost yields (kg ha^{-1} t^{-1} lost C^{-1})**	**Total lost yields (t)**	**Yield price (EUR kg^{-1})**	**Lost crop value (EUR)**
Cereals						
Wheat	144	159,940	30.0	4,802.5	0.11	528,276
Barley	34	38,021	20.0	761.1	0.11	83,722
Oats	13	14,254	20.0	285.3	0.12	34,239
Rye	2	2,453	20.0	49.1	0.13	6,385
Maize	22,481	312,240	15.0	5,020.8	0.11	552,290
Others	1	580	20.0	11.6	0.11	1,277
Subtotal	22,675	527,488	-	10,930.5	-	1,206,189
Oil crops						
Sunflower	18	20,023	6.5	130.3	0.21	27,356
Rape seed	9	10,524	5.9	62.1	0.22	13,672
Others	0	543	5.9	3.2	0.22	705
Subtotal	28	31,090	-	195.6	-	41,733.5
Dry pulses and beans						
Soyabean	1,121	35,592	6.6	242.3	0.21	50,884
Beans	149	4,727	1.0	4.9	2.00	9,751
Other pulses	40	1,267	1.0	1.3	2.00	2,614
Subtotal	1,310	41,585	-	248.5	-	63,248.8
Root crops						
Potatoes	3,345	46,464	27.5	1,369.8	0.16	219,163
Subtotal	3,345	46,464	-	1,369.8	-	219,163.0
Industrial crops						
Sugar beet	1,035	19,174	112.4	2,271.5	0.03	68,145
Tobacco	221	4,099	5.6	24.2	1.15	27,826
Subtotal	1,257	23,273	-	2,295.7	-	95,970.9
Vegetables	1,672	46,436	20.0	962.2	0.80	769,729
Other crops						
Herbs	17	1,887	0.8	1.5	5.00	7,615
Ornamentals, nurseries	137	1,527	0.9	1.5	5.00	7,488
Subtotal	154	3,413	-	3.0	-	15,103.3
Total arable land	**30,441**	**719,750**	**-**	**16,005**	**-**	**2,411,137**
Fruit and grape						
Orchards	4,207	31,163	1.9	67.2	0.50	33,602
Vineyards	3,738	27,688	2.8	88.0	0.47	41,356
Subtotal	7,945	58,851	-	155.2	-	74,958.0
Total	**38,386**	**778,601**	**-**	**16,160**	**-**	**2,486,095**
Damage to soil (MEUR)		**54.14**	**-**	**-**	**-**	**2.49**

Table 35 Off-site erosion damage

Crop	ha	Soil erosion (t ha^{-1})	Soil eroded (t)	Lost SOM (t)	Lost C (t)	Lost N (t)	Lost P (t)	Lost K (t)
Cereals								
Wheat	159,940	0.10	15,994	288	144	16	0.3	1.2
Barley	38,021	0.10	3,802	68	34	4	0.1	0.3
Oats	14,254	0.10	1,425	26	13	1	0.0	0.1
Rye	2,453	0.10	245	4	2	0	0.0	0.0
Maize	312,240	8.00	2,497,920	44,963	22,481	2,498	54.3	187.3
Others	580	0.10	58	1	1	0	0.0	0.0
Subtotal	527,488		2,519,445	45,350	22,675	2,519	54.8	189.0
Oil crops								
Sunflower	20,023	0.10	2,002	36	18	2	0.0	0.2
Rape seed	10,524	0.10	1,052	19	9	1	0.0	0.1
Others	543	0.10	54	1	0	0	0.0	0.0
Subtotal	31,090		3,109	56	28	3	0.1	0.2
Dry pulses and beans								
Soyabean	35,592	3.50	124,571	2,242	1,121	125	2.7	9.3
Beans	4,727	3.50	16,543	298	149	17	0.4	1.2
Other pulses	1,267	3.50	4,434	80	40	4	0.1	0.3
Subtotal	41,585		145,549	2,620	1,310	146	3.2	10.9
Root crops								
Potatoes	46,464	8.00	371,715	6,691	3,345	372	8.1	27.9
Subtotal	46,464		371,715	6,691	3,345	372	8.1	27.9
Industrial crops								
Sugar beet	19,174	6.00	115,042	2,071	1,035	115	2.5	8.6
Tobacco	4,099	6.00	24,597	443	221	25	0.5	1.8
Subtotal	23,273		139,639	2,513	1,257	140	3.0	10.5
Vegetables	46,436	4.00	185,745	3,343	1,672	186	4.0	13.9
Forage crops								
Alfalfa	30,249	0.05	1,512	27	14	2	0.0	0.1
Grass-clover	25,711	0.05	1,286	23	12	1	0.0	0.1
Other fodder crops	32,488	0.10	3,249	58	29	3	0.1	0.2
Subtotal	88,448		6,047	109	54	6	0.1	0.5
Other crops								
Herbs	1,887	1.00	1,887	34	17	2	0.0	0.1
Ornamentals, nurrseries	1,527	10.00	15,267	275	137	15	0.3	1.1
Subtotal	3,413		17,153	309	154	17	0.4	1.3
Total arable land	**808,198**		**3,388,401**	**60,991**	**30,496**	**3,388**	**74**	**254**
Meadows and pastures								
Meadows	149,790	0.05	7,490	135	67	7	0.2	0.6
Pastures	60,561	0.05	3,028	55	27	3	0.1	0.2
Subtotal	210,351		10,518	189	95	11	0.2	0.8
Fruit and grape								
Orchards	31,163	15.00	467,445	8,414	4,207	467	10.2	35.1
Vineyards	27,688	15.00	415,320	7,476	3,738	415	9.0	31.1
Subtotal	58,851		882,765	15,890	7,945	883	19.2	66.2
Total	**1,077,400**	**3.97**	**4,281,684**	**77,070**	**38,535**	**4,282**	**93.1**	**321.1**
Damage (MEUR)					**2.7**	**6.5**	**1.4**	**2.7**

Table 36 Summary damage to soil

	Damage (MEUR)	Share %	Cost per capita (EUR yr-	Cost per ha UAA (EUR yr^{-1})
On-site erosion				
Lost crop value	2.49	3.31	0.56	2.31
Damage restoration costs	5.39	7.16	1.21	5.00
Subtotal	7.87	10.47	1.77	7.31
Off-site erosion				
Soil erosion C losses	2.68	3.56	0.60	2.49
Nitrogen losses	6.47	8.60	1.46	6.00
Phosphorus losses	1.40	1.86	0.31	1.30
Potassium losses	2.65	3.52	0.60	2.46
Subtotal	13.19	17.54	2.97	12.24
SOM mineralisation C losses	54.14	71.99	12.20	50.25
Total	75.21	100.00	16.95	69.80

7.5. Discussion

Soil erosion rate

The total soil erosion appears to be some 30 percent higher than the estimates by Kisić *et al.* (Kisić, Bašić et al. 2003). However, the erosion per hectare is some three times higher in our calculation. This is because Kisić *et al.* (Kisić, Bašić et al. 2003) have divided their total soil erosion estimates between 3.15 million hectares, while we've divided it between 1.08 million hectares of the actual agricultural land in use (UAA). This discrepancy is interesting as both estimates have largely relied on the results obtained from the Daruvar experimental site (Kisić, Bašić et al. 2002; Bašić, Kisić et al. 2004). A more detailed analysis of this gap is difficult since the work of Kisić *et al.* does not specify the average erosion rates for different crops or indicate their area.

SOM and carbon losses

The SOM and carbon loses per hectare obtained in this study are based on the indications on the SOM lost over the last decades made by the Croatian soil scientists (Martinović 1997; Vidaček, Bogunović et al. 2005). Our results on the carbon losses per hectare are much higher than reported for Croatia by Bašić (2002), but are quite comparable with the carbon losses rates reported for other European regions (Pretty, Brett et al. 2000; Robert, J et al. 2001; Lal 2003; Freibauer, Rounsevell et al. 2004).

Some costs remain uncalculated

Due to the lack of data this assessment was not able to cover some soil-related externalities included in other studies, notably those from Tegtmeier and Duffy (Tegtmeier and Duffy 2004):

- Damage to irrigation systems
- Cost to the water industry
- Cost to replace the lost capacity of reservoirs
- Flood damage
- Damage to recreational activities

- Cost to navigation: shipping damages, dredging
- In-stream impacts: commercial fisheries, preservation values
- Off-stream impacts: industrial users, steam power plants
- Value of non-carbon substances and biota lost in SOM

The above costs are most likely to be substantial. As some 15 per cent of Croatian territory is prone to flooding and flooding risk is high due to the only partially completed protection systems (MZOPU 2003), this cost category deserves a special attention.

The damage costs arising from the reduced yields (some 100 MEUR) resulting from the neglected maintenance of the hydraulic systems on agricultural land as suggested by Marušić (2003; 2003) are not taken into account. This is because the reduction of crop yields is dependent on a number of agro-ecological factors and management techniques and cannot be attributed solely to the regime of hydrological systems. However, as eroded agricultural soil does diminish the retention capacity of the channels and by enhancing eutrophication accelerates the growth of the riverbed and bank vegetation, this topic deserves further attention.

Comparison with studies for other countries

Comparison with similar studies from other countries is difficult due to the different methodological framework, valuation of carbon and other pollutants, and the cost categories included. The per hectare damage to soil resources calculated here is some 13 percent lower than the damage obtained in the calculations for the EU (Pimentel, Harvey et al. 1995; ECAF 2000). It is also similar to the upper estimate from recent study for the USA (Tegtmeier and Duffy 2004). However our damage cost per hectare is nearly four times higher than the cost reported for the UK by Pretty *et al.* (2000) - if calculated on the base of the UK arable land. This difference comes because Pretty *et al.* have, due to the specific conditions in the UK, calculated soil carbon losses resulting from mineralization on only 20 percent of UK arable land. However, as Croatian estimates of the SOM losses relate primarily to the arable land under intensive agricultural use (Martinović 1997; Vidaček, Bogunović et al. 2005), we have calculated carbon losses only for the utilised agricultural area under vineyards, orchards and arable land. The rest of the UAA- arable land under forage crops and permanent grassland is assumed to be carbon neutral or positive. The inclusion of the area under these crops would due to the carbon sequestration effect to a degree counterbalance the carbon losses presented here. It would result in a total carbon loss of some 510.000 t C, instead of the 821.665 t C presented here. However, as this effect is considered to be a positive externality, it is outside the research boundaries of this study, and as such not taken into account.

Question of pricing

As with the assessment of the damage to air, carbon pricing remains a key factor in valuation of the damage to soil. The problems regarding a “fair” price for carbon have been discussed in the chapter on the damage to air.

The shadow prices applied to phosphorus and especially potassium are subject to further inspection. The phosphorus price has been derived from a single reference (although the value used has been reduced by 50 percent), while the potassium shadow price remains questionable, because it is assumed to be in between those for nitrogen and phosphorus.

8. PUBLIC INVESTMENTS

8.1. General

Public investments enable cheaper food

Agriculture and FULS benefit from certain public investments and at the same time are the causes of some other ones. The best known public investments in the agricultural sector are the various forms of agricultural subsidies. Economically speaking, agricultural subsidies are not externalities, but as payments from taxpayers to farmers are an integral part of the full cost of agriculture (Pretty, Ball et al. 2005). Besides these regular agricultural subsidies, there are a number of hidden public investments providing farming and FULS with an extra income/profit. These are brought about as the result of the agricultural and economic policies of a country, aimed at providing a better income of those directly or indirectly involved in farming, with the final objective to produce cheap food. In spite of criticism regarding the high cost of agricultural policies (subsidies), taxpayers' money has been returned back to the taxpayers (consumers) in many countries. Agricultural prices of the EU-15 in real terms have fallen fourfold since 1950 and this economic benefit has been passed on to consumers (Boussard 2003). However, this enormous economic success has been made at the expense of the environment/nature, which farmers have not returned to the taxpayers in the same or a better state.

Croatian agricultural and economic policies also provide direct and hidden subsidies to farming and FULS and this chapter presents an attempt to quantify the Croatian public investments associated with farming and FULS.

8.2. Investment to public institutions providing service to agricultural sector

As already mentioned in the chapter on value added, a number of administrative, research, education and advisory organisations provide services to the Croatian agricultural sector. These organisations are financed by public money, and their average annual expenditure in the period 2001-2003 was 50.77 MEUR.

8.3. Farming subsidies

Regular MPŠ subsidies

Subsidies run by MPŠ included direct payments (production subsidies) and various other supports to agriculture, rural development, marketing, etc. The exact total annual amount of these subsidies is difficult to estimate, since actual annual expenditures differed from the planned budgets and because there were some retroactive payments for the claims from the previous years. Therefore official reports give slightly different figures on these (MF 2003; MPŠ 2003; MPŠ 2003; VRH 2003; AZZTN 2004; MPŠVG 2004). The agricultural subsidies issued by the MPŠ in 2002 and 2003 were assessed from the Ministry of Finance data on the state budget (MF 2002; MF 2003), while for 2001 we relied on the figures provided by MPŠ (2003). Only agriculture-related subsidies, aids and programmes were taken into account, leaving aside those directed to forestry, fisheries, hunting and other non-agricultural activities. The average annual agriculture-related subsidies in the period 2001-2003 run by the MPŠ were 245.15 MEUR.

Agricultural diesel

Croatian farmers have been entitled to subsidised fuel, so called “blue” diesel. This fuel is exempted from road tax and special fuel tax (N.N. 2002) worth 0.33 EUR per litre. A per hectare quota of 80 litres has been set for cereals, oil crops and sugar beet, while tobacco producers are entitled to only 40 litres per hectare. Multiplication of the area under these crops as reported by MPŠ (2003; 2003; 2004) with the prescribed per hectare fuel quota results in an average annual quantity of 45.6 ML in the period 2001-2003. If each litre was subsidised with 0.33 EUR (N.N. 2002), the total average annual subsidy was 14.84 MEUR (Table 37). This subsidy was paid by the Ministry of Finance and this support scheme was not deducted from the MPŠ budget.

County subsidies

Several counties, cities and municipalities run their own support programmes for agriculture. These also include subsidies and various loans and/or co-financing for capital investments. Farmers from these regions are entitled to such subsidies in addition to those issued by the Ministry of Agriculture. This practice seems to be against WTO rules, but is still ongoing. The biggest single regional agricultural support programme is run by the city of Zagreb. Based on the figures for 2003 (Grad Zagreb), and applying a discounted rate of 7 per cent for the other two years, we have assessed the average annual support given in the period 2001-2003 at some 1.6 MEUR. Similarly, the agricultural support scheme of Zagrebačka county (Glasnik Zagrebačke županije 2004) is estimated at 0.95 MEUR. Average annual subsidies in the period 2001-2003 for all other counties are estimated at 0.13 MEUR per county, resulting in an amount of 2.34 MEUR. Additionally, counties seem to have invested annually on average some 3.93 MEUR in various loans and/or co-financing for capital investments (MPŠ 2003). In total, counties on average spent 8.83 MEUR per year on all their support programmes to agriculture (Table 37).

Local subsidies

We have assumed that the average annual agricultural expenditure in the period 2001-2003 per city was 26.774 EUR and 40.016 EUR per municipality, resulting in the total average annual subsidy of 3.10 MEUR (Table 37).

Table 37. National, regional and local farming subsidies

	Cost (MEUR)	Share %	Cost per capita (EUR yr^{-1})	Cost per ha UAA (EUR yr^{-1})
Ministry of agriculture	245.14	90.15	55.25	227.52
"Blue diesel"	14.84	5.46	3.34	13.77
Counties	8.83	3.25	1.99	8.20
Cities and municipalities	3.10	1.14	0.70	2.88
Subtotal	271.91	100.00	61.28	252.37

8.4. Subsidies to agri-industrial complexes

The need for revitalisation

In December 2000 the government decided to write off the debts of eight agri-industrial complexes: PIK Vrbovec, Vupik Vukovar, Đakovština Đakovo, PPK Kutjevo, PP Orahovica, PIK Jasinje Slavonski Brod, PIK Belje Darda i IPK Osijek (VRH 2000). These organisations were the remains of the former big state co-operatives and the government was their major shareholder. Their cumulative debt by the end of 2000 was 508 MEUR (VRH 2000; Šimić 2001) Apart from primary agricultural production they are engaged in food processing: they own a substantial portion of the food-processing capacities of the country and employ thousands of people. It is against this background that the government decided to assist in their financial "revitalisation".

Non-transparent operation

However, the government intervention in their economic «recovery» hasn't been transparent and the exact amount of public money invested in this project remains a puzzle. The Ministry of Finance does not have a sound overview on the magnitude of this operation since its expenditures seem to be not well recorded and are dispersed among various cost categories of the state budget (Karačić 2005). A recent report from the State Auditing Agency (DUR 2005) - the highest state authority for financial auditing - also points at a number of irregularities and inaccurate book-keeping regarding financial arrangements between the State and agri-industrial companies.

Amount unknown

Through various financial arrangements, the government has written off substantial parts, and most likely all the debts of these companies. According to Lončar (Andrijanić 2003; Lončar 2004), an independent member of Parliament and vice-chairman of the parliamentary agricultural committee, in the period 2001-2003, the Croatian government spent some 535 MEUR on various financial "revitalisation" schemes of the big agri-industrial companies. The Croatian Legal Party has the same estimate (HSP 2003). However, according to the deputy prime minister at the time, Linić, in 2002 the government spent only 268 MEUR for this expenditure (Bankamagazine 2002). On the other hand, 535 million EUR was reported to have been invested in PIK Vrbovec alone (Pulić 2002). As it is quite difficult to obtain reliable figures on the magnitude of this support, we assume it to be equal to 508 MEUR, the amount of the debt reported by the end of 2000 (VRH 2000; Šimić 2001). As these companies practice both primary agricultural production and processing, we estimate that only some 20 percent of the support relates to the primary agricultural production, resulting in a support of 101.61 MEUR. Assuming that this amount was equally distributed in the period 2001-2003, the average annual cost was 33.87 MEUR.

8.5. Public investments in water and road conveyance systems

Roads

According to the data from the Croatian Roads, the public company responsible for road maintenance (Hrvatske ceste 2005), as well as those from the Croatian Highways (Hrvatske autoceste 2005), the public company maintaining highways, the cleaning of the road conveyance system (channels, ditches, etc.) from eroded soil represents some 3.5-4.5 per cent of the regular road maintenance costs. From the figures provided by the same sources, we calculated that the average annual cost for the removal of eroded soil and damage reparation in the period 2001-2003 was 2.5 MEUR. Assuming that 50 percent of the eroded deposits originate from agriculture, the cost is 1.25 MEUR. However, according to the national roads maintenance programme (VRH 2001; VRH 2003), the budget made available for road maintenance in the period 2001-2004 is far below the minimum requirements. Assuming that 4 per cent of the costs for regular road maintenance relates to eroded soil, from the figures presented in this programme it can be calculated that some 7 MEUR per year is needed for this operation, of which 3.5 MEUR goes to agriculture. Since the actual expenditure of 1.25 EUR was sufficient to remove only a portion of eroded soil, we took the figure of 3.5 MEUR as the external cost, because the remaining eroded soil deposits still cause damage. Even if soon removed, it is a cost that was caused by the agricultural practices of the period 2001-2003. From the methodological point of view, the removal of eroded soil should be included in the cost category damage to soil. However, as this is at the same time a public investment, we have included it in this calculation instead.

Water

According to Croatian Waters (Biondić 2005) the average annual cost spent on bank restoration and removal of eroded soil from the water conveyance systems classified as state water courses in the period 2001-2004 was 9.10 MEUR. An additional amount of 14.20 MEUR was spent for the same purpose for local watercourses. However, as this cost was paid by farmers and not from public money, we do not take it into account. Assuming that 50 percent of the indicated cost for the state water conveyance systems relates to removal of eroded soil and that 50 percent of this soil derives from agriculture, the average annual cost is 2.28 MEUR. However, similarly as for roads, this cost represents only a portion of what was required to remove all eroded soil. Biondić *et al.* (2003) indicate that some 43.65 MEUR is needed for the regular maintenance of the state watercourses. Assuming that 50 percent of this is required to remove eroded soil and that 50 percent of the soil derives from agriculture the cost needed was 10.19 MEUR - an amount that we reckon to be the external cost.

8.6. Transport subsidies

Port subsidies

In 2002 Croatian ports received a subsidy of 11.25 MEUR (AZZTN 2004). From the transport statistics (DZS 2004; DZS 2005) it appears that that agricultural inputs (genetic material, feeds, raw phosphates, fertilisers, pesticides and veterinary medicine) and petroleum products consumed by farming and FULS in the period 2001-2003 accounted for 15 percent of all goods handled by the Croatian ports. Therefore we assign 15 percent of the above-mentioned subsidy (1.57 MEUR) as external costs. In the absence of data for other two years, we take this amount as the average annual subsidy for the period 2001-2003.

Railway subsidies

From the statistical data provided by Croatian railways (HŽ 2005), it appears that agricultural inputs and petroleum products consumed by farming and FULS account for 14.6 percent of all t-km carried by the Croatian Railways in the period 2001-2003. In the same period, through regular subsidies, written-off loans and subsidies for capital investments for the freight transport alone, Croatian railways received an amount of 373.60 MEUR, or 124.54 MEUR on average per year. Assuming that farming and FULS account for 14.6 percent of this subsidy, we set the average annual cost at 18.16 MEUR.

8.7. Subsidy to fertiliser production

Written-off debts

Until 2000 the fertiliser price in Croatia was prescribed by the government and the sole Croatian fertiliser manufacturer Petrokemija was prohibited from establishing its own, market driven prices (Mesarić 2005). While the fertiliser price was artificially kept low, gas prices substantially increased and Petrokemija ended up in debt. In 2001 the government-owned gas company INA wrote off 50 percent of Petrokemija’s gas debt for 1999 (Petrokemija 2003). The written-off amount was 41.34 MEUR, made of 25.01 MEUR debt and 16.33 MEUR accompanying interest (Table 38), which according to the Croatian law of that time, had to be calculated with an annual interest rate of 18 percent. It was agreed that the remaining 50 percent of the debt was to be paid over the next five years with the annual interest rate of 6 percent. However, Petrokemija so far has not repaid anything and has instead filed a request to the government for total debt forgiveness (Mesarić 2005). The government decision is still pending, but INA hasn’t taken any legal or political action against this request. Since this debt has not been repaid and because it very unlikely that it will ever be paid, we take it as a public investment. However, one could argue that the gas debt from 1999 should not be the subject of a study assessing impacts of 2001-2003 agriculture and thus should be excluded from the calculation. However, as this cost was imposed on Croatian society in 2001 and was decisive for Petrokemija’s future existence, enabling it to play a major role in supplying Croatian agriculture in the period 2001-2003 with (cheaper) fertilisers, we think it is fair to include this hidden subsidy in the assessment.

If the remaining 50 percent of the debt is updated to its 2001-2003 value applying the interest rates for late payments prescribed by the Croatian regulations (N.N. 1996; N.N. 2002), the average annual cost amounts

48.20 MEUR. If both written-off and non-repaid gas debts are summed up and corrected for the percentage reflecting the share of domestic fertiliser consumption, the average annual cost in the period 2001-2003 is 26.00 MEUR (Table 38).

Table 38 Petrokemija's written-off gas debt (MEUR)

	2001	2002	2003	2001-2003
Written-off gas debt	25.01	-	-	-
Written-off accompanying interest	16.33	-	-	-
Remaining debt	41.34	48.57	54.70	48.20
Subtotal	82.68	48.57	54.70	61.98
Share of fertilisers for domestic market	0.41	0.48	0.38	0.42
Total	33.90	23.31	20.78	26.00

Subsidised gas price

Gas is by far the most expensive cost in fertiliser production (Mesarić 2004; Vešligaj 2004; Mesarić 2005). The government-owned gas and oil company INA is the exclusive supplier of gas to Petrokemija. In the period 2001-2003, INA was supplying gas to Petrokemija at a price that is cheaper than the gas price on the international market. (SING 2004; Molak 2005; Molak 2005). This was possible thanks to a long-term contract between INA and Petrokemija. The contract enables Petrokemija to get cheap gas, while INA keeps the right to cut the gas supply to Petrokemija during very cold periods when household gas consumption drastically increases and the Croatian gas supply infrastructure is not able to support the gas supply to both. Both the Ministry of the Economy and the Ministry of Agriculture have been informed about this deal and have (in)formally approved it (Granić 2005; Mesarić 2005). In the period 2001-2003 Petrokemija was getting gas for \$0.09 per cubic metre (Molak 2005; Molak 2005). This estimate corresponds with the price of some \$0.13 per cubic metre, including transport costs, indicated by other sources (Bankamagazin 2002; HINA 2002; Mesarić 2005). However, Petrokemija (Mesarić 2005) argues that the gas price it pays to INA is fair because:

- It is, after HEP (Croatian Electricity Company), the biggest single gas consumer in Croatia, making up some 30 percent of the entire national gas consumption
- It consumes constant gas quantities throughout the year, enabling INA to strike a better price deal with Gazexport, its exclusive Russian gas supplier
- Its gas consumption outside the heating season stabilises Croatian gas storage capacities, enabling more gas to be stored.

In order to get more information on the issue, we also asked for both INA and the Ministry of Economy for their comments. INA's management team discussed our request internally, but decided to refrain from comments, arguing that its gas prices are the company's business secret (Čičko 2005), while the Ministry of the Economy never replied (Tomšić 2005).

As one government-owned company sells gas to another government-owned company below the market price, we consider this as hidden subsidy. Its magnitude has been calculated largely on the basis of the gas price analysis for Petrokemija made by the leading Croatian energy institute Hrvoje Požar (Vulama 2005). We have adapted this calculation with the information on gas prices provided by other sources (EC 2004; Heren Energy 2004; VRED 2004; Mesarić 2005; Molak 2005) and compared the gas price Petrokemija pays to INA with the price that INA pays on the international market.

INA imports Russian gas from the Baumgarten gas hub at the border between Austria and Slovakia. We assume that INA's price at the Baumgarten hub is between the prices paid by the Italian gas company ENI and the Slovenian gas company OMV. This is because INA is a smaller buyer than ENI, but bigger than OMV. Under this assumption, the average annual Baumgarten hub price per cubic metre of gas in the period 2001-2003, would be $c13.49, while the price at Petrokemija gate would be $c17.95. However, at the same time, the average annual INA gas price at Petrokemija gate was $c10.31, which is 42.04 percent cheaper than the Baumgarten hub gas price, making an annual difference of 36.47 MEUR in average (Table 39). However, in order to reflect the fact that Petrokemija has financial losses because INA has the right to cut off its gas supply during very cold periods, we have subtracted the value of these losses from the difference between INA and Baugarten hub gas prices. Our assumption is that in the period 2001-2003, Petrokemija was on average 30 days a year out of production due to the gas supply shortage and that it had to re-start the ammonia synthesis plant three times a year. The daily losses are estimated to be 178 000 EUR for each day out of production (Mesarić 2005) and the cost of each new start of the ammonia plant at 670 000 EUR (Mesarić 2005). Finally, a correction is made for the share of fertilisers produced for the domestic market only. The calculation suggests that the average annual hidden subsidy in the period 2001-2003 was 12.14 MEUR.

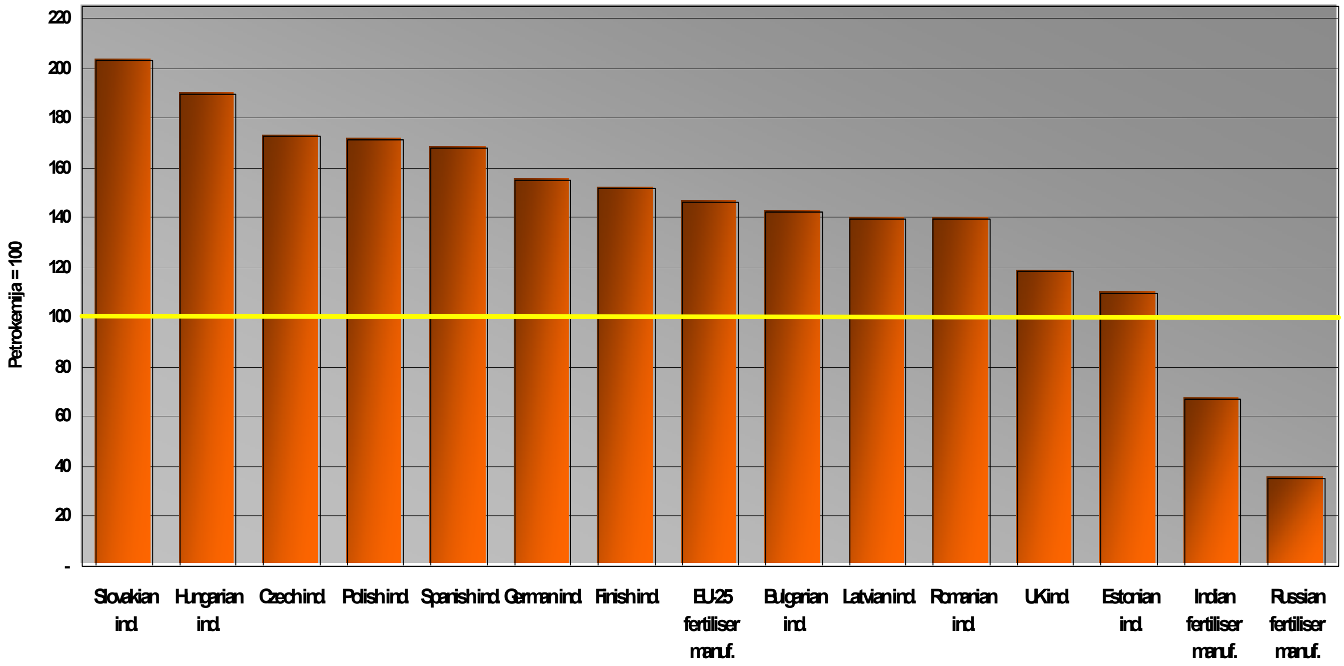
Table 39 Hidden subsidy resulting from INA's gas supply to Petrokemija

Baumgarten price	**Unit**	**2001**	**2002**	**2003**	**2001-2003**
ENI, Italy	$\$\text{c/m}^3$	12.50	11.30	15.26	13.02
OMV, Slovenia	$\$\text{c/m}^3$	13.38	12.08	16.41	13.96
INA (estimate)	$\$\text{c/m}^3$	12.94	11.69	15.84	13.49

	Unit	2001	2002	2003	2001-2003
Cost of INA gas					
Gas price paid by Petrokemija	$\$\text{c/m}^3$	9.56	9.00	9.00	9.19
Gas transport price paid by Petrokemija	$\$\text{c/m}^3$	-	1.55	1.82	1.69
Cost of INA gas at factory gate	USc/m^3	9.56	10.55	10.82	10.31
Cost of Baumgarten hub gas					
Average gas price at Baumgarten hub	$\$\text{c/m}^3$	12.94	11.69	15.84	13.49
Gas transport price from Baumgarten to HR border	$\$\text{c/m}^3$	2.00	2.00	2.00	2.00
Gas transport price from HR border to Petrokemija	$\$\text{c/m}^3$	1.46	1.55	1.82	1.61
Administrative/commission costs (5% estimate)	$\$\text{c/m}^3$	0.82	0.76	0.98	0.85
Cost of Baumgarten hub gas at factory gate	USc/m^3	17.22	16.00	20.64	17.95
INA gas price vs. Baumgarten hub gas price					
INA gas cheaper than Baumgarten hub gas	%	44.47	34.07	47.57	42.04
INA gas cheaper than Baumgarten hub gas	$\$\text{c/m}^3$	7.66	5.45	9.82	7.64
INA vs. Baumgarten gas bill					
Petrokemija gas consumption (fertiliser production only)	Mm^3	480.50	435.73	497.71	471.31
Annual gas bill paid to INA	M $	45.95	45.98	53.85	48.59
Annual gas bill if gas bought from Baumgarten	M $	82.75	69.73	102.72	85.07
INA vs. Baumgarten hub gas bill difference	M $	36.79	23.76	48.86	36.47
Petrokemija's losses due to INA's cuts in gas supply					
Losses due to INA's cuts in gas supply	M $	4.78	5.07	5.95	5.27
Cost of re-starting plants	M $	1.80	1.91	2.24	1.98
Total losses due to cuts in gas supply	M $	6.58	6.98	8.19	7.25
Subsidy	M $	30.21	16.78	40.67	29.22
Subsidy	M EUR	33.73	17.81	36.04	29.19
Subsidy related to fertiliser manufacture for HR market	M EUR	13.98	8.61	13.82	12.14

The subsidised gas price enables Petrokemija to sell fertilisers for a cheaper price both on the domestic and international market. Figure 22 shows the relative comparison of gas prices without taxes between Petrokemija and comparable industries in other countries and the calculation is based on the data from EFMA (2004) and EUROSTAT (2004).

Figure 22 Relative comparison of gas prices between Petrokemija and comparable industries in selected countries as per July 1st, 2004.



8.7.1 Allergy-related public investments

Allergenic plants on uncultivated land

A vast area of Croatian agricultural land remains uncultivated. This situation enhances the development of some plant species causing allergy to humans. Seven of the highly allergenic plant species (Alnus sp., Ambrosia sp., Betula sp., Carpinus sp., Poaceae, Quercus sp. and Taxus/Juniperus) producing the greatest amount of pollen in Croatia (Peternel, Culig et al. 2003; Peternel, Culig et al. 2005) are typical for the vegetation of uncultivated agricultural land.

Type of public costs

Public investments related to allergy-causing plant species include:

- Cost of medical drugs (in Croatia most drugs are covered by the obligatory medical insurance)
- Cost of medical treatments (also largely covered by the obligatory medical insurance)
- Monitoring, research and public awareness programmes
- Local and regional combat programmes against allergenic plant species
- Reduced working activity of the population

The public investments associated with allergy in Croatia are still not known, although there is an on-going project recording the quantity of medicine used by allergic patients (Peternel 2005).

Besides the public, allergies lead to substantial private costs: expenditures for drugs and medical treatments not covered by the obligatory medical insurance and in some cases a forced stay in the pollen-free coastal region.

Percentage of the affected population

Reliable statistics on the number of people suffering from pollen allergies do not exist (Stevanović 2005), but expert opinions indicate that some 10-15 percent of the Croatian adult population suffers from pollen allergies, while the percentage of the affected children and youth is most likely to be higher (Peternel 2005).

Costs estimate

Assuming that 0.5 million people (11.3 percent of the population) suffer from pollen allergies and that each person on average gets drugs worth 10 EUR and medical service (examination, laboratory testing, advice, etc.) worth another 10 EUR per person, it results in a cost of 10 MEUR. The average GDP per capita in the period 2001-2003 was 5,400 EUR. Allergic people have to adjust their outdoor activities to avoid contact with the allergen (Peternel, Culig et al. 2005), which reduces their working abilities. The pollen allergy season in Croatia starts in March and ends in October (Peternel, Culig et al. 2005). If the average duration of pollen allergies is 45 days (MZSS 2005), and working ability during these days reduced by only 10 percent, the GDP loss is 66.58 EUR per person, or 33.29 MEUR for the whole country. The public health service in Croatia has been providing information to individuals allergic to pollen (Peternel, Culig et al. 2005) and there is some research ongoing in this field. We assess the provision of pollen-related information and research costs at an additional 3 MEUR. Besides, some regional and local authorities also run programmes to combat plant species causing allergy, of which those targeted at ragweed (*Ambrosia Artemisiifolia*) are most massive (Gorjanski 2005; Stevanović 2005). Ragweed is particularly widespread in the Croatian Pannonian plain and has been rapidly expanding. In the Hungarian part of the Pannonian plain, the number of the population with asthma has increased four-fold in ten years and this development has been associated with the spread of ragweed (Járai-Komlódi 1998). Experiences from the Osijek region indicate that total land abandonment suppresses ragweed, while occasionally cultivated, semi-abandoned agricultural land drastically encourages its distribution (Gorjanski 2005). A calculation from the Association for Combating Allergic Diseases in Osijek (UBPABO 2001) indicates that a cost of 1.1 EUR per inhabitant is required for successfully combatting ragweed, in addition to some voluntary work of the local communities (NGOs, citizens, schools, etc.). We take half of their estimate for the combat of ragweed, assuming that this lower per capita investment would be more representative for the country average.

Table 40 Estimated pollen allergy related public investments

	Cost (MEUR)	Share %	Cost per capita (EUR yr^{-1})
Cost of drugs	5.00	10.26	1.13
Cost of medical examination	5.00	10.26	1.13
Reduced working ability	33.29	68.31	7.50
Combating costs	2.44	5.01	0.55
Research, monitoring & information	3.00	6.16	0.68
Total	48.73	100.00	10.98

8.8. Summary of findings

Table 41 gives the overview of the identified public investments that are associated with Croatian farming and FULS. The average annual cost in the period 2001-2003 is estimated at 477.57 MEUR. It is the equivalent of 107.63 EUR per capita, 443.24 EUR per ha of UAA or 562.14 EUR per hectare of agricultural land inscribed in the Ministry of Agriculture Farm Register of 2003. Farming subsidies paid by the Ministry of Agriculture account for more than 60 percent of its entire public investment costs, followed by the operational costs of the administrative, research, education and advisory institutions dealing with agriculture. The cost of pollen allergies and the money paid to revitalise indebted agri-industrial complexes make two other important public investments. Although these costs have been reported here they will be excluded from the comparison of environmental and economic performance of the baseline situation (2001-2003) with that of organic farming. Pollen allergies are linked to uncultivated, semi-abandoned land and do not relate to any particular farming style. The investments made for the economic recovery of the agri-industrial complexes are considered as a one-time payment and will for this reason be excluded from the comparison.

Table 41 Average annual public investments for Croatian farming and FULS in the period 2001-2003.

	Cost (MEUR)	Share %	Cost per capita (EUR yr^{-1})	Cost per ha UAA (EUR yr^{-1})	Cost per MPŠVG Registry 2003 ha (EUR yr^{-1})
Cost of agri-linked public institutions	50.78	10.63	11.44	47.13	59.77
Farming subsidies	271.91	56.94	61.28	252.37	320.07
Subsidies to agri-industrial complexes	33.87	7.09	7.63	31.44	39.87
Soil removal from roads conveyance systems	3.50	0.73	0.79	3.25	4.12
Soil removal from water conveyance systems	10.91	2.29	2.46	10.13	12.85
Agriculture-related subsidy to railways	18.16	3.80	4.09	16.85	21.37
Agriculture-related subsidy to ports	1.57	0.33	0.35	1.46	1.85
Written-off debts to fertiliser industry	26.00	5.44	5.86	24.13	30.60
Subsidised gas price to fertiliser industry	12.14	2.54	2.74	11.27	14.29
Cost of agriculture-linked allergies	48.73	10.20	10.98	45.23	57.36
Subtotal	477.57	89.80	107.63	443.24	562.14

9. BASELINE SCENARIO: SUMMARY

Externalities higher than value-added

In the period 2001-2003 Croatian farming and FULS created the average annual value added of 636.72 MEUR. However, this economic chain also generated substantial external costs: 1,107.91 MEUR (Table 42). The external costs are made up of the environmental damage caused to air, water and soil and public investments. The net (real) value added is (external costs subtracted from value added) is -471.18 MEUR, suggesting that in the period 2001-2003, Croatian farming and FULS even created a negative value to society.

Public investments are the highest single external cost, accounting for 43.11 percent of the total external costs. With a share of 37.37 percent, damage to air comes second and is followed by damage to water and (12.76 percent) and damage to soil (6.79 percent). Of all environmental costs, damage to air is the most significant as it accounts for 65.66 percent of the total environmental damage to air, water and soil. Damage to water makes up 22.42 percent and damage to soil 11.93 percent of the environmental costs.

Costly farming sector

Among all economic activities considered, farming generates the most external costs. This is because farming consumes 77.25 percent of all public investments and 76.83 percent of all damage to air, water and soil. It accounts for 83.81 percent of all external costs. With a share of 7.64 percent, fertiliser manufacture is the second largest single contributor to external costs.

Table 42 Baseline scenario: summary of added value and external costs

NCEA code	NCEA subcode	Economic activity	No. of employees linked to HR agric. (FTE)	GVA from agri-linked HR market (MEUR)	% GDP	Damage to air (MEUR)	Damage to water (M EUR)	Damage to soil (M EUR)	Public investment (MEUR)	Real cost (FUTURO) (MEUR)	Net value-added (MEUR)
A		**Agriculture, hunting and forestry**									
A	01-04	Farming	134,196	391.27	1.743	358.65	125.77	75.21	368.92	928.55	-537.28
		Subtotal	134,196	391.27	1.743	358.65	125.77	75.21	368.92	928.55	-537.28
C		**Mining and quarrying**									
CA	11	Oil and gas extraction	109	3.61	0.016	2.33	0.00	0.00	0.00	2.33	1.28
		Subtotal	109	3.61	0.016	2.33	0.00	0.00	0.00	2.33	1.28
D		**Manufacturing**									
DA	15.71	Feedstuff production	1,093	13.98	0.062	0.02	0.00	0.00	0.00	0.02	13.96
DF	23.2	Manufacture of refined petroleum products	780	26.51	0.118	8.23	0.00	0.00	0.00	8.23	18.28
DG	24.15	Manufacture of fertilisers	1,394	14.52	0.065	30.98	15.58	0.00	38.14	84.70	-70.17
DG	24.2	Manufacture of pesticides	425	10.51	0.047	0.07	0.00	0.00	0.00	0.07	10.44
DG	24.42	Manufacture of veterinary medicine	252	9.50	0.042	0.18	0.00	0.00	0.00	0.18	9.31
DK	29.3	Manufacture of agri. and forestry machinery	674	5.95	0.026	0.00	0.00	0.00	0.00	0.00	5.95
		Subtotal	4,619	80.97	0.361	39.48	15.58	0.00	38.14	93.20	-12.24
E		**Electriciy, gas and water supply**	158	4.72	0.021	3.34	0.00	0.00	0.00	3.34	1.38
		Subtotal	158	4.72	0.021	3.34	0.00	0.00	0.00	3.34	1.38
G		**Wholesale and retail trade; repair**	3,821	62.81	0.280	0.00	0.00	0.00	0.00	0.00	62.81
I		**Transport, storage and communication**									
I	60.1	Railway transport	839	5.02	0.022	0.01	0.00	0.00	18.16	18.17	-13.15
I	60.24	Road freight	537	8.29	0.037	9.62	0.00	0.00	0.00	9.62	-1.32
I	60.3	Pipeline transport	22	2.92	0.013	0.01	0.00	0.00	0.00	0.01	2.91
I	61.10.2	Marine freight	16	1.95	0.009	0.34	0.00	0.00	0.00	0.34	1.62
I	61.2	River freight	17	0.09	0.000	0.00	0.00	0.00	0.00	0.00	0.09
I	63.11	Transshipment of goods	236	2.19	0.010	0.00	0.00	0.00	1.57	1.57	0.62
		Subtotal	1,668	20.47	0.091	9.97	0.00	0.00	19.73	29.70	-9.23
K		**Real estate, renting and business activities**									
K	73.10.2	Technical and techn. research and dvlp.	902	23.68	0.105	0.00	0.00	0.00	13.55	13.55	10.13
K	74.14	Business and mngm. advisory services	170	2.39	0.011	0.00	0.00	0.00	3.49	3.49	-1.10
K	74.30	Technical testing and analysis	33	0.46	0.002	0.00	0.00	0.00	0.68	0.68	-0.22
		Subtotal	1,105	26.54	0.118	0.00	0.00	0.00	17.72	17.72	8.82
L		**Public administration, defence and social security**									
L	75.11.1	Central government	342	5.18	0.023	0.00	0.00	0.00	8.58	8.58	-3.40
L	75.11.2	Regional governments (counties)	77	1.82	0.008	0.00	0.00	0.00	1.92	1.92	-0.10
L	75.11.5	Local governments (municipalities)	147	2.16	0.010	0.00	0.00	0.00	2.94	2.94	-0.78
		Subtotal	566	9.16	0.041	0.00	0.00	0.00	13.44	13.44	-4.28
M		**Education**									
M	80.3	Higher education	892	12.76	0.057	0.00	0.00	0.00	19.62	19.62	-6.86
		Subtotal	892	12.76	0.057	0.00	0.00	0.00	19.62	19.62	-6.86
N		**Health and social work**									
N	85.2	Veterinary services	1,474	24.42	0.109	0.00	0.00	0.00	0.00	0.00	24.42
		Subtotal	1,474	24.42	0.109	0.21	0.00	0.00	0.00	0.00	24.42
		Total	**148,607**	**636.72**	**2.836**	**413.99**	**141.35**	**75.21**	**477.57**	**1,107.91**	**-471.18**

10. LARGE-SCALE ORGANIC FARMING SCENARIOS

10.1. Comparison issues

Methodological problems

The comparison of environmental and economic performance between organic and conventional farming is difficult and requires some methodological clarifications. Lampkin (Lampkin 1992), based on the arguments from organic agriculture pioneers (Koepf 1983; Lockeretz 1989; Vogtmann 1990) stresses that the problem arises at the level of definition of agricultural systems, the objectives and design of the study, the methods and standards used for comparison, as well as the need to isolate performance indicators, which are not necessarily part of the system being compared. An additional problem is that a number of comparison studies indicate that the difference within the organic and conventional groups is greater than the average difference between the groups (Lampkin 1992; van Mansvelt and Mulder 1993). This can be explained by the physical and financial constraints of the examined farms as well as the management ability of the individual farmer. Management skills, which are difficult to evaluate, seem to play a crucial role in any comparison (Oenema and Pietrzak 2002). Skilled, well trained, hard-working farmers tend to be successful regardless whether they are organic or conventional. These are most likely to out-compete less skilled and trained farmers regardless the farming style these practice (Znaor 1995). Another important aspect is whether the comparison between high-external input and organic farming is fair at this point in time. This is because the comparison of the two is the comparison of the potential of an immature system with the achievements of a mature one in which decades of research and billions of dollars have been invested (Lampkin 1992).

General results

In the beginning of the nineties van Mansvelt and Mulder (van Mansvelt and Mulder 1993) published an overview of the performance of organic farming. Based on the available literature at the time it concluded (van Mansvelt and Mulder 1993; van Mansvelt and Znaor 1999) that in comparison with conventional, organic farming:

1. results in less nutrient leaching into the water, largely complying with the requirements of the EU for drinking water.
2. does not cause the loading of synthetic pesticides into soil, water and air
3. results in lower yields
4. is more favourable for genetic, species and habitat diversity
5. is economically as attractive as conventional farming.

10.2. Environmental and economic performance of organic farming

Environmental impact

Any form of agriculture means intervention and the alteration of processes occurring in (natural) eco-systems by a human being (van Mansvelt and Znaor 1999). Therefore such intervention always involves a certain disturbance of natural processes and the possible initiation of environmentally undesirable processes. Organic faming strives to operate under minimum environmental damage (Lampkin 1990; Znaor 1995; Scialabba El-Hage and Hattam 2002). This is not easy to achieve - certainly not under present macro-economic circumstances. However, there is ample evidence that organic farming can contribute to environmental protection and to the rational use of natural resources (Lampkin 1990; van Mansvelt and Mulder 1993; Pretty 1995; Alföldi, Lockeretz et al. 2000). Following the report by Stolze *et al.*(2000), Mäder (2004), made an updated comparison between the environmental performance of organic and conventional farming systems, making a review of some 400 studies. The subjective confidence interval of the final assessment showed that the environmental performance of organic farming systems is better than that of conventional farming in most aspects.

Yields somewhat lower or same

Data on yields obtained under ecological management show great variation in yields. Most studies report 20-40% lower average yields than those under conventional management (Lampkin 1990; Lampkin 1992; van Mansvelt and Mulder 1993; Lampkin 1999) (Goewie 2002). However, there are also studies showing far less significant differences. Among the most comprehensive seems to be the one from Stanhill (Stanhill 1990) who evaluated the results of 205 reports on yield comparisons of 26 different crops, milk and eggs. More than half of these reports showed higher yields on ecological farms. Thus the overall calculation showed that organic farms obtained only 9% less yields than conventional counterparts. In a 21-year study of the agronomic and ecological performance of biodynamic, organic, and conventional farming systems in Switzerland, the crop yields in biodynamic and organic systems were found to be 20 per cent lower than in conventional, although input of fertilizer and energy was reduced by 34 to 53 per cent and pesticide input by 97 per cent (Mäder, Fliessbach et al. 2002). A 22-year trial study by Cornell University in the USA proved that organic farming produces the same corn and soybean yields as conventional farms, but consumes less energy and utilizes no pesticides (Lang 2005).

... but not necessarily in less developed countries

The assumption is often made that the yield reductions associated with organic farming in western Europe will also apply in other parts of the world (Lampkin 1999). However, the evidence from the so called less developed countries indicate the contrary – organic yield levels are often very similar to those achieved in conventional systems (van Elzakker, Witte et al. 1992; Pretty 1998; Lampkin 1999; Znaor and Kieft 2000). Several authors suggest that in the so called less developed countries and Eastern Europe, organic yields can even be higher than conventional (Buys 1993; Busemann and Heusinger 1999; Lampkin 1999).

Stockless organic systems

Although organic farming systems are often perceived to require both livestock and crop production enterprises to form a viable agronomic and economic unit, there may be economic and other circumstances leading to stockless farming production (Philipps, Welsh et al. 1999). The stockless organic farming systems have proved to be capable of supporting soil fertility in several European regions (Philipps, Welsh et al. 1999; Schmidt, Philipps et al. 1999; Robson, Fowler et al. 2002; Sorensen and Thorup-Kristensen 2003; Mäder 2004). The yields obtained are comparable with those achieved by other organic farms and organic stockless systems seem to be economically viable (Bulson, Welsh et al. 1996; Philipps, Welsh et al. 1999; Huxham, Sparkes et al. 2005). Stockless organic farming is becoming increasingly important in Europe since the introduction of agri-environment measures (Huxham, Sparkes et al. 2005). In the mid nineties the proportion of stockless farms in Germany varied between 20 and 50 per cent (von Fragstein 1966) while France and the U.K also recorded a substantial portion of stockless farms (Stopes, Bulson et al. 1966; David, Fabre et al. 1996).

Profitability

Most available studies report similar or better economic performance than conventional farms, even without taking into account external costs of production (Böckenhoff, Hamm et al. 1986; LEI 1990; Lampkin 1992; Reganold, Palmer et al. 1993; van Mansvelt and Mulder 1993) (Onstad, 1999). This is mainly due to the lower production (especially input) costs and the premium price ecological products attract (on average a 20-50% higher price than conventional products).

Promising for less developed countries

Several authors suggest that organic farming is a promising solution for Central and Eastern Europe, both from the economic and environmental point of view (Buys 1993; Znaor 1994; Znaor 1997; Znaor 2002; Meeusen, Bont et al. 2004). Options and implications of converting to organic (and other more sustainable farming practices) in the so-called less developed countries have been considered and positively assessed in several studies (van Elzakker, Witte et al. 1992; Funes, García et al. 2002; Pretty, Ball et al. 2002; Pretty 2003; Pretty, Morison et al. 2003). Besides, studies about national food security and sufficiency show that, based on the WHO recommended daily nutrient intake, organic agriculture can well feed the populations of less developed countries (Van Mansvelt and Mulder, 1993).

Large-scale conversion

The studies on the widespread conversion to organic farming are scarce and suffer from serious problems regarding underlying assumptions, availability of data and the limited range of factors analysed (Lampkin 1999). The available studies on the consequences of large-scale conversion to organic farming suggest considerable environmental gains (Bechmann, Meier-Schaidnagel et al. 1993; Bechmann and Meier-Schaidnagel 1996; Halberg and Kristensen 1997; Hansen, Alroe et al. 2001; Bechmann and Meier-Schaidnagel 2004; Pretty, Ball et al. 2005). Pretty *et al.* (2005) compared the external costs of the current UK agricultural system with those that would arise if the whole country were farmed organically. Their results indicate that a 100 per cent shift to organic farming would generate only about 25 per cent of the current external costs of the UK agriculture.

10.3. Methodology

No data on low-input farming

The calculation of GVA of farming and FULS from large-sale conversion to organic farming is done using the same methodology as applied for the baseline scenario. The scenarios focus primarily on organic farming and not include low-external input farming. This is because contrary to organic farming, low-external input farming has no clearly defined system of standards. Besides, the data on low-input farming for Europe and Croatia are scarce and unsystematic. Currently only 4 per cent of Croatian agriculture receives less than 50 kg of fertiliser N (Table 29) and Croatia has no significant area under low external-input agriculture. A threshold of 50 kg N ha^{-1} is taken as the reference for low external-input farming in Eastern Europe (Kieft 1999; Wit, Posma et al. 1999). This "rigid" boundary is difficult to defend from the scientific point of view, as under different soil, climate, crop and livestock production systems and socio-economic circumstances may call for different limits. However, a threshold of 50 kg N ha^{-1} is considered to be a good environmental indicator, since nitrogen leaching at higher N application rates seems to follow a linear pattern (Sumelius, Grgić et al. 2003; Sumelius, Mesić et al. 2005).

Croatian experiences with organic farming

Questionnaires received from Croatian organic farmers indicate that the organic yield is approximately 30% lower than on conventional farms. However, there is a great variation both among the farms and produce and organic yields for some products are close to or even better than the conventional ones – see Table 43. However, the current yield levels have to be treated with caution, as most organic farmers have converted only recently. The situation with the Croatian farmers that have been practicing organic farming for more than 3 years is slightly different. These farms tend to achieve yields that are comparable or even higher than the average for the region.

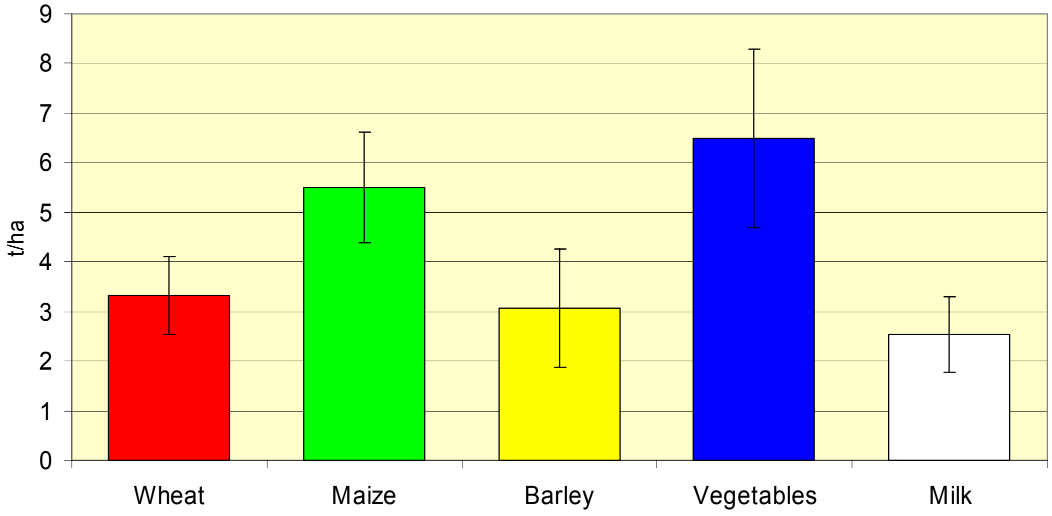


Table 43 Organic yield of selected commodities

Experiences from Slavonia and Baranja (main Croatian agricultural regions) show that application of appropriate organic plant protection measures gives good results in protecting organic crops against pest and diseases (Šamota and Brkić 2002), including the greenhouse production (Parađiković, Milaković et al. 2002).

Assumptions

In the comparison scenarios, the following assumptions have been made:

- The surface area of UAA remains the same as in the baseline scenario
- The crop and livestock mix remains the same as in the baseline scenario. This assumption, however, might be problematic. The current crop mixture (cropping pattern) in Croatia is certainly not in line with a number of organic farming principles (Figure 6). Organic farming is most likely to have a different cropping pattern. However, comparing a different cropping pattern than that of the baseline scenario would create an unjustified comparison. The same goes for the livestock mix. A greater share of more profitable crops or livestock for instance would immediately lead to a better result for the organic scenario. We have therefore in spite of these shortcomings decided to compare the organic potential of the current crop and livestock mix.
- The current share of nitrogen-fixing crops in Croatia is low. Organic farming is most likely to require a greater surface area under legumes and more livestock. However, the inclusion of more legumes and livestock would again create an unfair position for comparison.
- Crop and livestock subsidies remain the same per crop and livestock category as in the baseline scenario.

The scenarios involve the following areas under organic management: 10, 25, 50 and 100 per cent of UAA. For each of these, a simulation has been made for the hypothetical yield of 100, 75 and 50 per cent as compared with the baseline scenario. Except in the two scenarios of 10 and 25 per cent organic area, which include a 10 per cent premium price, organic products are assumed to obtain no premium price. This enables the same purchasing power and does not put an additional financial strain on Croatian consumers.

10.4. Results

100% area and 100% yield

Table 44 shows the GVA that would be generated through 100 per cent conversion, assuming the same yield levels as in the baseline scenario. This scenario achieves an output of 970.58 MEUR and has the intermediate consumption of 443.83 MEUR, resulting into a gross margin of 526.75 MEUR - an amount that is 164.89 MEUR better than the baseline scenario. Table 45 gives the gross margin that would be achieved if all Croatian livestock were raised organically, assuming however, the same yield level as in the baseline scenario. It suggests a gross margin of 539.44 MEUR, which is 237.85 MEUR better than the baseline situation. The GVA obtained through a 100 per cent organic crop and livestock production with the same yield level as the baseline scenario is presented in Table 46. The scenario results in an output of 2,271.13 MEUR, intermediate consumption of 1,204.94 and GVA of 796.25 MEUR. Finally, Table 47shows the consequence for the national economy of a 100 per cent conversion to organic farming with the same yield levels as in the baseline scenario. Farming and FULS generate a GVA of 915.81 MEUR, which is 276.85 MEUR more than in the baseline scenario. Since this sector implies a reduction in energy use and refraining from the use of nearly all agri-industrial inputs, it creates substantially less GVA in the FULS than the baseline scenario (119.56 MEUR vs. 245.46 MEUR). However, due to the added value created by farming (accounts for 86.94 per cent of the entire GVA of this scenario), this scenario still results in a 276.85 MEUR higher GVA than the baseline scenario. It also generates less external costs than the baseline scenario: 658.89 MEUR vs. 1,107.91 MEUR. Due to the lower emissions into the environment as compared with the baseline scenario, the damage to air, water and soil is 283.95 MEUR, which is about three times lower than the environmental damage caused by the baseline scenario (630.55 MEUR). A low N input of 100 per cent organic scenario results in a nitrogen balance 8 kg N ha^{-1}, leading to practically no leaching and damage to water. Since this scenario implies no use of fertilisers, its public investments in fertiliser manufacturing and railway transport are close to zero.

Table 44 Gross margins of Croatian organic crop production (same yields as baseline scenario)

Cronos	Product	Area (ha)	Yield ha^{-1} (t)	Yield ('000 t)	Price kg^{-1} (EUR)	Revenue from sale (MEUR)	Revenue from subsidies (MEUR)	Subsidy ha^{-1} (EUR)	Output (MEUR)	Output ha^{-1} (EUR)	IC (MEUR)	IC ha^{-1} (EUR)	GM (MEUR)	GM ha^{-1} (EUR)
01000	Cereals	566,517	-	2,487	-	287.85	77.5		365.3		211.9		153.39	-
01100	Wheat	182,635	3.74	683.1	0.13	88.80	34.7	190	123.5	676	48.4	265	75.12	411
01200	Rye	3,558	2.23	7.9	0.13	1.03	0.4	107	1.4	397	0.8	235	0.57	161
01300	Barley	48,022	2.97	142.6	0.11	15.69	5.8	120	21.4	447	11.3	235	10.15	211
01400	Oats	17,762	2.24	39.8	0.12	4.77	1.9	107	6.7	376	4.2	234	2.52	142
01500	Grain maize	312,240	5.15	1,608.0	0.11	176.88	34.6	111	211.5	677	146.8	470	64.70	207
01700	Others	2,300	2.24	5.2	0.13	0.67	0.2	84	0.9	375	0.5	234	0.33	142
02000	Industrial crops	123,116	-	1,122.1	-	89.25	43.3		132.5		57.3		75.23	-
02100	Oil seeds and oleaginous crops	89,348	-	191.9	-	40.75	24.2		65.0		29.9		35.08	-
02110	Rape seeds	13,299	1.99	26.5	0.22	5.82	4.4	331	10.2	769	5.5	413	4.73	355
02120	Sunflowers	25,741	2.17	55.9	0.21	11.54	8.2	318	19.7	767	10.5	407	9.27	360
02130	Soya	47,402	2.19	103.8	0.21	22.15	10.7	225	32.8	692	12.8	271	19.98	421
02190	Other oleaginous products	2,906	2.00	5.8	0.21	1.24	1.0	331	2.2	758	1.1	380	1.10	378
02200	Protein crops (incl. seeds)	3,063	1.20	3.7	0.90	3.31	0.7	223	4.0	1,303	1.1	370	2.86	933
02300	Raw tobacco	6,289	1.86	11.7	1.15	13.46	8.1	1,285	21.5	3,426	7.6	1,203	13.98	2,223
02400	Sugar beet	24,401	37.49	914.8	0.03	31.71	10.3	421	42.0	1,721	18.7	766	23.31	955
02900	Other industrial crops	15	1.60	0.0	0.50	0.01	0.0	0	0.0	800	0.0	380	0.01	420
03000	Forage plants	273,621	-	900.0	-	95.9	1.8		97.7		53.9		43.77	-
03100	Fodder maize	8,399	27.00	226.8	0.03	7.03	0.2	28	7.3	865	4.1	482	3.21	383
03200	Fodder root crops	2,000	33.00	66.0	0.03	2.29	0.1	28	2.3	1,172	1.3	650	1.04	522
03900	Other forage plants	263,222	-	607.3	-	86.57	1.5		88.1		48.6		39.51	
	Fodder peas and broadbeans	1,800	11.00	19.8	0.20	3.96	0.0	0	4.0	2,200	1.5	820	2.48	1,380
	Alfalfa	29,550	3.45	102.0	0.16	16.20	0.8	28	17.0	576	10.6	360	6.39	216
	Grass-clover	21,521	3.09	66.4	0.16	10.54	0.6	28	11.1	518	7.6	355	3.51	163
	Meadows	149,790	2.43	364.5	0.13	48.60	0.1	0	48.7	325	22.5	150	26.19	175
	Pastures	60,561	0.90	54.5	0.13	7.27	0.0	0	7.3	120	6.4	105	0.93	15

Gross margins of Croatian organic crop production (same yields as baseline scenario) (continued)

Cronos	Product	Area (ha)	Yield ha^{-1} (t)	Yield ('000 t)	Price kg^{-1} (EUR)	Revenue from sale (MEUR)	Revenue from subsidies (MEUR)	Subsidy ha^{-1} (EUR)	Output (MEUR)	Output ha^{-1} (EUR)	IC (MEUR)	IC ha^{-1} (EUR)	GM (MEUR)	GM ha^{-1} (EUR)
04000	Vegetables and hort. products	18,305		46.56	-	116.82	1.0		117.8		60.5		57.29	3,130
04110	Cauliflower	1,496	11.00	16.5	0.93	15.36	0.0	21	15.4	10,288	6.7	4,494	8.67	5,794
04120	Tomato	3,203	9.40	30.1	0.39	11.74	0.1	21	11.8	3,687	12.1	3,786	-0.32	-99
04190	Other fresh vegetables	11,477	-	0.0	-	40.41	0.6	-	41.0		18.5		22.50	
	Onions	2,202	7.29	16.1	0.41	6.64	0.0	21	6.7	3,034	3.6	1,649	3.05	1,385
	Cabbages	5,303	11.07	58.7	0.31	18.00	0.1	21	18.1	3,416	7.6	1,430	10.53	1,986
	Others	1,589	7.82	12.4	0.40	4.97	0.0	21	5.0	3,150	3.5	2,230	1.46	920
	Herbs	2,383	2.67	6.4	1.70	10.80	0.4	165	11.2	4,699	3.7	1,570	7.46	3,129
04210	Nursery plants	673	0.00	0.0	0.00	20.19	0.3	461	20.5	30,461	10.6	15,820	9.85	14,641
04220	Ornamental plants and flowers	1,456	0.00	0.0	0.00	29.12	0.0	0	29.1	20,000	12.5	8,610	16.58	11,390
05000	Potatoes	11,768	9.17	107.9	0.16	17.27	0.2	21	17.5	1,488	22.1	1,877	-4.57	-388
06000	Fruits	58,851	9.59	564	-	237.62	2.1	35	239.7	4,073	38.0	646	201.64	3,426
06100	Fresh fruits	27,320	-	289.1	-	105.22	0.2	-	105.4		21.5		83.98	
06110	Dessert apples	8,950	18.00	161.1	0.35	55.85	0.1	8	55.9	6,248	10.8	1,204	45.15	5,044
06120	Dessert pears	3,980	10.00	39.8	0.53	21.23	0.0	8	21.3	5,341	4.4	1,102	16.87	4,239
06130	Peaches	460	10.00	4.6	0.67	3.07	0.0	8	3.1	6,675	0.4	959	2.63	5,716
06190	Other fresh fruits	13,930	6.00	83.6	0.30	25.07	0.1	8	25.2	1,808	5.9	420	19.34	1,388
06200	Citrus fruits	843	20.00	16.9	0.60	10.12	0.0	8	10.1	12,008	1.3	1,490	8.87	10,518
06400	Grapes	27,688	9.00	249.2	0.47	116.29	1.5	55	117.8	4,255	14.9	538	102.90	3,717
06500	Olives	3,000	3.00	9.0	0.67	6.00	0.3	107	6.3	2,107	0.4	142	5.89	1,964
	Crops total	1,052,178	-	5,227	-	844.69	125.9	119.65	970.6	922	443.83	421.82	526.75	501

Table 45 Gross margins of organic livestock production (same yields as baseline scenario)

Cronps	Product	Unit	No. of units	Yield per unit (kg)	Total yield (t)	Price (EUR kg-1)	Revenue from sale (MEUR)	Subsidy per unit (EUR)	Revenue from subsidies (MEUR)	Output (MEUR)	Output per unit (EUR)	IC (MEUR)	IC per unit (EUR)	GM (MEUR)	GM per unit (EUR)
11000	Animals (meat)	head	11,478,862		483,869		809.45		28.95	838.40		503.14		335.26	
11100	Cattle	head	258,715	279.8	72,377	2.12	153.18	40.9	10.59	163.77	633	119.97	464	43.80	169
11200	Pigs	head	1,924,672	149.1	286,938	1.60	459.10	5.3	10.26	469.36	244	261.37	136	207.99	108
11300	Equinex	head	15,474	190.0	2,940	2.20	6.47	0.0	0.24	6.70	433	4.69	303	2.01	130
11400	Sheep and goats	head	822,319	19.3	15,832	3.00	47.50	9.3	7.68	55.17	67	33.39	41	21.79	26
11500	Poultry	head	7,994,683	13.0	103,931	1.33	138.57	0.0	0.19	138.76	17	83.14	10	55.62	7
11900	Other animals	head	463,000	4.0	1,852	2.50	4.63	0.0	0.00	4.63	10	0.58	1	4.05	9
12000	Animal products		9,207,079		618,645		398.91		63.25	462.15		258		204.18	
12100	Milk	head	339,214		614,260		269.23		61.49	330.72		204.54		126.19	
	Cow milk	head	229,931	2,632.0	605,178	0.25	252.77	260.3	59.84	312.61	1,360	199.15	866	113.46	493
	Sheep milk	head	98,632	64.0	6,312	0.73	9.96	8.4	0.82	10.78	109	4.42	45	6.36	64
	Goat milk	head	10,652	260.0	2,769	0.53	6.51	77.3	0.82	7.33	689	0.97	91	6.36	598
12200	Eggs *	bird	7,994,683	136.0	1,087	0.11	123.22	0.0	0.00	123.22	15	53.28	0.0	69.95	15
12910	Raw wool	head	768,182	1.6	1,229	0.20	0.25	0.0	0.00	0.25	0	0.00	0.0	0.25	0
12930	Honey	hives	105,000	19.7	2,068	3.00	6.20	16.7	1.76	7.96	76	0.16	1.5	7.80	74
13000	Animals total		20,685,941		1,102,514		1,208.35		92.20	1,300.55		761.11		539.44	

** The yield referes to millions of eggs*

Table 46 GVA of a 100 per cent organic scenario (same yields as baseline scenario)

	Value (MEUR)	Share %	Per capita (EUR yr^{-1})	Per ha UAA (EUR yr^{-1})
Crop sale	844.69	87.03	190.37	783.98
Crop subsidy	125.89	12.97	28.37	116.84
Crop output	970.58	100.00	218.75	900.82
Livestock sale	1,208.35	92.91	272.34	1,121.51
Livestock subsidy	92.20	7.09	20.78	85.57
Livestock output	1,300.55	100.00	293.12	1,207.08
Farming output	2,271.13	200.00	511.86	2,107.90
Crops intermediate consumption	443.83	36.83	100.03	411.93
Livestock intermediate consumption	761.11	63.17	171.54	706.41
Intermediate consumption farming	1,204.94	100.00	271.57	1,118.34
Gross margin crops	526.75	49.40	118.72	488.89
Gross margin livestock	539.44	50.60	121.58	500.67
Gross margin farming	1,066.19	100.00	240.30	989.56
Fixed costs farming	269.94	-	60.84	250.54
GVA farming	796.25	-	179.46	739.02

Table 47 GVA of farming and FULS in a 100% organic scenario (assuming same yields as in the baseline scenario)

NCEA code	NCEA subcode	Economic activity	No. of employees linked to HR agric. (FTE)	GVA from agri-linked HR market (MEUR)	% GDP	Damage to air (MEUR)	Damage to water (M EUR)	Damage to soil (M EUR)	Public investment (MEUR)	Real cost (FUTURO) (MEUR)	Net value-added (MEUR)
A		**Agriculture, hunting and forestry**									
A	01-04	Farming	174,455	796.25	3.547	274.53	0.00	41.31	279.12	594.95	201.30
		Subtotal	174,455	796.25	3.547	274.53	0.00	41.31	279.12	594.95	201.30
C		**Mining and quarrying**									
CA	11	Oil and gas extraction	33	1.08	0.005	0.70	0.00	0.00	0.00	0.70	0.38
		Subtotal	33	1.08	0.005	0.70	0.00	0.00	0.00	0.70	0.38
D		**Manufacturing**									
DA	15.71	Feedstuff production	328	4.19	0.019	0.01	0.00	0.00	0.00	0.01	4.19
DF	23.2	Manufacture of refined petroleum products	390	13.25	0.059	4.12	0.00	0.00	0.00	4.12	9.14
DG	24.15	Manufacture of fertilisers	0	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
DG	24.2	Manufacture of pesticides	0	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
DG	24.42	Manufacture of veterinary medicine	76	2.85	0.013	0.06	0.00	0.00	0.00	0.06	2.79
DK	29.3	Manufacture of agri. and forestry machinery	674	5.95	0.026	0.00	0.00	0.00	0.00	0.00	5.95
		Subtotal	1,468	26.2	0.117	4.18	0.00	0.00	0.00	4.18	22.07
E		**Electricity, gas and water supply**	111	3.31	0.015	2.34	0.00	0.00	0.00	2.34	0.97
		Subtotal	0	3.31	0.015	2.34	0.00	0.00	0.00	2.34	0.97
G		**Wholesale and retail trade; repair**	1,799	29.34	0.131	0.00	0.00	0.00	0.00	0.00	29.34
I		**Transport, storage and communication**									
I	60.1	Railway transport	168	1.00	0.004	0.00	0.00	0.00	3.63	3.63	-2.63
I	60.24	Road freight	107	1.66	0.007	1.92	0.00	0.00	0.00	1.92	-0.26
I	60.3	Pipeline transport	2	0.29	0.001	0.00	0.00	0.00	0.00	0.00	0.29
I	61.10.2	Marine freight	3	0.39	0.002	0.07	0.00	0.00	0.00	0.07	0.32
I	61.2	River freight	3	0.02	0.000	0.00	0.00	0.00	0.00	0.00	0.02
I	63.11	Transshipment of goods	47	0.44	0.002	0.00	0.00	0.00	0.31	0.31	0.12
		Subtotal	331	3.80	0.017	1.99	0.00	0.00	3.95	5.94	-2.14

GVA of farming and FULS of a 100% organic scenario (assuming same yields as in the baseline scenario) (continued)

NCEA code	NCEA subcode	Economic activity	No. of employees linked to HR agric. (FTE)	GVA from agri-linked HR market (MEUR)	% GDP	Damage to air (MEUR)	Damage to water (M EUR)	Damage to soil (M EUR)	Public investment (MEUR)	Real cost (FUTURO) (MEUR)	Net value-added (MEUR)
K		**Real estate, renting and business activities**									
K	73.10.2	Technical and techn. research and dvlp.	902	23.68	0.105	0.00	0.00	0.00	13.55	13.55	10.13
K	74.14	Business and mngm. advisory services	170	2.39	0.011	0.00	0.00	0.00	3.49	3.49	-1.10
K	74.30	Technical testing and analysis	33	0.46	0.002	0.00	0.00	0.00	0.68	0.68	-0.22
		Subtotal	1,105	26.54	0.118	0.00	0.00	0.00	17.72	17.72	8.82
L		**Public administration, defence and social security**									
L	75.11.1	Central government	342	5.18	0.023	0.00	0.00	0.00	8.58	8.58	-3.40
L	75.11.2	Regional governments (counties)	77	1.82	0.008	0.00	0.00	0.00	1.92	1.92	-0.10
L	75.11.5	Local governments (municipalities)	147	2.16	0.010	0.00	0.00	0.00	2.94	2.94	-0.78
		Subtotal	566	9.16	0.041	0.00	0.00	0.00	13.44	13.44	-4.28
M		**Education**									
M	80.3	Higher education	892	12.76	0.057	0.00	0.00	0.00	19.62	19.62	-6.86
		Subtotal	892	12.76	0.057	0.00	0.00	0.00	19.62	19.62	-6.86
N		**Health and social work**									
N	85.2	Veterinary services	442	7.33	0.033	0.00	0.00	0.00	0.00	0.00	7.33
		Subtotal	442	7.33	0.033	0.21	0.00	0.00	0.00	0.00	7.33
		Total	**181,090**	**915.81**	**4.079**	**283.95**	**0.00**	**41.31**	**333.84**	**658.89**	**256.93**
		Baseline	148,607	638.97	2.846	413.99	141.35	75.21	477.57	1,107.91	-468.94
		Scenario better	32,483	276.85	1.233	-130.04	-141.35	-33.90	-143.73	-449.02	725.87
		Farming %	96.34	86.94	86.94	96.68		100.00	83.61	90.30	
		Farming % of enviro externalities									97.10
		Farming % of total externalities									90.27

Scenario codes

The GVA generated through other scenarios are summarised in Table 48 and Figure 23. The scenarios are named after the share of organic farming and anticipated yields. The letter “A” stands for the area and the number following it indicates the per centage under organic surface. Similarly, the letter “Y” stands for yields and the adjacent number indicates the per centage of yields as compared with the baseline scenario. In the case of the 10 and 25 per cent scenarios with 75 per cent yield level as compared with the baseline scenario there is also the abbreviation P10, which stands for 10 per cent premium price for organic produce as compared with the baseline prices. The 10 per cent premium price has been applied only for these two scenarios, because it has been assumed that a share of organic farming of more than 25 per cent of the total UAA would lead to the same price levels between organic and conventional food. Besides, we assumed that only a portion of Croatian consumers would be willing and able to pay higher prices for organic produce.

100% organic area

As seen in Table 48 and Figure 23, the 100 per cent organic scenario achieving 100 per cent yields as compared to the baseline scenario (A100 Y100) generates the most GVA (915.81 MEUR) and scores best in terms of net value added - gross value added corrected for environmental damages and public investments (256.92 MEUR). The scenario involving a 100 per cent organic area, but yielding only 75 per cent of the baseline scenario (A100 Y75) resulting in a GVA of 528.70 MEUR generates less GVA than the baseline scenario. It results in a negative net value added (-132.55 MEUR), but is still better than the net value added of the baseline scenario. The 100 per cent organic area scenario achieving only a half of the baseline yields (A100 Y50) results in a GVA of 163.20 MEUR and a net value of -500.51 MEUR, which is about 31 MEUR higher than the baseline scenario.

50% organic area

The scenarios involving 50 per cent of organic area and 100 (A50 Y100), 75 (A50 Y75) and 50 (A50 YY 50) per cent yields as compared to the baseline scenario result in the GVA of 832.55 MEUR, 583.88 MEUR and 401.08 MEUR respectively. This suggests that the scenario with 50 per cent organic area would generate a higher GVA than the baseline situation only in the case that organic production can achieve the same yields as the baseline situation. The net value added in all three cases of the 50 per cent organic area scenarios is negative and depending on the yield level range from –50.84 MEUR, -300.74 MEUR to -484.73 MEUR. The latter results in a slightly higher negative net value added than the baseline scenario.

25% organic area

Similarly to the 50 per cent organic area scenarios, the organic scenarios covering 25 per cent area result in a higher GVA compared to the baseline situation only if organic farming achieved the baseline level of yields. However, the scenario assuming a 75 per cent yield of the baseline situation and attracting a premium price of 10 per cent (A50 Y75 P10) results in nearly the same GVA as the baseline situation. All 25 per cent organic area scenarios generate a negative net value added, although the scenario achieving 50 per cent lower yields is the only scenario leading to the net added value that is more negative than that of the baseline situation.

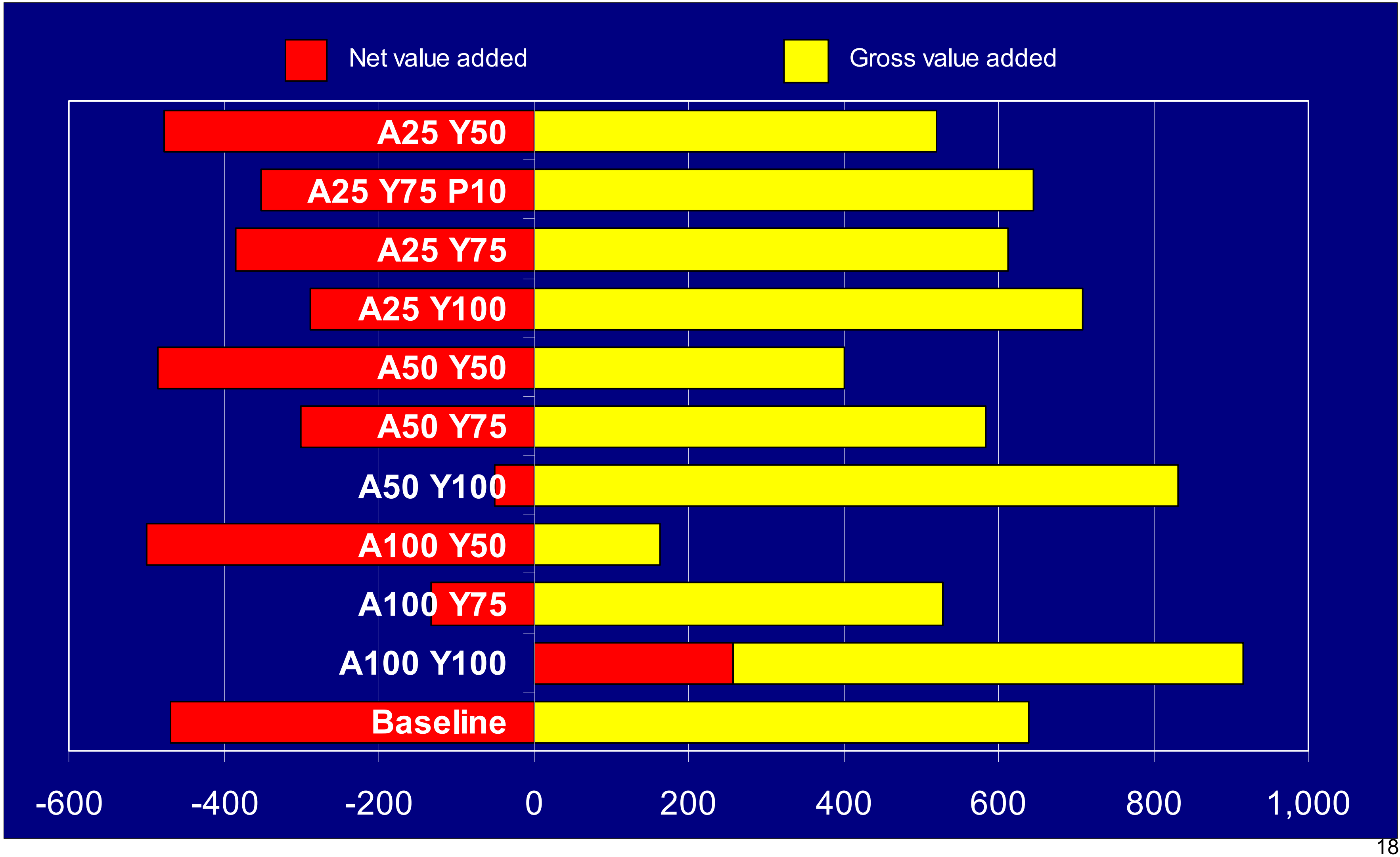
10% organic area

The organic scenarios occupying only 10 per cent of the UAA result in a fairly similar GVA and net added value as the baseline scenario. However, the scenario assuming the same yields level as the baseline situation (A10 Y100), is the only one that is better than the baseline situation both in terms of GVA and net added value. Similarly, the scenario with 50 per cent lower yields (A10 Y50) is the only scenario that leads to a lower result of both GVA and net added value as compared to the baseline scenario. It is interesting that the scenario including a 10 per cent premium price and 75 per cent yields (A10 Y75 P10) also results in worse results both in terms of GVA and net value added than the baseline scenario.

Table 48 Gross value added, external costs and net value added of different organic scenarios

Scenario name	Organic area (% of UAA)	Yield as compared to baseline (%)	Premium price (%)	**GVA (MEUR)**	Damage to air (MEUR)	Damage to water (MEUR)	Damage to soil (MEUR)	Public investment (MEUR)	Real cost (MEUR)	**Net value added (MEUR)**
Baseline	0	100	0	**638.97**	413.99	141.35	75.21	477.57	1,107.91	**-468.94**
A100 Y100	100	100	0	**915.81**	283.95	0.00	41.31	333.84	658.89	**256.92**
A100 Y75	100	75	0	**528.79**	283.88	2.51	41.31	333.84	661.34	**-132.55**
A100 Y50	100	50	0	**163.20**	283.05	5.72	41.31	333.84	663.71	**-500.51**
A50 Y100	50	100	0	**832.55**	348.97	70.68	58.26	405.71	883.40	**-50.84**
A50 Y75	50	75	0	**583.88**	348.94	71.93	58.26	405.71	884.62	**-300.74**
A50 Y50	50	50	0	**401.08**	348.52	73.53	58.26	405.71	885.81	**-484.73**
A25 Y100	25	100	0	**708.18**	381.48	106.01	66.74	441.64	995.65	**-287.47**
A25 Y75	25	75	0	**611.42**	381.46	106.64	66.73	441.64	996.26	**-384.84**
A25 Y75 P10	25	75	10	**645.09**	381.46	106.64	66.73	441.64	996.26	**-351.17**
A25 Y50	25	50	0	**520.02**	381.25	107.44	66.73	441.64	996.86	**-476.83**
A10 Y100	10	100	0	**666.65**	400.98	127.22	71.82	463.20	1,063.00	**-396.35**
A10 Y75	10	75	0	**627.95**	400.98	127.47	71.82	463.20	1,063.25	**-435.30**
A10 Y75 P10	10	75	10	**641.42**	400.98	127.47	71.82	463.20	1,063.25	**-421.83**
A10 Y50	10	50	0	**591.39**	400.89	127.79	71.82	463.20	1,063.49	**-472.10**

Figure 23 Gross and net value added through different organic scenarios (MEUR)



11. CONCLUSIONS

Negative net value added

The results of this study suggest that in the period 2001-2003 Croatian farming and FULS caused considerable damage to the environment (630.55 MEUR yr^{-1}) and consumed 477.57 MEUR yr^{-1} of public investment money. When the GVA generated by farming and FULS is corrected for the environmental damage and public investments, the real ("net") value added turns to be negative, about - 468.94 MEUR per year.

External costs not yet fully recognised

As elsewhere, the damage to the environment has not been internalised in the price of the Croatian agricultural commodities or farm inputs. Although it is difficult to assess and allocate them, these costs are real! They affect human health, damage materials (buildings, etc.) and ecosystems and raise public investments (e.g. cleaning of water and road conveyance systems from eroded soil). However, the current economic assessments do not take into account these costs, while any public investment strengthens the GDP by adding to the output side of the GDP equation. The adjustment of Croatian farming and FULS GVA for the environmental damage and public investments results in a negative added value. However, as long as the external costs are not recognised as an integral part of the GDP account, neither Croatia nor any other country will gear its policies towards more sustainable economics. The recent boom in international carbon emission trading marks a turning point in this respect. Both governments and businesses have begun to recognise and started paying for externalities. Due to the trans-boundary character of air pollution, only 41 per cent of all environmental damage caused by Croatian farming and FULS occurs in Croatia (260.54 MEUR out of 630.55 MEUR). The fact that the majority of external costs are imposed outside the country might make this concept even less attractive for the policy makers. However, this should not be the case as on the other hand the trans boundary pollution from other countries imposes costs in Croatia. The compulsory inclusion of environmental damages in the standard GDP calculation might lead to some kind of environmental debts of one country to another country. In the foreseeable future this might lead to economic swaps between the governments, similarly to the carbon credits trade of today.

Organic with lower yields: a Faustian bargain?

A 100 per cent conversion to organic farming in Croatia, provided this could ensure the same yields, would result in a higher annual gross and net value added than achieved on average in the period 2001-2003. However, if such conversion would imply a 25 per cent reduction in yields as compared to the 2001-2003 yields, it would result in a somewhat lower GVA, but still higher net value added. This would pose an interesting but very difficult dilemma for the policy makers. They would have to choose whether to trade the somewhat higher (12 per cent) GVA achieved in the baseline scenario for the substantially better (3.6 times) net value added from the 100 per cent organic scenario providing only 75 per cent of food (Table 48 and Figure 23).

Organic better for the environment

As it can be seen from Table 48, all scenarios involving an increase of area under organic farming decrease the current environmental damage. This is because organic farming has a better environmental performance than the baseline situation and provokes less environmental burden (emissions) in the FULS.

Organic farming lowers public investments

Organic scenarios require seem to result in lower public investments than the baseline scenario, mostly due to the omission of public investments related to fertiliser manufacturing and the railway freight of agricultural inputs. Besides, organic farming would provide more employment (see

Table 47).

A fair comparison is (in)possible?

A fair comparison between the baseline and organic scenarios is most probably the most critical methodological aspect of the calculations presented in this study. As already explained in the previous Chapter, it is nearly impossible to make a "fair" comparison between the present situation and large-scale organic scenarios. The concept and practice of organic farming differs fundamentally from those of conventional farming. Large-scale organic farming is most likely to lead to a quite different crop and livestock mix than that of the baseline scenario. It would require a greater area under legumes or grass-clover mixtures in order to provide enough nitrogen for crops and own animal feedstuff. A greater surface under grassland/legume crops would most probably lead towards an increase in the number of livestock. In the case of Croatia, this would not pose any (environmental) problem, since the current stocking rate is low anyhow (0.69 LU ha^{-1}). However, an increased number of animals in the organic scenarios would result in an increase of the agricultural physical output and inevitably favour the organic scenarios. But at the same time, it would also require substantial initial investments in livestock, stables and related machinery.

A similar dilemma exists for the premium prices. One could argue that organic produce is most likely to attain some higher prices than the conventional products, because these products are often associated with various environmental merits, better quality (taste, shelf-life) and a number of people believe that they are "healthier". However, in the case of a greater supply, the prices of organic products are most likely to level out with those of conventional farming, especially because of the limited purchasing power of Croatian consumers.

The yield level seems to be the main key determining the result of each scenario presented in this study. As already explained in the previous Chapter, in the case of countries with less developed agriculture, the organic yields are most likely not to substantially differ from the current yields. Moreover, as the organic farming management should go hand in hand with careful stewardship, organic yields might even increase. However, this assumption implies an improved management, which again creates injustice to the baseline situation, as an improved farm management would also lead to a better result of the baseline scenario.

Human and social capital

Conversion to large-scale organic farming requires high human and social capital. Organic farming is low-input from the point of view of the use of external farming inputs, but is high-input from the point of view of the knowledge and skills needed (Lampkin 1990; Lampkin 1992; Znaor 1994; Pretty and Ward 2001). In the case of Croatia and other countries where farmers (and some other stakeholders) have a relatively low level of general education and hardly any agricultural training, this point will certainly be of the main obstacle preventing a greater spread of organic-like farming systems (Znaor and Karoglan Todorović 2004).

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