UNIVERSITY OF MARIBOR, SLOVENIA
FACULTY OF AGRICULTURE AND LIFE SCIENCES
DEPARTMENT OF AGRICULTURAL ECONOMICS AND RURAL DEVELOPMENT

APPLICATION OF THE ANALYTIC HIERARCHY PROCESS FOR THE ASSESSMENT OF AGRI-ENVIRONMENTAL MEASURES OF THE RURAL DEVELOPMENT PROGRAMME

Ph. D. THESIS

UPORABA ANALITIČNEGA HIERARHIČNEGA PROCESA ZA OCENJEVANJE KMETIJSKO-OKOLJSKIH UKREPOV PROGRAMA ZA RAZVOJ PODEŽELJA

DOKTORSKA DISERTACIJA

Maribor, 2015 Monica Rudawiro HUEHNER

SUPERVISION

This dissertation was undertaken within the programme of the postgraduate studies in Agricultural Economics at the Faculty of Agriculture and Life Sciences of the University of Maribor, Slovenia.

The senate of the University of Maribor approved the topic of the dissertation at their regular meeting on 09.07.2013. Prof. Dr. Črtomir ROZMAN was appointed as the supervisor.

Members of the committee for the defense and rating of the dissertation are:

Chairman: Prof. Dr. Jernej TURK
Supervisor: Prof. Dr. Črtomir ROZMAN
Other member: Prof. Dr. Vjekoslav PAR

Proofread by: Mr. Steffen BIRKELBACH

Date of the defense: 11.06.2015

Monica Rudawiro Huehner

Confirmation

This is to confirm that I, Studienrat Steffen Birkelbach, certified teacher for English as a foreign language with a state examination degree from the Friedrich-Alexander-University Erlangen-Nuremberg, Germany, have read Mrs Monica Hühner's PhD thesis *Application of the Analytic Hierarchy Process for the assessment of agri-environmental measures of the Rural Development Programme* for the University of Maribor. I have performed the tasks of a copy editor for English with regards to style and grammar.

I do not posses any specific knowledge about the topic the thesis was written on and my work was purely language related.

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Rural Development Programmes (RDP) of the member states are an established component of the Common Agricultural Policy (CAP) of the European Union (EU). One of the objectives of the RDP is the "Improvement of the environment and the countryside", which includes agri-environmental measures (AEM), crucial activities towards the integration of the environmental aspect into the CAP. AEM encourage farmers to make an environmental commitment aiming at preserving the environment and maintaining the countryside, for which they are financially compensated (EC, 2005).

The objective of this dissertation was to assess the agri-environmental measures with the help of the Analytic Hierarchy Process (AHP) and its supporting software Expert Choice, showing at the same time how this most used multicriteria decision method (MCDM) can also be used for agricultural problems. For this dissertation, three criteria and their attributes were identified and arranged hierarchically. With the help of questionnaires, experts made pairwise comparisons of the elements and the judgement on the contribution of the measures towards achieving the sub-goals.

The intention of the assessment of agri-environmental measures was to get their precise ranking, which could be a basis for further discussions about which of the AEM are considered most effective and feasible.
The results show that organic and integrated agricultural production make the greatest contribution to establishing sustainable agriculture and secure income for the farmers. They also show that activities for landscape management, maintenance and conservation are possible ways of creating employment in rural areas.

Key words: rural development programme, agri-environmental measures, analytic hierarchy process, expert choice

This dissertation consists of: 195 pages, 63 tables, 43 figures and 176 References

PODATKI O OSREDNJI DOKUMENTACIJI

Uporaba analitičnega hierarhičnega procesa za ocenjevanje kmetijsko-okoljskih ukrepov Programa za razvoj podeželja

UDK: 338.43.02:631.1:711.3:005.311.6(043.3)=163.6

Programi za razvoj podeželja (PRP) držav članic so uveljavljena komponenta Skupne kmetijske politike (SKP) Evropske unije (EU). Eden izmed ciljev PRP je »izboljšanje okolja in podeželja«, ki vključuje tudi kmetijsko-okoljske ukrepe (KOU), ključne ukrepe za vključevanje okoljskih vidikov v SKP. KOU spodbuja kmete k sprejemanju okoljske zaveze za ohranjanje okolja in življenjskega prostora na podeželju, za kar so upravičeni do denarnih nadomestil (ES, 2005).

Cilj pričujoče doktorske disertacije je bila uporaba analitičnega hierarhičnega procesa (AHP) in spremljajoče programske opreme Expert Choice za ocenjevanje kmetijsko-okoljskih ukrepov, obenem pa smo želeli predstaviti, kako je to večkriterijsko metodo odločanja (VMO) mogoče uporabiti pri vprašanjih na področju kmetijstva. Za namene te disertacije smo prepoznali in hierarhično uredili tri kriterije in njihove atribute. Strokovnjaki so s pomočjo vprašalnikov izvedli parne primerjave pomebnosti elementov in pripravili mnenja o učinkovitosti teh ukrepov za doseganje vmesnih ciljev glede na izbrane kriterije.

Namen ocenjevanja kmetijsko-okoljskih ukrepov je bila njihova natančna razvrstitev, ki bi lahko predstavljala osnovo za nadaljnje razprave o tem, kateri kmetijsko-okoljski ukrepi so najbolj uporabni in izvedljivi.

Rezultati so pokazali, da ekološka in integrirana kmetijska pridelava zagotavljata največji prispevek pri vzpostavljanju sonaravnega kmetijstva. Prav tako kažejo, da so aktivnosti na področju upravljanja, vzdrževanja in ohranjanja krajine ena izmed možnosti za ustvarjanje delovnih mest na podeželju.

Ključne besede: program za razvoj podeželja, kmetijsko-okoljski ukrepi, analitični hierarhični proces, Expert Choice

Delo vključuje: 195 strani, 63 preglednic, 43 slik, 176 virov literature

DEDICATION

I dedicate this dissertation to my father, to my daughter Vimbai and my husband Gerald for his endless support and motivation.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

AEM	Agri-environmental Measures
AHP	Analytic Hierarchy Process
ANPS	Agricultural Non-Point Source
CAP	Common Agricultural Policy
CBA	Cost Benefit Analysis
CBD	Convention on Biological Diversity
CBNRM	Community-Based Natural Resource Management
CI	Consistency Index
CIALCA	Consortium for Improving Agriculture-based Livelihoods in Central Africa
CMS	Convention on Migratory Species
CR	Consistency Ratio
DEA	Data Envelopment Analysis
DG	Directorate General
DINA	Decision Support Systems in Agriculture
DMCE	Deliberate Multi-Criteria Evaluation
DSS	Decision Support System
DWD	Drinking Water Directive
EAFRD	European Agricultural Fund for Rural Development
EAP	Environmental Action Programmes
EC	European Commission
EEB	European Environmental Bureau
EEC	European Economic Community
ELC	European Landscape Convention
ELECTRE	ELimination Et Choix Traduisant la REalité; Elimination and Choice Expressing Reality
EQSD	Environmental Quality Standards Directive
EU	European Union
EUR	Euro

FAO	Food and Agricultural Organisation of the United Nations
FiBL	Forschungsinstitut für biologische Landwirtschaft
GAIA	Graphical Analysis for Interactive Assistance
GDP	Gross Domestic Product
GFM	Green Field Margins
GHG	Green House Gases
GIS	Geographic Information System
GP	Goal Programming
GR	Green Revolution
GVA	Gross Value Added
GWD	Groundwater Directive
ha	hectare
IFOAM	International Federation of Organic Agriculture Movements
IOBC	International Organisation for Biological and Integrated Control
IPM	Integrated Pest Management
LAG	Local Action Group
LDCs	Least Developed Countries
LEADER	Liaison Entre Actions de Développement de L'Économie Rurale (Links between the rural economy and development actions)
LFA	Less Favoured Areas
MAUT	Multi Attribute Utility Theory
MAVF	Multi Attribute Value Function
MCA	Multiple Criteria Analysis
MCDA	Multiple Criteria Decision Analysis
MCDM	Multiple Criteria Decision Making
NEPA	National Environmental Policy Act (USA)
NUTS	Nomenclature des Unités Territoriales Statistiques (Nomenclature of Statistical Territorial Units)
OECD	Organisation for Economic Co-operation and Development
PRB	Population Reference Bureau

PROMETHEE	Preference Ranking Organization Method for Enrichment of Evaluations
RDP	Rural Development Programme
SEA	Strategic Environmental Assessment
SMCE	Social Multi Criteria Evaluation
SMART	Simple Multi Attribute Rating Technique
SWOT	Strengths, Weaknesses, Opportunities, Threats
TEU	Treaty establishing the European Union
TFEU	Treaty on the Functioning of the European Union
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
TWW	Treated Waste Water
UAA	Utilised Agricultural Land
UK	United Kingdom of Great Britain and Northern Ireland
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nation Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
WFD	Water Framework Directive
WPRS	West Palaearctic Regional Section
WWD	Waste Water Directive

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX I

LIST OF APPENDIX II

LIST OF APPENDIX III

1. INTRODUCTION

Agri-environmental measures (AEM) are a set of compulsory courses of action the European Union (EU) compiled for its member states to take, in order to integrate the environmental aspect into the Common Agricultural Policy (CAP), a set of guidelines which each member state adopted after conforming them to their specific needs, conditions and economic capabilities. A regular assessment of AEM is of paramount importance for a constant record of the effectiveness of the measures during the programming period, especially because they are associated with a large financial expenditure. Regular assessment of AEM also helps to set new goals for a new programming period and make improvements where necessary. The question which can be raised at this point is: how best can we assess AEM which are very complex, with many participants involved and affected who have different interests? We are therefore interested in reliable results from which reliable conclusions can be drawn.

1.1 Goals and aims of the thesis

The intention of this dissertation is the use of Multicriteria Decision Analysis (MCDA) for the assessment of agri-environmental measures. The Analytic Hierarchy Process (AHP), one of the most used multi criteria decision methods (MCDM), will be used for the assessment. Right from its beginnings, AHP was used as a tool for analysis or evaluation, resource allocation and choice (see Saaty 1990; Saaty and Vargas 2001). Not only its applicability but also its reliability is of great value in agriculture. Compared to other scientific and industrial fields, AHP has not been used as often in agriculture. The Hierarchon, a dictionary of AHP hierarchies by Saaty and Forman (2003), does not show any hierarchy from the agricultural field.

Through the assessment a ranking of agri-environmental measures (AEM) will be achieved, which will show which of them can be considered most important. This information might be useful to determine their acceptance.

1.2 The Hypothesis

We assume that AHP will enable precise ranking of AEM.

1.3 Scientific relevance

Since its introduction in the 1970s, AHP serves as a valuable alternative method to support decision procedures instead of making decisions spontaneously, by intuition or gut feelings. A scientific method was developed which helps to analyse or evaluate complex problems and support decision procedures on a scientific basis. It was designed to support both individual and group decision processes. Through modelling unstructured problems, AHP makes them more comprehensive. The interactions or counteractions of the criteria and their attributes can easily be followed and understood. Thus AHP also has its relevance in agriculture.

1.4 Challenges and constraints

The biggest challenge in AHP is the formulation of the problem or main goal. A well formulated problem or goal will also deliver reliable and realistic solutions (Saaty, 1990).
The next biggest challenge, mostly at institutional or company level, is that AHP is not a one man method. The decision as to who should be included in the decision process is a big challenge. It is important to include all relevant beneficiaries (stake holders) who will authentically represent the problem. The expertise and opinion of many different beneficiaries and experts is necessary to have representative and realistic information. It takes a lot of effort and time to collect all this information since the experts and stake holders might not always be in the same place. Thus, data acquisition is a long procedure and its availability not always guaranteed. A thorough processing of the acquired data is necessary to bring it in a form conducive to AHP and make it usable in Expert Choice™ (EC), a software programme designed to execute AHP.

Significant constraints of AHP are therefore its time consuming nature and expensive supportive software. Group decision procedures are made difficult by the number of beneficiaries involved. The different opinions always need to be reconciled. Compromises

might have to be made without neglecting important or valuable stake holders. At the end of the decision procedure a consistent and for all stake holders representable decision result needs to be achieved.

2. LITERATURE REVIEW

Until the beginning of the 21st century, a greater part of the world population lived in rural areas. In 2002 Watson stated that 75% of the earth´s poor reside in rural areas. In 2005 53% of the world´s population was still residing in rural areas (Population Reference Bureau, United States of America). The Population Reference Bureau (PRB) then noted a further decrease of the rural population to 50% in 2010. The Revision of the United Nations (UN) in 2011 showed that 47, 9% were living in rural areas. The revision of the world urbanization prospects in 2014 by the UN shows that 46% of the global population live in rural areas. This reveals fast urbanization, mostly caused by rural to urban migration (Buhaug and Urdal 2013). The reasons for this migration vary from region to region, from country to country and from continent to continent. The fastest urbanization is occurring in the developing countries ”because of perceived opportunities in growing urban areas and lack of opportunities in rural settings due to degraded landscapes and imbalanced economic systems” (Grimm et al. 2008). In his journal publication in 1998, Puga mentioned the process of rapid urbanization taking place in the less developed countries (LDCs). According to Puga “the urban population in these countries increased from 17 to 37% between 1950 and 1990, and was expected to exceed 50% before 2010”. The result is “an alteration of land use” (Grimm et al. 2008) or “land conversion” as Azadi et al. (2010) call it, “and in developing countries, also a transfer of poverty from rural areas to the cities”. The poorest population still remains in the rural areas. The World Bank (2013) sees rural poverty as a widespread problem in many developing countries, making it a key component of any poverty reduction strategy. “For rural population, agriculture remains the main source of income and employment, yet it can no longer be considered as a backbone for rural economy” (Terluin 2003). To improve the situation of the rural population in the developing countries, rural development programmes were initiated with the help of the World Bank and International Monetary Fund, “to tackle problems such as poverty, illiteracy, inequality, hunger, diseases, unemployment” (Nwagboso and Duke 2012).

The developed countries are considered to be highly urbanized (Brown 2012), but this might be true only for some of them. The statistics of the 28 countries of the EU shows a very different picture (see point 2.1).

2.1 Rural Development Programme

According to Keating et al. (2011) "global food demand is estimated to increase between 50 and 80% between 2010 and 2050, with the range driven by variation in the key drivers such as population growth, per capita consumption trends, diversion to biofuels and food wastage rates". To be able to meet this high food demand the rural areas play a crucial role in all regions of the world.

Defining the term "rural" is not always easy as it touches many aspects of life: economic, social, health, geographic and demographic aspects and land use. The structure of rural areas is very heterogeneous and differs from continent to continent, country to country and region to region. The dictionary defines rural as "in or like the country; pastoral, agricultural" (Garmonsway and Simpson 1991). Many terms are used worldwide to describe rural areas: countryside, remote areas, non-urban, non-metropolitan. Different organisations, institutions and individuals define "rural" differently, usually to comply with their objectives. The Organisation for Cooperation and Economic Development (OECD) defines "rural" based on the population density, thus a community with less than 150 inhabitants per square kilometre is regarded as rural (OECD 2011). Establishing which regions are rural is achieved by collecting statistical data. This is important to determine which regions need administrative and financial assistance. "At European Union (EU) level there is no common definition for rural areas. Member states develop their own definition. This is often based on socio-economic criteria such as agricultural patterns, density of inhabitants per square kilometer or population decline" (Bakx et al. 2009). "The European Commission (EC) has constantly used the OECD definition of rural areas, e.g. in the Strategic guidelines for RDP 2007-2013" (EC 2009), which in most cases does not fully reflect the rural characteristics. There is a proposal that a multidimensional approach to define "rural" should take into consideration economic activities and geographic

dimensions along with population density and agriculture (Pizzoli and Gong 2000). As far back as the beginning of the 1970s a common Nomenclature of territorial units for statistics (NUTS) was launched, which enables them collection of common EU regional socio-economic statistics. It was put into law in 2003, came into force in the same year and was amended in 2007 (EC 2007) to take new member states into consideration. "The NUTS classification is hierarchical. It subdivides each Member State into NUTS level 1 (NUTS 1) territorial units, each of which is subdivided into NUTS level 2 (NUTS 2) territorial units, these in turn are subdivided into NUTS level 3 (NUTS 3) territorial units" with the following minimum and maximum population thresholds (EU 2011):

Table 1: Population thresholds for NUTS territories (Eurostat 2011)

Level	Minimum	Maximum
NUTS 1	3 million	7 million
NUTS 2	800 000	3 million
NUTS 3	150 000	800 000

Until 2010 the EU made use of the OECD methodology to subdivide the EU territory into NUTS regions. The subdivision had two phases:
"First, local units (e.g. municipalities) were identified as rural if their population density was below 150 inhabitants per square kilometre.
Secondly, regions (e.g. NUTS 3 or NUTS 2), were classified in one of the three categories (OECD 2009):

- Predominantly Rural region (PR): if more than 50% of the population of the region lives in rural communes (with less than 150 inhabitants per square kilometre)
- Intermediate Region (IR): if 15% to 50% of the population of the region lives in rural local units
- Predominantly Urban region (PU): if less than 15% of the population of the region lives in rural local units".

The new urban/rural classification developed by the EU´s Directorate General (DG) for Regional and Urban Policy in cooperation with the DG for Agriculture and Rural Development, Eurostat, the DG for Joint Research Centre and the OECD and introduced in 2010, uses NUTS 3 regions for rural classification, based on the "share of their population" (Eurostat 2013). For that purpose, the NUTS 3 regions are first divided into grid (raster) cells of 1 square kilometre. Two steps are then used to identify rural areas:

- Defining urban clusters as clusters of neighbouring "grid cells of 1 square kilometre with a density of more than 300 inhabitants per square kilometre and a minimum population of 5 000".

- Deducing from the definition of urban that "rural areas are all areas outside urban clusters".

The three categories into which NUTS 3 regions are classified according to the share of their population in rural areas are (Eurostat 2013):

- "Predominantly rural if the share of the population living in rural areas is higher than 50% of regional population

- Intermediate if the share of the population living in rural areas is between 20% and 50% of regional population

- Predominantly urban if the share of the population living in rural areas is below 20% of regional population"

To support the development of rural areas in its member states, the EU compiled a Rural Development Policy with proposals to promote sustainable development of the European rural areas, taking into consideration economic, social and environmental concerns. The Rural Development Policy for 2007-2013 focused on four main objectives:

- Improving the competitiveness of the agricultural and forestry sector

- Improving the environment and the rural areas

- Improving the quality of life and diversification of job opportunities in rural areas and

- Promoting the LEADER approach

The EU member states are obliged to implement the Rural Development Policy by designing Rural Development Programmes (RDP) based on the main objectives of the Rural Development Policy.

2.1.1 Improving the competitiveness of the agricultural and forestry sector

"Agriculture and forestry occupy 39% and 42% of the EU-28[1] territory, respectively" (Eurostat 2014). The production of food, raw materials for the renewable energy industry and timber for the building industry, among other activities[2], are therefore concentrated in rural areas. In 2010 at EU-28 level agriculture contributed 1.4% of the total gross value added (GVA)[3] and employed 12,2 Million persons (EC 2010). There is a significant variation in the role of agriculture in the economies of EU member states. In the EU-12[4] agriculture plays a greater role and makes a greater contribution to the gross domestic product than in the EU-15[5]. Within the EU-12 there is also a great difference in the role of agriculture and its contribution to the GVA, the biggest contribution being in Bulgaria (8%) and Romania (7%). Today there is a notable decrease in the overall contribution of agriculture to the EU economy. Nevertheless, it plays a major role in job creation and raising the standard of living in the rural areas of the EU.

While the technological development in agriculture and forestry is very advanced, change regarding human capital has come very slowly in the mostly family owned agricultural and forestry enterprises in the rural areas of the EU. One third of the agricultural population in the EU are small farmers who own 3% of the agricultural land (EC 2012). These small farmers have to be encouraged to continue with their farming activities, not only for self-

[1] EU-28 denotes the 28 member states of the European Union from July 2013
[2] Forestry, fishery and hunting are considered in statistics as agricultural activities.
[3] Gross Value Added (GVA) in this context is the value of output less consumption
[4] The 12 states which acceded to the EU in 2004 and 2007
[5] The 15 EU member states before 2004

sufficiency but also as a source of their livelihood. The average age of farmers in the EU is high. Table 1 shows the decreasing number of agricultural farm holders aged 35 and younger. The farm holders aged 65 and older are also decreasing in number (Table 2) but they still own the greater number of agricultural farms in all member states of the EU. Since the average age of farmers in the EU is high, there is need to encourage the younger generation to take over farms from their families or to take up farming as a source of their livelihood. Supporting the young farmers financially during their first years of agricultural activities gives them the possibility to invest in new and modern equipment, thus modernising the farms. Modernisation of all farms regardless of the age of the farm holders is therefore one of the priorities the first axis of the Rural Development Policy set, which aims at improving the competitiveness of agriculture and forestry.

The adoption of new and modern technologies also demands and requires farmers who are prepared to take up some training more than once in a year. It also requires a generation of farmers who are prepared to accept extension services and vocational guidance. Vocational education and training will help all farmers to get acquainted with new technologies, making it possible for these technologies to reach practise faster. Information measures will keep farmers and farm workers well informed about new achievements in agriculture. Competitive agricultural and forestry sectors are significantly coupled with the innovative and progressive young generation.

By building new and improving of the existing infrastructure, conditions are created which help to stabilise the agricultural production process. For reasonable management, agriculture and forestry require large amounts of land. Therefore in some cases reorganisation of rural land ownership is necessary. Increasing the added value[6] of agricultural and forestry products together with the processing industry is one of the major goals towards competitive agriculture and forestry.
Competitive agriculture and forestry seek to:

- Secure food production and guarantee self sufficiency

- Increase investment
- Create and secure jobs in the rural areas
- Increase the quality and quantity of agricultural and forestry products
- Take stringent consideration of the environment under which they take place, thus careful, regenerative and sustainable use of natural resources like soil and water.
- Stop declining of biological diversity (hereafter biodiversity) by safeguarding a powerful ecosystem

The preservation of genetic resources is a major goal. This can be achieved by the rearing of traditional indigenous domestic animal breeds and the cultivation of traditional indigenous plant varieties. Efficient breeding programmes using this natural genetic diversity lead to increased yields by "increasing disease resistance, harvest index, growth rate, tolerance to heat, cold and waterlogging" (Andrew 2010).
Competitiveness of agriculture and forestry does not only play a role on the local, national or EU level, but also has to take into consideration today´s globalised agricultural markets. On the other hand, consumers demand for healthy agriculture worldwide has increased. Agriculture today therefore aims at producing safe and healthy agricultural products.

Together with agriculture, forestry plays a role in the mitigation of climate change. By removing carbon from the atmosphere and binding it in the biomass, trees help to counter the high levels of carbon in the atmosphere. All activities that support planting trees or enhance tree growth are therefore very welcome. This effect, however, is short lived because as soon as the trees are old enough to be utilized, they are then harvested. They release a substantial amount of the bound carbon back to the atmosphere.

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[6] Increasing the added value = a productive activity transforms a present product into a product with a higher monetary value (Begg et al. 1984 cited by Wood 1996)

Forests produce a large part of the biomass which is the main source of bioenergy, part of the renewable energy generation. Proper management of forests and making them competitive is therefore crucial to meeting the high demand of biomass.

Table 2: Agricultural holders < 35 years old (1000 persons); Source: Eurostat

country\time	**1990**	**1993**	**1995**	**1997**	**2000**	**2003**	**2005**	**2007**
EU (27 countries)	:	:	:	:	:	1260,24	956,29	822,67
Belgium	9,83	9,13	10,88	9,14	6,64	4,42	3,39	2,59
Bulgaria	:	:	:	:	:	33,71	21,97	15,05
Czech Republic	:	:	:	:	:	4,04	3,97	3,59
Denmark	8,78	6,93	6,56	6,5	5,44	4,02	3,68	2,6
Germany	101,43	103,42	98,16	85,89	72,53	49,33	35,42	28,28
Estonia	:	:	:	:	:	3,44	1,84	1,22
Ireland	22,45	23,53	20,89	17,71	18,38	15,1	10,79	8,88
Greece	73,77	58,87	49,03	44,36	71,25	60,43	56,8	60,42
Spain	113,27	88,44	76,59	69,29	110,82	67,72	53,51	44,26
France	:	:	:	:	:	54,37	42,43	33,84
Croatia	:	:	:	:	:	:	:	:
Italy	137,59	132,96	110,21	119,45	110,6	76,13	56,49	49,07
Cyprus	:	:	:	:	:	2,91	1,45	0,98
Latvia	:	:	:	:	14,63	10,86	9,85	7,76
Lithuania	:	:	:	:	:	19,17	13,19	9,74
Luxembourg	0,45	0,38	0,36	0,3	0,29	0,2	0,16	0,12
Hungary	:	:	:	:	87,68	44,53	54,68	46,85
Malta	:	:	:	:	:	0,65	0,57	0,46
Netherlands	11,29	11,8	10,31	7,35	6,46	5,78	4,09	2,83
Austria	:	:	39,71	34,76	30,87	21,86	18,27	15,66
Poland	:	:	:	:	:	353,43	313,35	293,75
Portugal	39,66	22,81	18,52	15,05	17,02	9,41	6,86	5,17
Romania	:	:	:	:	:	391,54	218,37	166,87
Slovenia	:	:	:	:	4,49	2,98	3,42	2,99
Slovakia	:	:	:	:	3,65	3,82	2,76	2,39
Finland	:	:	16,12	13,09	8,67	7,32	6,46	6,12
Sweden	:	:	7,45	6,42	5,27	3,83	3,9	3,73
United Kingdom	16,81	15,45	13,65	13,45	11,66	9,32	8,63	7,46
Norway	:	:	:	:	9,62	6,03	4,59	3,7

: not available

Table 3: Agricultural holders > = 65 years old (1000 persons) Source: Eurostat

country\time	**1990**	**1993**	**1995**	**1997**	**2000**	**2003**	**2005**	**2007**
EU (27 countries)	:	:	:	:	:	4639,15	4722,98	4584,02
Belgium	17,24	15,72	11,82	12,07	11,74	10,54	10,12	9,39
Bulgaria	:	:	:	:	:	270,17	222,19	221,89
Czech Republic	:	:	:	:	:	7,86	7,03	6,76
Denmark	16,31	15,93	15,65	13,17	11,31	7,83	9,47	8,87
Germany	47,02	42,24	41,84	40,55	25,68	24,22	28,11	27,33
Estonia	:	:	:	:	:	10,2	7,99	7,28
Ireland	38,65	32,31	32,5	32,31	28,04	26,81	31,61	31,87
Greece	215,74	240,79	248,5	281,06	253,46	292,63	306,73	321,15
Spain	383,9	364,07	371,35	368,36	347,42	366,25	359,37	361,35
France	:	:	:	:	:	84,92	75,11	65,8
Croatia	:	:	:	:	:	:	:	:
Italy	850,95	850,58	912,29	827,65	825,95	788,4	734,95	740,54
Cyprus	:	:	:	:	:	9,26	12,18	11,69
Latvia	:	:	:	:	36,32	34,46	36,93	31,69
Lithuania	:	:	:	:	:	102,28	80,66	93,46
Luxembourg	0,66	0,64	0,61	0,57	0,52	0,42	0,41	0,36
Hungary	:	:	:	:	268,98	229,47	194,75	171,84
Malta	:	:	:	:	:	2,52	2,59	2,79
Netherlands	18,69	19,11	19	20,2	18,22	13,53	13,29	13,27
Austria	:	:	20,94	20,93	20,26	14,56	18,7	17,8
Poland	:	:	:	:	:	320,01	421,95	387,9
Portugal	170,86	161,48	156,99	154,97	154,6	163,85	150,13	129,62
Romania	:	:	:	:	:	1719,35	1848,97	1761,76
Slovenia	:	:	:	:	27,71	26,2	26,22	26,29
Slovakia	:	:	:	:	19,43	18,93	20,04	22,02
Finland	:	:	7,07	5,41	4,59	4,82	4,39	4,16
Sweden	:	:	18,04	17,69	15,92	11,6	14,85	14,67
United Kingdom	50,05	51,34	55,19	49,87	56,23	77,46	84,24	92,47
Norway	:	:	:	:	6,23	4,46	4,12	3,87

: not available

Since farmers are the first link in the food production chain but are usually less well organised, help from the EU in financial, consulting and training form is very crucial for them to benefit from the food production chain, get organised, negotiate fair prices for their products and to get onto the right marketing channels. A CAP reform was therefore proposed to simplify administrative and payment procedures (EC 2012).

2.1.2 Improving the environment and the rural areas

Until the beginning of the 1980s agricultural production was based on the paradigm of the green revolution. New plant and animal breeds were developed during the course of the green revolution, which demanded excessive use of synthetic mineral fertilisers and pesticides, irrigation and intensive tillage, without which they could not reach their yield potential. The new animal breeds demanded concentrated feed; grass, silage and hay were no longer sufficient. Irrigation led to enormous depletion of ground water and water from terrestrial water bodies and waterways. Agricultural machines came with the industrial revolution. Intensive agricultural production was normal. Intensive agricultural production also meant high yields were achieved on less area than with extensive or traditional production. Keating et al. (2011) noted that "in many parts of the world, production increases were achieved by intensification of agricultural practices, in particular by combining inorganic fertiliser and agro-chemical inputs with intensive tillage and improved varieties". Keating et al. (2011) also point out that "the longer term sustainability of such intensive systems remains a concern, but there is little doubt that without the higher yields now being achieved in much of the developing world, the numbers of undernourished would be much higher than the current levels". For decades, The green revolution was welcome and a remedy at the time of its introduction because of previous years of severe food shortages, especially after the end of the Second World War. Agricultural production processes had to be resumed in such a way that adequate and affordable food be brought onto the market. This meant that large amounts of food had to be produced. Intensive rearing of domestic animals was the usual practice. This led to the deterioration of environmental conditions. The pollution of soils and ground water was the result; what followed was the dwindling away of biodiversity (Tamis and van den Brink

1999). Today the agricultural production process has become very fragile. The green revolution has served its time. Today´s agriculture needs a new standard which takes into consideration the global changes in climate, markets and eating habits and it needs to focus on a sustainable management of natural resources. The emphasis and focus in today's agricultural policies therefore has to be on sustainable agricultural production, which can be practised and maintained when three main features are fulfilled (Liu et al. 2007, Perpar 2007):

- Social acceptability
- Environmental reliability and
- Economic feasibility

Hatfield et al. (2007) also stressed that "there is a growing interest in agricultural systems that serve multiple purposes, in the context of driving factors such as climate change, liberalization, environmental concerns, and changing agricultural institutions".

Sustainable agricultural production is strongly linked to the environmental aspect. Many countries or regions in the world have therefore adopted environmental programmes to slowly suit the changing agricultural production methods and to counter climate change. A couple of years ago environmental protection was a fashion; today it has become a strong and indispensable philosophy affecting many aspects of life.

At its introduction in 1962, the Common Agricultural Policy (CAP) of the EU aimed at letting "people have good food at affordable prices and to make it possible for farmers to earn a fair living" (EC 2012). In the five decades of its existence, CAP has been modified, transformed, reformed and amended to suite the changing conditions. From 1992 on CAP has strived to promote and support sustainable agriculture in EU member states, with a strong focus on environmental friendly production methods. With its reform in 1992, CAP gave farmers the responsibility for managing the countryside and its biodiversity. Within the scope of the CAP and to be able to successfully integrate the environmental aspect, agri-environmental measures (hereafter AEM) were compiled as part of the Rural Development Programme (RDP), aiming at improving the environment and the rural areas.

AEM are now compulsory for all EU member states. The European commission set up a framework with priorities to be included, but each EU member state designs its own RDP especially compiled to suit their circumstances and special conditions.

Petersen (2003) from the European Environment Agency gathered information on the countries preparing to access the European Union using questionnaires and information from the responsible national ministries. He used this data for his exposition with the main focus on agri-environmental programmes of the candidate countries. AEM enabled payments to farmers who voluntarily took up environmental commitment for at least five years. In these five years they committed themselves to use environment friendly production methods (RDP 2007-2013). The emphasis is on the right balance between competitive agricultural production and the respect of nature and the environment (Toth 2005). Furthermore, awareness of sustainable production with a focus on regenerative use of the available natural resources has to be roused (van Ittersum et al. 2008). AEM also ensure agricultural production that suits the needs of consumers and protects their health.
For the reasons mentioned in 1.1.2, forests also need maintenance to rebuild their potential. Investing in reforestation or afforestation of non-agricultural land pays off in the course of time. Therefore the main goal should be to preserve a substantial amount of forest holdings. Through these measures the standard of living in the countryside is expected to be improved.

2.1.3 Improving the quality of life and diversification of job opportunities in rural areas

The NUTS classification according to the OECD method reveals that in 2008, about 23% of the population in the EU member states lived in predominantly rural areas which cover 57% of the territory (EC 2011). The new typology method for EU regions from 2010 has corrected these figures to 22 % of the rural population living on 51% of the EU territory. Though they do not make a great contribution to the Gross Domestic Product (GDP), farming and forestry remain the main methods of land use and resource management in rural areas of the EU. Agricultural production and forestry are not just a matter of food production and production of raw materials for the pulp industry and renewable energy

sector. They are also about the communities in the rural areas and the people who live there. Predominantly rural regions generated 17% of the GVA and provide 22% of employment in EU-27[7] in 2008 (EC 2011), in 2010 they generated 16% of GVA and provided 21% of employment (EC 2013).

Although agriculture and forestry are the main activities for resource use and management in the rural areas of the EU, they can no longer be considered as the economic backbone (EC 2010). There are many reasons for this development:

- Demographic. Abandonment of farms and forestry holdings because of age is increasing.
- Rural depopulation. Many young and well qualified people leave the rural areas, looking for better prospects in the conurbations and big cities
- Perception. There is a change of perception on how to manage rural resources. Rural is no longer strictly seen only as agricultural land use.

There are significant differences in the economic role of agriculture, however, among the member states. An average of 5,3% of the total employment in the EU-27 in 2011 was in the primary agricultural sector (agriculture, forestry, hunting and fishing), ranging from 1,3% in the United Kingdom to 32,6% in Romania (Table 4).

The EU is therefore encouraging diversification of job opportunities in the rural areas towards non-agricultural activities to secure the source of income and livelihoods for the rural population. Rural areas are seen nowadays as recreational places, places where the population working in big towns and conurbations seek rest and recovery from a hectic everyday life. Rural areas are also rich in cultural and natural heritage which if preserved, could be attractive for tourists, so promotion of tourism is one of the activities the rural residents could take up. Preservation of natural heritage includes the protection of nature and landscape including their development as well as the protection of stagnant and

[7] 27 member states of the European Union before the accession of Croatia on 1July 2013.

flowing water. Preservation of cultural heritage can be carried out by designing and maintaining museums of local history with documentation on village life in the past and present. Restoration and conservation of historical sites of the village also help to strengthen its identity.

Besides jobs, bearable rural life presupposes basic service facilities for both rural population and businesses. For the rural population, comfortable surroundings also play a big role for their wellbeing, thus village renewal and development, a place they spend most of their lives, is a precondition. This also serves to preserve the appearance of the village and landscape.

Table 4: Agricultural statistics of EU member states (Eurostat 2012)

	Utilized agricultural area (1000 ha)	Number of holdings (1000 holdings)	UAA per holding (ha)	Employment in the agricultural, forestry, hunting and fishing sector	
				Number (1000 persons)	Employed working population (%)
	2011	2010	2010	2011	2011
Belgium	1 358	42	32,3	64	1,4
Bulgaria	4 476	357	12,5	677	19,9
Czech Republic	3 484	23	151,5	152	3,0
Denmark	2 647	41	64,6	73	2,6
Germany	16 704	298	56,1	658	1,6
Estonia	941	19	49,5	26	4.4
Ireland	4 991	140	35,7	83	4,6
Greece	3 478	717	4,9	513	11,6
Spain	23 753	967	24,6	755	4,1
France	27 837	507	54,9	753	2.8
Italy	12 856	1 616	8,0	965	3,9
Cyprus	118	38	3,1	18	4,6
Latvia	1 796	83	21,6	75	8,8
Lithuania	2 743	200	13,7	116	8,5
Luxemburg	131	2	65,5	Na	na
Hungary	4 686	534	8,8	291	7,2
Malta	11	12	0,9	5	2,8
Netherlands	1 872	71	26,4	226	2,6
Austria	2 878	149	19,3	202	4,9
Poland	14 447	1 499	9,6	2 036	12,7
Portugal	3 668	304	12,1	520	10,7
Romania	13 306	3 724	3,6	2 962	32,6
Slovenia	483	74	6,5	79	8,4
Slovakia	1 896	24	79,0	71	3,2
Finland	2 291	63	36,4	114	4,6
Sweden	3 066	70	43,8	92	2,0
United Kingdom	15 686	183	85,7	408	1,3
EU-27	**171 603**	**11 757**	**14,6**	**11 935**	**5,3**
Croatia	1 326	177	na	186	13,0

2.1.4 The LEADER approach

LEADER, a French shortcut for “Liaison Entre Actions de Développement de L'Économie Rurale” which means "links between the rural economy and development actions", is a bottom-up approach linking activities of rural development. It is complementary to all the measures of the rural development programme and takes place at the local level. LEADER addresses all stakeholders in the rural areas who are prepared to take part in the development of their surroundings. The seven characteristics of LEADER make it a powerful tool for rural development (EC 2006):

- Area based local development strategies take into consideration a small area whose population has common traditions, interests, expectations etc. This ensures that the stakeholders involved participate out of interest for their small community.

- Bottom-up elaboration and implementation of strategies aims at having all rural stakeholders who are interested (residents at large, social and economic interest groups, farmers, local administration) take part in the decision making processes concerning their local entity.

- Local public-private partnerships, local action groups (LAG) have “the task of identifying and implementing local development strategies, making decisions about the allocation of its financial resources and managing them”.

- Integrated and multi-sectoral activities in local development strategies are common. The consultation and involvement of all local actors is crucial for LEADER. Thus all activities carried out should be well coordinated for them to be consistent with each other.

- Innovation in the rural areas might not find its breakthrough since the rural areas usually lack contact to research and development institutions. LEADER, with the help of LAG, could be of great help in supporting and facilitating innovative ideas in the rural areas. Innovation in rural areas should be seen from a broader point of view. It could mean modernisation of a farm, introduction of a new product or

taking up an idea which was practised elsewhere, as long as it is useful for the local community.

- Networking is a means of exchanging experiences, achievements and technical know-how among rural areas, LAG, organisations and administrations involved in rural development in the EU. Adoption of know-how from other regions where it has proved to be useful is possible. Vertical and horizontal networking helps in achieving the goal of bringing development to rural areas. Networking links people, projects and rural areas which can take some rural areas out of their isolation.

- Cooperation "goes further than networking. It involves a local action group undertaking a joint project with another LEADER group, or with a group taking a similar approach in another region, member state or even a third country. Cooperation projects are not just simple exchanges of experience. They must involve a concrete joint project, ideally managed under a common structure."

The new scheme for the rural development programme for 2014-2020 has retained the general approach; "it has been improved through the process of wider CAP reform" recorded in a number of legislative documents (EC 2013). The three main guiding principles as elaborated in 2.1.1-2.1.4 still stay the same. The member states or regions will continue to draw up their annual concepts according to the needs of their rural areas but with the help of the main proposals from the EU. These measures will also still be co-funded by the EU and national budget. "However, measures will no longer be classified at EU level into axes with associated minimum spending requirements per axis" (EC 2013). Instead, it will be up to member states or their regions to make thorough analysis before deciding which measures they use and how they use them in order to achieve targets set against six expansive objectives (EC 2013):

- Encouraging transfer of knowledge and new ideas in agriculture, forestry and rural areas.

- Boosting farm activity and competitiveness of all types of agriculture in all regions and promoting innovative farm technologies and sustainable management of forests.
- Supporting food chain organisation (including processing and marketing of agricultural products), animal welfare and risk management in agriculture.
- Restoring, preserving and improving ecosystems related to agriculture and forestry.
- "Promoting resource efficiency and supporting the shift towards a low carbon and climate resilient economy in agriculture, food and forestry sectors.
- Promoting social inclusion, poverty reduction and economic development in rural areas".

2.2 Environmental programmes and their assessment

2.2.1 Environmental programmes

Industrialisation, urbanisation, economic growth and environmental pollution go hand in hand. “Following industrialisation, the income per head and the population in the world increased. The standard of living became better. The success of this development was based on the quantity-oriented, factor-intensive and fossil fuel-driven growth model” (Seung-soo 2012), a model which did not take ecological consequences into consideration. Industrialisation brought about urbanisation, the increase in population in the conurbations in turn led to environmental pollution. Doyle (2010) states that “until relatively recently few have explored the link between urban and environmental history, and, in particular, the impact of air pollution on the health of the population has been largely ignored. Nor have they addressed the responses of the local stakeholders — politicians, businessmen, officials and labour leaders — to the issue of environmental degradation”. The quest for growth with failure to take ecological consequences into consideration, has led to today´s climate

change which is causing natural disasters. With the start of the green revolution in the 1960s another big ecological disaster began. Just as with the industrial revolution, no thoughts were given to the consequences of the intensive agricultural production methods, so no concepts were put in place with regard to the protection of the soil, water and air.

The green revolution (GR), was defined by Bezner Kerr (2012) citing Conway 1997 and Perkins 1997, as "the particular historical events, social and political conditions, and technical changes, which led to the development and large-scale adoption of high-yielding maize, rice and wheat varieties, largely focused in Mexico, India and the Philippines", and by Schuh (1970) as "the development of new, improved varieties whose primary characteristic is that they have a greater response to the application of fertilizer". Cleaver (1972), defined the green revolution as "the rapid growth in the third world grain output associated with the introduction of a new package of tropical agricultural inputs which consists essentially of a combination of improved grain varieties, mainly rice and wheat, heavy fertilizer usage and carefully controlled irrigation". The GR soon spread to all regions of the world except Africa (Jama and Pizarro 2008). It also did not remain limited to rice, wheat and maize. The measures of the green revolution aimed at creating food security by increasing agricultural production, thus reducing hunger and undernourishment. The high yielding varieties did not only demand irrigation and an increased use of mineral fertilizers, but also the use of pesticides. Since the GR started at the beginning of the 1960s, soil and ground water quality have been threatened by pollution. Today great effort diverted to the agricultural sector to reduce or even stop this trend.

Environmental quality was brought into focus at government level in the early 1970s after it had become clear that the production process, be it agricultural or industrial, is strongly correlated to the environment in which it is taking place. The need for regulations towards respectful, careful treatment and sustainable use of natural resources increased. The National Environmental Policy Act (NEPA) signed on January 1, 1970, in the United States of America by President Nixon (Mills and Peterson 1975) gave an impulse to "take consideration of and discuss openly about environmental impacts of public policies" prior

to their implementation. NEPA however did not have any executive mandate, but just made recommendations (Hill 1975). Environmental awareness was not only limited to the USA but spread all around the world. The reasons which triggered this awareness were different in each region or country. In 1972 Haarhoff observed that "Japanese school children have been knocked down by smog and some have been crippled for life by mercury poisoning, despite antipollution legislation dating as far back as 1955. Ancient Italian monument decay under sulphur attacks. The Rhine is filled with industrial waste." These alarming conditions led to an increasing number of "environmentalists in Japan and Europe pressing to clean up the fouled air, water and land. Many governments responded with new laws." The German government for example, responded with "a comprehensive environmental programme." France, Italy and Great Britain followed suit. These alarming environmental conditions worldwide also led to Sweden´s initiative to set a stage for international discussion on the "world´s pollution problems and discuss them intensively", as done in Stockholm in June 1972 at the UN Conference on Human Environment (Harrhoff 1972, Engfeldt 1973). The conference was dominated by the problem of "reconciling environmental quality with economic development" (Berry 1972). At the beginning of the 1980s, what had started as a protest movement against nuclear power and to draw attention to the devastating environmental conditions became a political programme. The green party in Germany, the first of its type, emerged in 1980. By 1984 "green movements were flourishing in nearly every country in Western Europe, as well as in Japan, Canada and Australia." (Spretnak 1984) Today the green party in Germany focuses on combining ecological with economic and social sustainability (Buendnis 90/Die Gruenen 2002). It was just a matter of time before the guiding principle in many sectors of life was the environmental aspect. 1990, Hayes noted that "increasingly, environmental issues influence politics, law, education, religion, investments and lifestyle". Environmental issues also strongly influence agriculture, the producing industry, processing industry, construction industry, energy industry, civil engineering, the health sector and many others. Many consumers today buy their foodstuff, clothes, shoes, household goods or cosmetics with the environmental aspect in mind.

The enhanced global effort to draw attention to deteriorating environmental conditions which started in Stockholm in 1972 saw many conventions and other conferences following. The Convention on Migratory Species (CMS) signed in Bonn, Germany, in 1979 "aims to conserve terrestrial, aquatic and avian migratory species throughout their range" (www.cms.int). The Vienna Convention for the Protection of the Ozone Layer came into force in 1988 and was universally ratified in 2009. The Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal was made into law in 1992 (www.basel.int). In the same year the United Nations Conference on Environment and Development in Rio de Janeiro, better known as the Earth Summit, was called "partly to harmonize the many disparate paths of environmental protection that countries have pursued during the two decades since the UN Conference on the Human Environment held in Stockholm" (Haas et al. 1992). "Countries joined an international treaty in 1992, the United Nations Framework Convention on Climate Change (UNFCCC), to cooperatively consider what they could do to limit average global temperature increases and the resulting climate change, and to cope with whatever impacts were, by then, inevitable" (www.unfccc.int). "Desertification, along with climate change and the loss of biodiversity were identified as the greatest challenges to sustainable development during the 1992 Rio Earth Summit Established in 1994, the United Nations Convention to Combat Desertification (UNCCD) is the sole legally binding international agreement linking environment and development to sustainable land management" (www.unccd.int). The convention "addresses specifically the arid, semi-arid and dry sub-humid areas known as the drylands, where some of the most vulnerable ecosystems and peoples can be found" (www.unccd.int). The Convention on Biological Diversity (CBD) which came into force in 1993 was "inspired by the world community's growing commitment to sustainable development" (www.cbd.int). "International concern about climatic change and the realization that emission reductions provisions in the UNFCCC were inadequate, led to the Kyoto Protocol in 1997 which contains legally binding emission targets for industrialized countries" (www.unfccc.int; Böhringer 2003). The "industrialized nations committed themselves to reducing their emissions of greenhouse gases (GHG) by roughly 5% on average, compared with their 1990 emission levels" (Böhringer and Vogt 2003). Following the Kyoto protocol was the World Summit on Sustainable Development convening in

Johannesburg, South Africa, in 2002. The Stockholm Convention on Persistent Organic Pollutants came into force in 2004 "to protect human health and environment from persistent organic pollutants" (chm.pops.int). In the same year the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade also came into force (www.pic.int). Not to forget the Regional Seas Programme whose aim is "to address the accelerating degradation of the world's oceans and coastal areas through the unsustainable management and use of the marine and coastal environment, by engaging neighbouring countries in comprehensive and specific actions to protect their shared marine environment" (unep.org). All these environmental conventions and conferences mentioned above are under the patronage of the United Nations Environmental Programme (UNEP).

Internally, environmental protection has a long tradition in the EU. "Starting in 1967 with the directive[8] for harmonised classification and the labelling of dangerous chemicals, environmental protection objectives and principles were finally given their own chapter in 1987, in the Treaty establishing the European Union (TEU). Today, the vast majority of national environmental policies and laws have their origins in EU law" (European Environmental Bureau (EEB) 2005). "Environmental policy has been a growing area of EU competence through the development of six environmental action programmes (EAP) and a range of policy initiatives accompanying them" (Lightfoot and Burchell 2005, EEB 2005). In the Treaty on the Functioning of the European Union (TFEU), the objectives of the EU environmental policy are clearly stated in paragraph 191(1):

- preserving, protecting and improving the quality of the environment,
- protecting human health,
- prudent and rational utilisation of natural resources,
- promoting measures at international level to deal with regional or worldwide environmental problems, and in particular combating climate change.(EC 2008)

[8] Directive 67/548/EEC

The enforcement of "Europe's environmental policy started in 1973, following the 1972 UN Conference on Environment, addressing the public and scientific concerns about the ´limits of growth´" (EEB 2005). With the first EAP between 1973 and 1976, objectives were defined which had to "result in an improvement in the quality of life as well as in standards of living. Particular attention was to be given to intangible values and to protecting the environment so that progress may really be put at the service of mankind. The importance of a Community environmental policy was emphasized" (EC 1973). This led to a policy which aimed to:

- "prevent, reduce and as far as possible eliminate pollution and nuisances,
- maintain a satisfactory ecological balance and ensure the protection of the biosphere,
- ensure the sound management of and avoid any exploitation of resources or of nature which cause significant damage to the ecological balance,
- guide development in accordance with quality requirements, especially by improving working conditions and the settings of life,
- ensure that more account is taken of environmental aspects in town planning and land use,
- seek common solutions to environment problems with States outside the Community, particularly in international organizations"(EC 1973).

The first EAP "proposed a gradual approach to defining environmental quality objectives, based on the protection of single environmental media (water, air, soil etc.)" (EEB 2005).

The second EAP (1977-1981) continued with the implementation of the objectives of the first EAP, "nature protection received special attention" (EEB 2005). It was made clear that combating pollution of sea and fresh water is of great importance (EC 1997). The second EAP also drew attention to the atmospheric pollution occurring "most acutely in the large industrial complexes and conurbations" (EC 1997). Another task set in the second

EAP was “defining and implementing a community anti-noise policy” (EC 1997). “Non-damaging use and rational management of land” as strived for by the Commission involves “policies and guidelines designed on one hand to emphasize the good effects of agriculture and forestry on environment and on the other to reduce its adverse ones“ (EC 1977).

By the third EAP in the period 1982-1986 it was clear that the common environmental policy has to therefore aim “not only to protect human health, nature and the environment, but also to ensure that natural resources are well managed, in particular by introducing qualitative considerations into the planning and organization of economic and social development. Environmental protection measures therefore support and complement economic development” (EC 1983). The main focus of the third EAP was on the development of an overall environmental strategy, prevention and reduction of pollution and nuisances in the different environments, the protection and rational management of land, environment and natural resources and action at an international level.

In the fourth EAP (1987-1992), “for the first time environmental protection was not perceived as an additive, but rather as an integrated activity within the whole production process. Part of the integrated approach was to reduce energy or material inputs and to close cycles, so that waste streams could be minimised. Furthermore, pollution control was to systematically control all environmental media (water, air and soil) and involve an evaluation of the problem causing substances” (EEB 2005). By this time the continuing and increasing deterioration of the environment had convinced the Community that “putting into place of stringent standards of environmental protection was urgently required” (EC 1987). Another “conclusion of importance for environmental policy is the recognition by the European Council in March 1985 that environmental protection policy can contribute to improved economic growth and job creation” (EC 1987).

The fifth EAP (1993-2000) introduced a new strategy for environment and development, with an approach which had not been used for the first four action programmes (EC 1993) with:

- *"*focus on agents and activities which deplete natural resources and damage the environment without waiting for problems to emerge,
- endeavour to initiate changes in current trends and practices which are detrimental to the environment,
- the aim to achieve such changes in society´s patterns of behaviour through the optimum involvement of all sectors of the society in a spirit of shared responsibility and
- responsibility being shared through a significant broadening of the range of instruments to be applied at the same time to the resolution of particular issues or problems.*"*

Thus, the following fields of action were given priority, with the outlook of achieving tangible improvements or changes during the set period (EC 1993):

- "Sustainable management of natural resources: soil, water, natural areas, coastal areas.
- Integrated pollution control and prevention of waste.
- Reduction in the consumption of non-renewable energy.
- Improved mobility management including more efficient and environmentally rational location decisions and transport modes.
- Coherent packages of measures to achieve improvements in environmental quality in urban areas.
- Improvement of public health and safety, with special emphasis on industrial risk assessment and management."

The programme targets five sectors: industry, energy, agriculture, transport and tourism.

The sixth EAP from 2002 to 2012 promoted "full integration of environmental protection requirements into all community policies and actions and provides the environmental

component of the Community's strategy for sustainable development. The link is made between environment and European objectives for growth, competitiveness and employment" (EC 2002; www.eubusiness.com). It aimed at:

- *"*emphasising climate change as an outstanding challenge and contributing to the long term objective of stabilising greenhouse gas concentrations in the atmosphere
- protecting, conserving, restoring and developing the functioning of natural systems, natural habitats, wild flora and fauna with the aim of halting desertification and the loss of biodiversity, including diversity of genetic resources, both in the European Union and on a global scale
- contributing to a high level of quality of life and social wellbeing for citizens by providing an environment where the level of pollution does not give rise to harmful effects on human health and the environment and by encouraging a sustainable urban development
- better resource efficiency and resource and waste management to bring about more sustainable production and consumption patterns*"*

The global role of the EU in the environmental field is written in its Treaty on European Union article 21(2):

"The Union shall define and pursue common policies and actions, and shall work for a high degree of cooperation in all fields of international relations, in order to:

(d) foster the sustainable economic, social and environmental development of developing countries, with the primary aim of eradicating poverty;

(f) help develop international measures to preserve and improve the quality of the environment and the sustainable management of global natural resources, in order to ensure sustainable development" (EU 2010).

The research on the role of environmental attitudes towards the participation in the next generation of agriculture conservation programmes was already going on in the United States of America in 1999 (Luzar and Diagne). Ho and his colleagues (2001) point out the importance of the Environmental Technology Centre of the Murdoch University in

Australia with training and research programmes on renewable energy in the context of environmentally sound technologies. Zbinden and Lee (2005) state that since 1997, Costa Rica's Payments for Environmental Services Program has provided payments to more than 4,400 farmers and forest owners for reforestation, forest conservation, and sustainable forest management activities. The idea of a Danube river basin environmental programme was born in Sofia in 1991, the programme was started in 1992 as described by Nachtnebel (2000). Nachtnebel points out that the Danube river basin environmental programme provides for joint actions of the ten Danubian countries to assist integrated environmental management in the basin. Environmental programmes are not only limited to agriculture but are also found in the industrial sector. In their article published in 2010, Blackman and his colleagues analysed the impact of voluntary environmental regulation in Mexico, which aims to reduce industrial pollution. Abaza (1995) argued that the structural adjustment programmes of the World Bank in the 1990s, packages of economic reforms specifically designed to enhance the recovery of economies in crises, were urged to address environmental issues. Abaza elaborates further that efficient management of natural resources is essential for sustainable development and poverty alleviation.

2.2.2 Multicriteria decision methods and environmental programmes

Environmental programmes are mostly accompanied by their assessment or evaluation to find out whether the objectives have been fulfilled. They are also accompanied by decision processes to determine which measures should be continued, supplemented or whether new ones should be introduced. These processes are very complex. For such complex decision making procedures the traditional mathematical programming, especially linear programming, is therefore not adequate for modelling them (Romero and Rehman 2003). Also, just determining strengths, weaknesses, opportunities and threats (SWOT) does not analyse the problem being assessed thoroughly enough. The relations and interactions of the criteria are not determined. For decision making and assessment procedures, Multi Criteria Analysis (MCA) methods, sometimes termed Multi Criteria Decision Methods (MCDM) or Multi Criteria Decision Analysis (MCDA) are very useful. Multi criteria

analysis (MCA) is an umbrella term for a number of decision making techniques. As the name implies, MCA makes it possible to tackle "problems" with many different criteria, which in some cases might even be conflicting (Garcia-Cascales and Lamata 2011; Obradovic et al. 2012). According to the Department for Communities and Local Government in London, the role of MCDA is "to deal with the difficulties that human decision-makers have been shown to have in handling large amounts of complex information in a consistent way (Crown 2009)". Among the many which exist nowadays, two groups of the most widely used methods, outranking methods and methods based on multi-attribute utility theory (MAUT), are distinguished. The most commonly used outranking methods include ELECTRE (ELimination Et Choix Traduisant la REalité; Elimination and Choice Expressing Reality) and PROMETHEE (Preference Ranking Organization Method for Enrichment of Evaluations) introduced by Bernard Roy at the end of the 1960s (de Boer et al. 1998, Özerol and Karasakal 2007); since 1989 PROMETHEE has a descriptive counterpart GAIA (Graphical Analysis for Interactive Assistance). Methods based on multi-attribute utility theory (MAUT) are the simple multi-attribute rating technique (SMART) and the analytic hierarchy process (AHP). Balancing and ranking as well as cost benefit analysis (CBA) are also classified as MCDM but not widely used. Today, whether outranking or MAUT based, all the mentioned methods no longer only follow their initial objective as tools for making a choice from many given options; they have either been refined to cope with assessment and evaluation or they have been used for these procedures in their original state. MCDM have undergone further development to also cope with group decision procedures and they also now have software to support their implementation. Their use in environmental sciences is common, especially for risk assessment.

Pineda-Henson et al. (2002) found analytical hierarchical process (AHP) useful as a tool for evaluating environmental performance of pulp and paper manufacturing which they used in combination with the Life Cycle Assessment. Girard and De Toro (2007) proposed integration of AHP with geographic information system (GIS) for the strategies definition of planning choices for sustainable development of cultural and environmental heritage in San Marco dei Cavoti, Italy. Strassert and Prato (2001) showed how to use the balancing

and ranking method for selecting farming systems. Gómez-Limón et.al (2004) also made use of MAUT to analyse input usage in agriculture and the way it affects the environment. Madlener et al. (2006) compare ELECTRE TRI with Data Enveloping Analysis (DEA) for assessing the performance of biogas plants. They conclude that "MCDA constitutes an insightful approach, to be used alternatively or in a complementary way to DEA, namely in situations requiring a meaningful expression of managerial preferences regarding the relative importance of evaluation aspects to be considered in performance assessment". In 2005, Rossi et al. conducted a case study on multi-criteria assessment of drought mitigation measures in Italy. The results they got "confirm the applicability of the proposed multi-criteria methodology for a transparent comparison of drought mitigation measures to be adopted as a support for the decision making process". Solomon and Hughey (2007) proposed an MCA decision support tool for international environmental policy issues and showed its use on the example of emissions control in the international aviation sector. In Crete Tsoutsos et.al (2009) showed how sustainable energy planning can be done by MCA. The analysis of air pollution (2010) and soil pollution (2011) in an urban area in Serbia was done by Nikolić et.al using PROMETHEE/GAIA. In Mauritania Bayod Rújula and Dia (2010) used MCA to select the most suitable energy source and water desalination system. For improving strategic environmental assessment (SEA) of water programmes in Brazil, AHP was used by Garfì et al. (2011), with the conclusion that "AHP makes a valid contribution to the SEA procedure in human development projects". In Malaysia Al-Hadu et al. (2011) showed how useful MCA is for environmental management. Payraudeau and Gregoire (2012) modelled pesticides transfer to surface water with MCA. Herva and Roca (2013) reviewed MCA for corporate environmental evaluation and came to the conclusion "that multi-criteria analysis would benefit from the previous application of standardized methodologies to derive criteria. Hence, the most relevant environmental burdens and their severity would be identified and characterized in a previous step, helping to reduce the complexity of the decision-making problem and the possibility of duplicating effects. The scientific basis would be enhanced, making the selection of criteria and establishment of weights less arbitrary". PROMETHEE was relevant for Linkov et al. (2006) "as a tool for testing stakeholder responses to and improving expert assessment of innovative contaminated sediments technologies". Šauer et

al. (2012) "developed a novel methodology for ex-post environmental policy implementation assessment which applies multicriteria analysis as its main methodological tool". Roca et al. (2008) opted for social multicriteria evaluation (SMCE) for assessing the multidimensionality of coastal erosion risks.

2.3 Multicriteria decision methods in agriculture

Like in environmental sciences, selection, assessment, evaluation and analysis are also constant companions of agriculture. MDCM (see point 2.2.2) are likewise useful tools in the agricultural field.

Hellstrand (2006) found MCA useful to survey the sustainability effects of increasing concentrate intensity in Swedish milk production. His conclusion, "In a scientific context, adoption of the consultancy experience to the procedure of Integrated Assessment and Multi-criteria analysis improves the quality of the analysis. Multi-criteria impact matrix and multi–criteria representation provide a form to present results from analysis of complex issues that helps the communication with stakeholders". Cook and Proctor (2007) recommend the application of deliberative multicriteria evaluation (DMCE) for assessing the threat from exotic plant pests, a method which is not yet sound for use and therefore "application of the DMCE technique in a biosecurity resource-allocation context warrants further investigation". Taking into consideration public health risks, Al-Juaidi et al. (2010) give an insight on how weighted goal programming can be used for the analysis of treated waste water (TWW) use for agriculture in water deficit regions. According to the authors, "multi-criteria decision analysis using weighted goal programming can be successfully implemented in scenarios where single objectives have competing and conflicting results. One distinct advantage of this method is the ability to include a decision-maker preference in the analysis to develop a single composite objective function". Azmi et al. (2011) decided to use AHP, ELECTRE and TOPSIS for assessment of agricultural development feasibility at national level. AHP has since been very attractive and useful for water management engineers. Wolfslehner et al. (2012) conducted an exploratory multi-criteria analysis in sustainability impact assessment of forest-wood chains. In 1996 Pillai and Rasu

used this method for ranking irrigation management alternatives in an Indian region in order to increase the effectiveness of the irrigation system, which was underutilized.

Tiwari et al. (1999) used AHP to develop a framework for environmental-economic decision making that includes the environmental and economic sustainability criteria, and local people's preferences in the context of a lowland irrigated agriculture system in Thailand. The method was also relevant for Ni and Li (2003), who used it for the assessment of soil erosion in terms of land use structure changes. Thi Xuan My Tran et al. (2003) used AHP to prioritise future renewals of irrigation and drainage assets in the La Khe irrigation scheme in North Vietnam; Srdjevic and Medeiros (2004) also demonstrated the use of AHP for the assessment of water management plans. Braunschweig and Becker (2004) showed how AHP could be used in international agriculture to choose research priorities. Pažek et al. (2006) used AHP for the evaluation of business alternatives on organic farms. Wenna Liu et al. (2007) assessed how sustainable a high yield agro ecosystem in Huantai County, China was. Combining the Analytic Hierarchy Process with Social Choice (SC) Methods was of interest for Srdjevic (2007), to support group decision making in water management. He found "the second methodology (called AHP+SC) more promising for implementation in real-decision situations in water management". A panel of experts in Australia (Oliver et al. 2007) made use of AHP to assess attributes for natural variability benchmarks for biodiversity, a typical group decision situation. In Iran Rezaei-Moghaddam and E. Karami (2008) used AHP for the evaluation of sustainable agricultural development models. Ziolkowska (2008a) used AHP in combination with Cost-Effectiveness Analysis for the evaluation of the AEM and analysis of the economic aspects to support the decision making process of the Polish government. In the same year Ziolkowska (2008b) also combined AHP and Linear Programming to estimate the importance of AEM with respect to the environmental objectives and to calculate an objective orientated budget allocation for AEM. Ziolkowska (2009) also used the Analytic Hierarchy Process to investigate and evaluate the importance of AEM from the regional perspective in Poland. Mortazavi et al. (2009) showed how AHP can successfully be used for prioritizing agricultural research projects. Vindis et al. (2009) also used AHP to perform a further evaluation of simulation model results on energy crops for biogas

production. The case study in Iran (Keshavarzi et al. 2010) for the evaluation of land suitability shows an example of how AHP is also used as a complementary instrument. For the assessment of the regional aquatic ecological security in China (Hong et al. 2010), AHP was again used as a complementary tool. In this case it was vital to use AHP "to decompose the complicated issue into some related hierarchies for comparison". The comparison of AHP and Ideal Point methods for evaluating land suitability in Libya (Elaalem et al. 2011) showed that "while the Fuzzy AHP and Ideal Point approaches accommodate the continuous nature of many soil properties and produce more intuitive distributions of land suitability values, the Fuzzy AHP approach was found to be better than Fuzzy Ideal Point". In combination with the geographic information system and cellular automata models, AHP was taken into use for land suitability simulation for irrigated agriculture in China (Yu et al. 2011), whereas Yi and Wang (2013) made use of AHP in its classic form to assess land suitability on a watershed of Loess Plateau. To determine which agricultural productions are most important and to assess their contribution to economic development in an Iranian region, Shahroudi (2011) used AHP. For supporting community forestry management in Nepal, Khadka and Vacic (2012) chose AHP which they "used to examine the importance of six criteria and forty-four indicators in a sustainable forest management context with a broad range of stakeholder groups". Not only in management but also in practical contexts of forestry, AHP fulfilled its reliability when Melemez et al. (2013) used it to compare and choose an optimal concept of a forestry trailer to carry logs, for secondary transportation and agricultural activities. Prioritization of protection became necessary in a 50 km coastal segment in northwest Taiwan because of lack of funds. For this purpose Chang et al. (2012) proposed "the use of AHP together with technique for order preference by similarity to ideal solution (TOPSIS)", which they conclude "provides a good tool for coastal management and planning". Together with response surface modelling, AHP was applied to optimize cane traction output from a hopper in full-automatic sugarcane planters in Iran (Taghinezhad et al. 2013), for selecting the best operating condition in sugarcane billet metering device. "Taiwan's agricultural management is in need of a second innovation revolution to increase its competitiveness", so Huang and Chien (2013) set off to analyse the patterns and factors of farming innovation with the help of AHP aiming to:

- group different samples into four major innovation styles
- analyse the originality process and the success factors and
- build innovation models for future strategic use.

3. METHODOLOGY

On the basis of literature studied, the AHP and its supporting software Expert Choice was found to be suitable for the assessment of agri-environmental measures. In agriculture, decision making procedures are complex, mostly consisting not only of a single criterion but multiple criteria as in the implementation of the AEM. Thus many criteria determine or influence the optimum decision.

Decision making procedures might become even more challenging if the parameters involved are a mixture of quantifiable and non-quantifiable or tangible and non-tangible ones. AHP is able to tackle this mixture. AHP also copes with both rational and intuitive decision making procedures. Thus, it integrates subjective and personal preferences in performing analyses. It can be used "to measure the relative impact of numerous influencing factors on the possible outcomes and, in so doing, forecast outcomes. These forecasts are then used when evaluating the alternative courses of action" (Forman and Selly 2002). Besides forecasting outcomes, AHP can also be used to choose a course from a number of alternatives and for assessment purposes. As a further advantage of MCA, some comprehensible system is brought into the decision procedure by splitting a complex "problem" into its less complex sub problems which are easier to analyse (Saaty 1990, Saaty and Vargas 2001, Meixner and Hass 2002, Rozman and Pažek 2005). By structuring the "problem" into a hierarchy, the interaction of parameters becomes easier to determine. Saaty and Vargas (2001) state that "today, the combination of efficient computer technology with human rationality increases the efficiency of decision makers without limiting their creativity".

3.1 The scope of AHP

The basic principles of AHP are decomposition, comparative judgements and hierarchical composition (Forman and Selly 2002). The following steps were therefore developed for AHP and fully described by Saaty (1990), Meixner and Haas (2002 and 2010):

Step 1: It is very crucial to identify and formulate the main goal, sub-goals (attributes), criteria, people involved and/or affected and their objectives and the means of reaching the goal.

Step 2: The models in AHP are built by decomposing the complex main goal into smaller less complex sub-goals, factors which affect the sub-goals, people who influence the factors, then the people´s objectives and policies, followed by strategies and ending with the outcome of the strategies (Saaty 1990, Rozman et al. 2009). This leads to a hierarchical structure (Figure 1) with the main goal, criteria, attributes and alternatives (Saaty and Vargas 2001; Rozman et al. 2009). The specific measures to fulfil the defined objectives and finally reach the main goal are at the bottom of the hierarchy.

Step 3: To determine the relations in the hierarchy, pairwise comparisons of the parameters or elements at each level of the hierarchy are carried out with respect to the element immediately above them. Through pair-wise comparison of the elements at each level of the hierarchy, weights are determined which help to show the correlations within the structure (Saaty and Vargas 2001). AHP allows comparisons using actual measurements (quantitative judgement) or a scale created by Saaty (Table 5) which expresses the degree of preference, importance or likelihood (qualitative judgement) (Saaty 1990; Pažek et al. 2006).

Table 5: Saaty´s scale of comparative judgement (Saaty 1990)

Saaty's scale	The relative importance of the two sub-elements
1	Equally important
3	Weakly important
5	Strongly important
7	Very strongly important
9	Extremely/absolutely important
2*;* 4*;* 6*;* 8	Intermediate values

For the last level at the bottom of the hierarchy with the alternatives, a scale is set or real values are entered into the Formulas grid which helps to determine the degree of contribution of the alternatives to the attributes and criteria towards achieving the main goal. In the data grid the level of alternative contribution is specified.

Step 4: Control of consistency in the pairwise comparisons is an indispensable step in AHP. After the pairwise comparison of the objects in a hierarchy, a consistency test has to be carried out (Cheng et al. 2002; Bodin and Gass 2003). With the help of the calculated Consistency Index, the pairwise comparison is tested for its firmness (Forman and Selly 2002). Consistency index, CI is calculated as follows:

$$CI = \lambda max - n/(n-1) \quad (1)$$

Whereby:
CI--------Consistency Index
λ_{max}--------principal or maximum eigenvalue of the matrix
n----------size of matrix.

AHP allows inconsistency (Forman and Selly 2002) but it is acceptable up to set point after which the results are no longer plausible. By Saaty´s rule, the consistence index has to be 10% or less (Saaty 1990; Lane and Verdini 1989; Badri 2001). A consistency index of slightly more than 10% is not a problem. A larger deviation means that the judgements are not optimal and have to be improved. Improvement might make a restructuring of the hierarchy or repeating the pairwise comparisons necessary. AHP can chronologically show one by one which judgements are most inconsistent (Saaty and Peniwati 2013).

Step 5: A synthesis of priority weights is carried out to have a ranking of the alternatives. This is generally done by first calculating the weights of the alternatives with respect to each criterion immediately below the main goal, followed by a calculation of the sum of the product of the alternatives weights with respect to criteria and criteria weights (see appendix I, Table 51), which gives an overall weight that determines the ranking of each

alternative. In order to take rank reversal and preservation into consideration, AHP has two modes of synthesizing alternative priorities, distributive and ideal mode (Saaty and Vargas 2001). Expert Choice therefore also integrated the two modes of synthesizing alternative weights:

- “The ideal synthesis mode assigns the full weight of each covering objective to the best (highest priority) alternative for each covering objective. The other alternatives receive weights under each covering objective proportionate to their priority relative to the best alternative under each covering objective. The weights/priorities for all the alternatives are then normalized so they sum to 1.0. The addition or removal of alternatives (that are not best on any covering objective) will NOT impact the relative priorities (ratios or ranks) of other alternatives. The ideal mode is used when selecting one alternative from many and when the priorities of the alternatives not selected are not of interest" (EC 2000).
- "The distributive mode distributes the weight of each covering objective to the alternatives in direct proportion to the alternative priorities under each covering objective”. When the weights are synthesised using the distributive synthesis mode, the addition or removal of an alternative results in a re-adjustment of the priorities of the other alternatives such that their ratios and ranks can change. The distributive mode is used when measuring under conditions of scarcity – for example when forecasting outcomes whose probabilities must add to 1, or when looking at elections" (EC 2000).

Step 6: Prior to use of the obtained weights to make a decision, it is recommended to make a sensitivity analysis (the last step in AHP) of these to find out if changes of criteria weights affect the ranking of the alternatives. In other words, sensitivity analysis tests the stability of the priority weights (Saaty 1990; Meixner and Haas 2010). Sensitivity analysis is made from the goal node to show how the alternatives react to change of weight of the criteria below the goal. It can also be performed from the criteria nodes under the goal if the model has more than three levels, to show the reaction of the measures to the change of attribute weights. When performing a sensitivity analysis, the weights of the criteria or attributes are varied and observation is made on how the weights of the alternatives change and if the ranking of the alternatives is affected.

Expert Choice offers five ways of presenting results of sensitivity analysis:

- the performance sensitivity analysis shows how the alternatives were prioritized relative to other alternatives with respect to each objective as well as to the main goal
- the dynamic sensitivity analysis is used to dynamically change the priorities of the objectives
- the gradient graph shows the alternatives' priorities with respect to one objective at a time
- the head to head graph shows two alternatives compared to one another against the objectives in a decision
- the two dimensional plot shows the alternatives' priorities with respect to two objectives at a time

3.2 Group based AHP

Group decision procedures are characterised by varying knowledge, expertise, expectations and judgements among the people involved; different opinions and disagreements are the result (Saaty and Peniwati 2013). The challenge is therefore to combine these differences to a realistic judgement result. Saaty and Peniwati (2013) further note that a method is essential which

- captures diversity, processes agreement and disagreement systematically, efficiently and in a plausible way
- tolerates some degree of disagreement without affecting the soundness of the outcome
- incorporates different levels of authority and expertise
- numerically quantifies different strengths of opinion to be able to combine them and trade them off

- facilitates the decision process in a reliable way

AHP fulfils the above requirements.

Saaty and Peniwati (2013) propose a collective structuring of the problem by the group, a process which aggregates the knowledge of the people involved. The group can stay together and try to reach a consensus on the structure, details and judgements of the decision problem. On the other hand, the group does not need to reach a consensus at every step of the decision process; but the group does need to show a certain degree of unity in their way of thinking, to be able to reach a reasonable result (Saaty and Peniwati 2013). Meixner and Haas (2010) also suggest that group members could try to attain an evaluation matrix by discussing and reaching compromises. A bigger challenge is to harmonise the group to be able to resolve disputes quickly and channel the knowledge and expertise of each one of the group members towards a unanimous way of thinking. This process requires a leader who guides, coordinates and manages the decision procedure, keeping the goal in focus. The group leader is responsible for (Saaty and Peniwati 2013)

- planning the meeting,
- preventing the group from getting stuck in an endless discussion which might lead to a premature conclusion,
- keeping focus on the problem and track of the progress of discussion,
- controlling the balance between the group members working together and individually,
- supporting learning during and after the decision process,
- establishing fair decision making and
- providing for the best possible working environment for the group.

After structuring the problem, the members of the group can separate.

With the appropriate software, each group member can build his or her own hierarchy and come to his or her separate judgement. Group-enabled Expert Choice can combine the individual judgements. Manually, all the individual judgements can be combined by building the geometric mean of the judgements. The geometric mean is obtained by calculating the *n-th* root of the product of the individual expert judgements:

$$G = \sqrt[n]{x_1 x_2 \dots x_n} \qquad (2)$$

Whereby
G---Geometric mean
x ---individual expert judgements
n ---number of experts

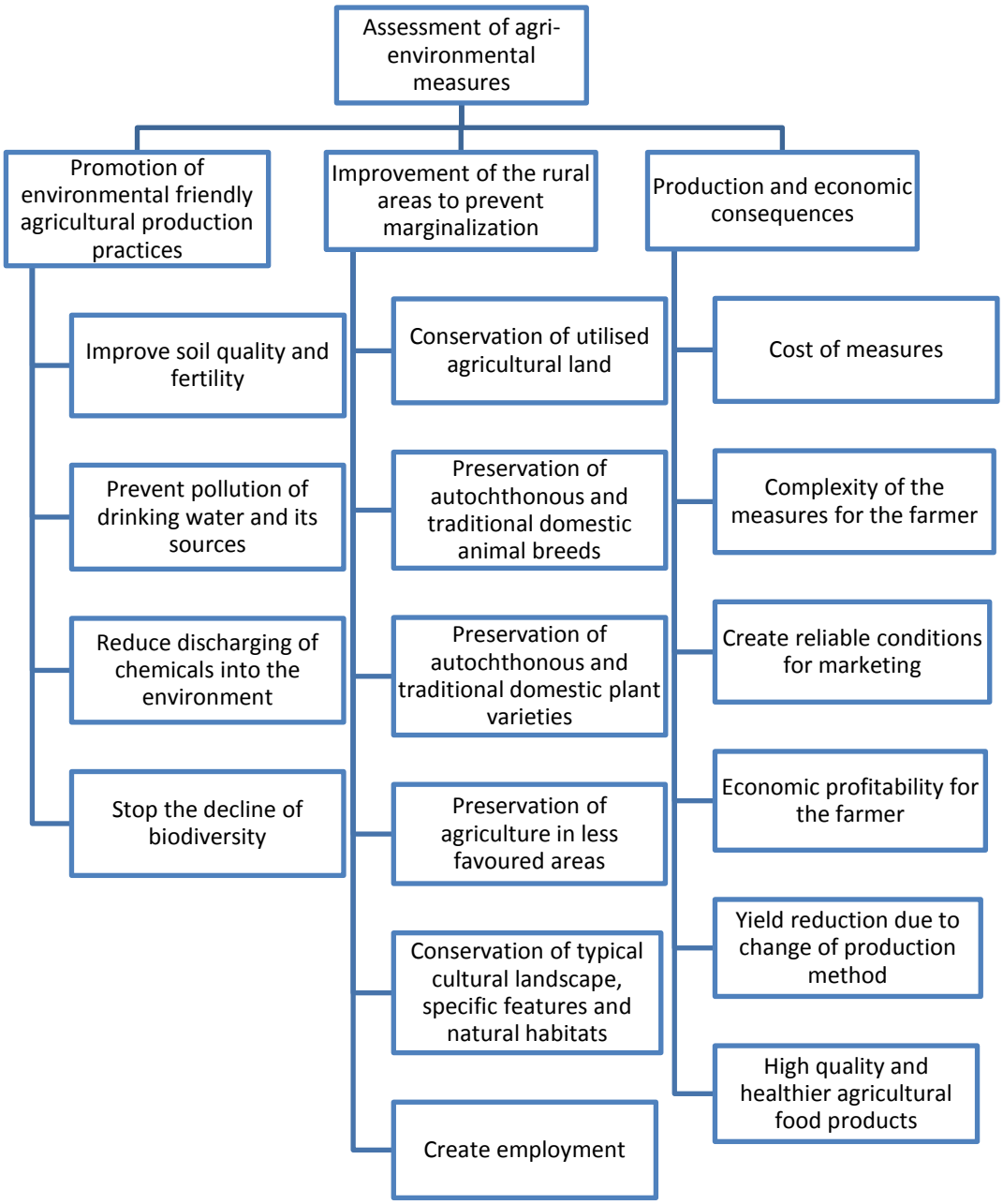
If the group consists of experts and they are ranked according to their expertise in a different hierarchy, their individual assessments can be raised to the power of their importance before calculating the geometric mean (Saaty and Peniwati 2013).
AHP supports group decision procedures following its four basic principles: structuring the problem using a hierarchy, deriving priorities from judgements, checking the results for logical consistency and performing the sensitivity analysis as described in 3.1

3.3 Practical application of AHP

3.3.1 Building of the model

At the beginning of a decision procedure, a meeting of all stakeholders is absolutely essential to define the problem and all its influencing factors and to be able to build the decision model. A well-defined and well-structured problem helps to make it more comprehensible. A decision model in the form of a hierarchy is the basis for AHP.
To build the model in Figure 1, the above mentioned steps (chapter 3.1) were followed.

Figure 1: Hierarchical structure of the problem



The hierarchical structure consists of four levels with the main goal, "Assessment of agri-environmental measures" as the first level. The second level has three criteria (•) and the third level a different number of attributes (-) for each criterion as shown in figure 1:

- Promote environmental friendly agricultural practices: sustainable and careful use of agricultural resources is the main focus in this sub-goal.
  - Soil quality and fertility will be improved by reducing soil erosion, loss of humus, and loss of nutrients through leaching (Parr et al. 1992)
  - Agri-environmental measures aim at reducing the contamination of ground water and drinking water sources through chemicals discharged into the environment during agricultural production
  - According to Latacz-Lohmann and Hodge (2003) there has been an exaggerated and uncontrolled use of chemical fertilisers and pesticides in the past. As a result, a considerable decline in biodiversity was observed among other negative consequences. The agri-environmental measures aim at reducing this unsustainable practice.
- Improve the rural areas to prevent marginalisation: Because of a lack of income in the rural areas there has been a significant amount of rural exodus, people moving to areas of industrial concentration and into bigger towns (EC 2008). With this sub-objective there is hope that the rural exodus might be reduced or even reversed to a certain degree.
  - Conservation of agricultural land implies minimal soil disturbance, permanent soil cover and crop rotation (FAO 2010).
  - Unique traditional and indigenous domestic animal breeds are mostly well known for their toughness and resistance against aggressive animal diseases. So the main aim here is to retain this valuable genetic material. Genetic diversity will help to reduce loss in times of drought and epidemics. (FAO 2004)
  - Climatic change has evoked unreliable weather conditions. The growing seasons are threatened by these unpredictable weather conditions. Traditional and indigenous plant varieties contribute to a greater diversity of crop plants which can be utilised for agricultural food production. They are a valuable genetic source towards food security since many can grow in harsh conditions. Their constituents are usually highly nutritious or medically effective. Preservation of a high agro-biodiversity is one of the important goals towards sustainable agricultural production.

- Less favoured areas already have the problem that agricultural land is limited and the conditions for agricultural production are not suitable. The little space that is available has to be used carefully to avoid deterioration. Traditional and indigenous domestic animal breeds and plant varieties could play a role in making these areas usable for agricultural purposes.
- The landscape has to preferably be kept in its natural state so that many animals, big and small, have their ideal habitat. This means for example that grasslands have to be maintained to avoid bush encroachment.
- Job creation is vital to make the rural areas an attractive place to live. This might help to attract many people out of the industrial or urban areas back to the rural areas.

- Production and economic consequences: With farmers investing in the rural areas and diversifying their source of income, new jobs will be created. If the rural areas are made attractive enough with the appropriate infrastructure, even young farmers might find it worth settling in the rural areas (Baum 2008).
  - Costs of measures play a major role as to whether they are successfully implemented until the end of the given period.
  - Successful implementation of the agri-environmental measures also depends on how complex they are for the farmers. Too complex measures will be wrongly put into practice, which leads to the wrong outcome.
  - To be able to get the produce from the rural areas on the markets, reliable channels for marketing have to be created. To achieve this, farmers need help as many of them are usually not well organised or networked and have no means to get access to the marketing channels.
  - If there is economic profitability for the farmers through implementation of the measures, the farmers might decide not to give up farming. They might also decide not to leave rural areas and migrate to urban areas. (Möllers et al 2008)
  - The farmers will probably encounter yield reduction if they change the method of production to suit the demand for more biologically produced food. Since their products are of a higher quality and healthier, they will be able to sell them at higher prices.

The fourth and last level at the bottom of the hierarchy consists of 29 measures.

3.3.2 Data Acquisition and Processing

After building the hierarchy, questionnaires were sent to several experts who made pairwise comparisons at all levels of the hierarchy under the main goal. There is a possibility that the experts feed this pairwise comparison data straight into the software Expert Choice™. However this demands that all stakeholders involved in the decision procedure must have Expert Choice for group decision, a very expensive venture. The Expert Choice used for this dissertation was for individuals, the reason why the expert judgements had to be obtained by questionnaires. The experts were asked to assess the importance of the three criteria (level 2 of hierarchy) with respect to the main goal "assessment of agri-environmental measures" and attributes (level 3 of the hierarchy) towards their parent criteria, by allocating values between 1 and 9, whereby a bigger number indicates a greater importance. The data collected on the questionnaires is shown in tables 1-4 in appendix I. Data processing in this dissertation was done using both Expert Choice and Microsoft Excel spreadsheets.

For assessment, the individual judgements obtained on questionnaires (Appendix I, Tables 1-4) were entered into Excel spreadsheets, and turned into pairwise comparison matrices for each expert.
Three steps were needed to turn the obtained questionnaire values for levels 2 and 3 of the hierarchy into AHP compatible matrices (Appendix I, Tables 5-44):

In step 1, the differences of the allocated questionnaire values between the criteria or attributes for each expert were determined and arranged as matrices in the Microsoft Excel spreadsheet. The determined values were entered into the area above the diagonal of the matrix. The diagonal of the matrix is built by comparing the criteria or attribute with itself, which always equals 1.

In step 2 the values from step 1 were made AHP compatible by using Microsoft Excel´s IF-Function:

=if(x>=0;x+1;1/(ABS(x)+1)) (3)

implying that if the value of x is greater or equal to 0, then 1 is added to x, otherwise the reciprocal of the absolute value of x+1 is correct.

The IF-Function is used because of the fact that when two items i and j in an AHP matrix are compared and item i gets a non-zero value between 1 and 9 (Saaty´s scale of comparison, Table 5) compared with j, then j gets the reciprocal value compared with i (Saaty 1990; Saaty and Vargas 2001).

Therefore, in step 3, values for the area below the diagonal of matrix were obtained by calculating the reciprocals of values from step 2.

Since this decision procedure is considered a group decision, the values of the decision matrices from each of the experts were first aggregated to one matrix at each level of the hierarchy for measures, attributes and criteria. Generally, this can be done by either aggregating the values of the individual pairwise comparison matrices at each level of the hierarchy and then using these values to calculate the priority weights or by first calculating the priority weights (of measures, attributes and criteria) at each level of the hierarchy for each individual expert and then aggregating these priority weights. In both cases the aggregation is done by calculating the geometric mean (see chapter 3.2) as recommended by Saaty & Vargas (2001), Meixner & Haas (2002, 2010) and Saaty & Peniwati (2013). In this dissertation, the expert assessment values from the pairwise comparison matrices were aggregated (see tables 45-48 in appendix I).

The values of the aggregated matrices at all levels of the hierarchy were fed into Expert Choice™. The aggregated values of the criteria and their attributes, above the diagonal in the matrices (appendix I, tables 45-48), were filled in using the graphical pairwise function (Figure 2)[9] which allows the entry of decimal numbers.

[9] Figure 2: Level 2 (criteria) as an example. The values are from Table 45 in appendix I.

For values which are less than 1, the reciprocal values (corresponding values at the bottom of the diagonal) were used. By then pressing the Invert button in Expert Choice™, the values turned red to show their inverse characteristic. The dominant value can also be set by moving the blue or red bar to the desired value, depending on which one of them is dominant.

Expert Choice™ calculated the weights of the criteria, attributes and alternatives (measures) with respect to importance. Expert Choice also calculates the consistency index during the processing of the data.

There are four ways of manually calculating priority weights as described by Saaty (1990):

- Option 1: The sum of each of the rows is determined, then the total of the sums. Dividing the sum of each row by the total of the sums, results in a column vector of priority weights.

- Option 2: The sum of each of the columns is calculated, then the reciprocals of each of these sums. The reciprocals are then added up. Dividing each reciprocal by their total results in a row vector of priority weights.

- Option 3: The sum of each of the columns is determined. Each of the elements in a column is then divided by the sum of that column. A normalised matrix is the result. The sum of each of the rows of the normalised[10] matrix is determined (Saaty, 1990; Meixner and Haas, 2010); dividing each of the sums by the size of the matrix produces a column vector of priority weights.

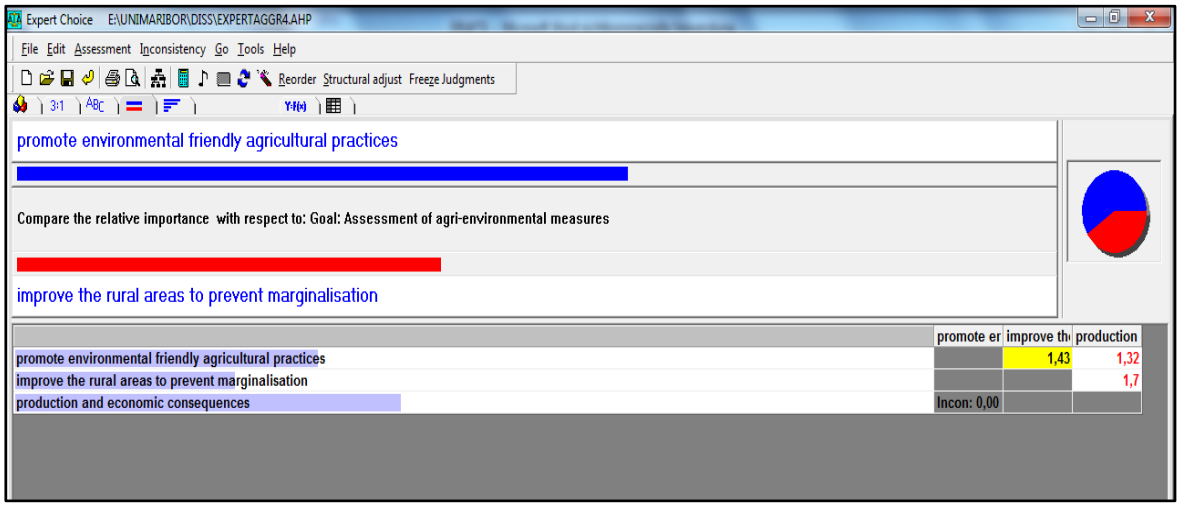
- Option 4: The geometric mean of each of the rows is determined, then the sum of these geometric means. Dividing each of the geometric means by their sum results in a column vector of priority weights.

The results from the four options are almost identical; the differences are negligible.

Option 3 is shown in appendix I, Table 49 by determining the weights of Table 47. In the majority of cases, decision matrices are square matrices with the same number of rows and columns.

[10] Normalising is done to bring values to a comparable basis by creating a reference value; in this case it is 1

Figure 2: Graphical pairwise comparison



Adding up the sum of the rows after normalization must always show the matrix size. The priority weights always add up to 1, our reference value. The same applies to the weights of the columns of the normalized matrix. They always add up to 1 (see appendix I, table 49).

To determine the principal/maximum eigenvalue[11] of the comparison matrix the normalized matrix is used. The sum of each row is divided by the normalized weight of the main diagonal for that row (arrow in Table 49, appendix I as an example). The sum of the resulting vector divided by the size of the matrix equals the maximum eigenvalue (Meixner and Haas 2010). The maximum eigenvalue for the matrix in table 49 is 6,0055.

Saaty (1990) proposes a "crude" way of determining the maximum/principal eigenvalue manually, in three steps:

Step1: Matrix of comparisons is multiplied by the eigenvector (vector of priorities). A new vector is the result (vector 1).

[11] The principal/maximum eigenvalue is needed to determine the consistency index of a comparison matrix in step 5 of AHP (see 3.1)

Step 2: First component of the vector from step 1 is divided by the first component of the eigenvector; the second component of the vector from step 1 is divided by the second component of the eigenvector, and so on. The result is yet another vector (vector 2).

Step 3: The sum of the components in vector 2 divided by the number of components equals the maximum/principal eigenvalue

The processing of the alternatives, the bottommost level of the hierarchy, is done with the help of the formulas and data grid. The data grid contains data on the alternatives, which are situated in the rows, with respect to the lowest level of sub-goals which are found in the columns. First and foremost, a scale for the judgement of the alternatives with respect to the sub-goals has to be determined, which is entered into the formulas grid using ratings, increasing or decreasing utility curve, step function or direct entry of priorities. Ratings use verbal preferences as in Table 6 and Table 7 or existing hard data whose relative intensities of preference are derived by pairwise comparison. Increasing or decreasing utility curves use a highest and lowest value. Increasing utility curve is used if the highest value is preferred and decreasing utility curve if the lowest value is preferred. The step function also uses both verbal preferences and hard data, whose relative intensity of preference is also determined by pairwise comparison. Direct entry of intensities of preferences is used when they are manually calculated. Direct assignment of intensities of preference is not recommended because it is not accurate and justifiable (Expert Choice Manual). The set scales are then used to make judgements of the alternatives with respect to the sub-goals.

For the 29 agri-environmental measures, the experts had to give their judgements using a scale between 1 and 4, on how strong the contribution of each of the measures is on each attribute of criteria “promote environmental agricultural practice” and “improve the rural areas to prevent marginalisation” to reach the goal (Table 6)

Table 6: Judgement scale 1 for measures

Strong contribution	1
Moderate contribution	2
Weak contribution	3
No contribution	4

or whether high costs are expected for each measure on attributes towards the criterion "production and economic consequences" (Table 7).

Table 7: Judgement scale 2 for measures

High costs	1
Moderate costs	2
Low costs	3
No costs	4

After entering judgement scales from tables 6 and 7 into the formulas grid in Expert Choice, aggregated data (Appendix I, Table 50) from the judgements at level 4 of the hierarchy (measures) was entered into the data grid.

To have the weights of the alternatives calculated by Expert Choice, the "Synthesize" menu is used for the goal, each criterion (Figures 3-5) and attribute (appendix II).

4. RESULTS AND DISCUSSION

Weights of criteria (Table 8) show that production and economic consequences (0,425) are considered to have the most substantial influence on the assessment of AEM, followed by the promotion of environmental friendly agricultural practices (0,333); improvement of rural areas to prevent their marginalisation (0,241) is third place. All three criteria are an integral part of the efforts towards improving the rural areas and the environment because they address different aspects of these efforts.

The weights of attributes towards each of the criteria (Table 9-11) show their contribution towards achieving the sub-goals, usually called criteria[12] in decision making procedures.
The weights of AEM for the individual criteria obtained by synthesizing them at the appropriate level of the hierarchy in Expert Choice are shown in figure 3-5 and the weights of AEM for individual attributes in appendix II. The weights of measures towards production and economic consequences are in figure 3, figure 4 shows weights which were allocated to the measures and their contribution to promoting environment friendly agricultural practices, figure 5 consists of weights towards improving rural areas to prevent marginalisation. The aggregation of the weights of measures at criteria level to obtain the global weights is fully described in step 4 (p. 50, also see appendix I, Table 51). The global priority weights of the measures with respect to global goal "assessment of agri-environmental measures" are shown in table 10. At all levels, the bigger the weight is, the more the measure is seen to make a considerable contribution to the achievement of the defined goal, sub-goal and sub-sub-goal.

[12] To be able to clearly distinguish the levels of the AHP model, the terms criteria for the second level and attributes for the third level were used. Throughout the work there might be constant commutation of these terms with sub-objectives, sub-sub-objectives and sub-goal, sub-sub-goal. The fourth and last level of the hierarchy in this dissertation consists of the alternatives, the proposed 29agri-environmental measures.

Table 8: Weights of criteria (level 2 of hierarchy)

Criterion	Weight
Production and economic consequences	0,425
Promote environmental friendly agricultural practices	0,333
Improve rural areas to prevent marginalisation	0,241

4.1 Production and economic consequences

The weights of the attributes towards production and economic consequences are 0,198 for economic profitability of the measures for the farmer, 0,195 for cost of measures, 0,177 for high quality and healthier agricultural food products, 0,160 for complexity of the measures for the farmer, 0,138 for creating reliable conditions for marketing and 0,133 for yield reduction by changing method of production (Table 9).

Economic profitability of the measures for the farmer is seen as the main driving force for acceptability of AEM. The allocated weights of measures for this attribute are 0,106 for organic crop, fruit, vine and horticultural production and 0,023 for the rest of the measures: reduction of soil erosion in fruit and wine growing, preservation of crop rotation, greening of arable land, integrated crop, fruit, vine and horticultural production, mountain pastures with and without herdsman, mowing steep slopes with 30-50% and over 50% inclination, mowing humpy meadows, maintaining meadow orchards, rearing of indigenous and traditional domestic animal breeds, production of indigenous and traditional agricultural plant varieties, sustainable rearing of domestic animals, maintaining extensive grassland, maintaining animal husbandry in areas with large carnivores, preservation of special grassland habitats, preservation of grassland habitats for butterflies, preservation of litter meadows, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, maintaining cultivated and populated landscape on

protected areas and permanent green cover on fallow land (Appendix II, Figure 1). The results show that organic production is seen to be economically most profitable for the farmer.

As agriculture together with forestry is the most important activity in rural areas, it is consequently the main source of income. All the same, small- and medium-scale farmers, who make up a bigger proportion of all farmers, have poor income. It is undisputed that the poorest population in lowest-income and medium-income developing countries live in rural areas (Wiggins et al. 2002). Small farmers even produce much of the food but they are usually poorer and less food secure than the rest of the population in these countries (Dixon et al. 2001). The conclusion is therefore that "dealing with poverty and hunger in much of the world means confronting the problems that small farmers and their families face in their daily struggle for survival" (Dixon et al. 2001). Investment programmes and public policies must therefore target increasing farm income and food security. In rural Europe agriculture no longer dominates economic activities, "most economic activity depends more and more on the service sector" (de Arriba Bueno 2009). Implementing AEM is a way of giving agriculture a chance to gain momentum again in rural areas, but it has to ensure that farmers and their families can earn a living. AEM also give the farmers a possibility to diversify their agricultural activities with the opportunity to exploit non-agricultural income sources. Increasing economic profitability of agricultural and related activities might attract more people to take up farming as their means of earning a livelihood. There are various motivations like environmental protection, nature conservation, cultivation of healthy food products, and in most cases, economic benefits (Defrancesco et al. 2008, Hynes and Garvey 2009, Ruto and Garrod 2009, Barreiro-Hurle et al. 2010), for a farmer to adopt AEM.

Rural areas are extremely valuable for the EU; their development to enhance the standard of living is seen as the primary target. The EU, with its member states as partners, is therefore prepared to invest large sums of money to raise the economic, social, cultural and environmental value of rural areas. AEM serve as a vehicle to achieve this target.

Table 9: Weights of attributes towards production and economic consequences

Attribute	Weight
Economic profitability of the measures for the farmer	0,198
Cost of measures	0,195
High quality and healthier agricultural food products	0,177
Complexity of the measures for the farmer	0,160
Create reliable conditions for marketing	0,138
Yield reduction by changing method of production	0,133

The weights of the measures with respect to the attribute cost of measures were distributed as follows: 0,064 for reduction of soil erosion in fruit and wine growing, preservation of crop rotation, and greening of arable land; 0,034 for integrated crop, fruit, vine and horticultural production, mountain pastures with and without herdsman, mowing steep slopes with 30-50% and over 50% inclination, mowing humpy meadows, maintaining meadow orchards, rearing of indigenous and traditional domestic animal breeds, production of indigenous and traditional agricultural plant varieties, sustainable rearing of domestic animals, maintaining extensive grassland, maintaining animal husbandry in areas with large carnivores, preservation of special grassland habitats, preservation of grassland habitats for butterflies, preservation of litter meadows, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, maintaining cultivated and populated landscape in protected areas and permanent green cover on fallow land; 0,017 for organic crop, fruit, vine and horticultural production. Among all 29 AEM, reduction of soil erosion in fruit and wine growing, preservation of crop rotation and greening of arable land are judged to take the most significant influence on the cost (Appendix II, Figure 2).

The cost of AEM decides whether or not these measures will succeed. To support and guarantee a continuity of the implementation of AEM for the programming period 2007-

2013, the EU spent "nearly 20 billion EUR[13], 12% of the expenditure for rural development" (EC 2013), financed by the European Agricultural Fund for Rural Development (EAFRD) which was established by the EU to financially support the rural development process. AEM are co-financed by EU member states. Agri-environmental payments are made for the costs which arise from implementation of AEM or as a compensation for income loss due to reduction of agricultural land or number of animals and due to change of method of production. The payments can also be seen as an appreciation for the service the farmers offer to the environment. The success of AEM is strongly linked to these payments. Some of the proposed AEM do not generate income for the farmers though the farmer invests his time and labour. The partnership between the EU administration, member states and EU farmers therefore enables conditions which secure sustainable implementation of AEM.

Figure 3 in Appendix II does not clearly identify which measures contribute most to obtaining high quality and healthier agricultural food products. All measures were allocated the weight 0,034. This is a very unusual result taking into consideration that organic and integrated production are distinguished by their reduced use of chemical inputs. It is probably because the experts took into consideration that AEM naturally lead to uncontaminated food products. The idea behind AEM is not only improvement of environment and mitigation of climatic change; it is also about producing high quality, safe and healthy agricultural products. A rise in demand for healthy and safe agricultural products by consumers is due to increased concern about their quality. Many consumers fear serious health hazards which could be caused by chemically contaminated food products. A gradual change from conventional to integrated and organic agriculture is a logical consequence which will pay off for the farmers in the long run.

The role of the measures towards the attribute "complexity of the measures for the farmer" are made clear by the weights 0,096 for organic crop, fruit, vine and horticultural production; 0,044 for integrated crop, fruit, vine and horticultural production and 0,021 for

[13] EUR=Euro, the official currency of the Euro Zone consisting of 19 EU member states, is also used by the institutions of the EU.

reduction of soil erosion in fruit and wine growing, preservation of crop rotation, greening of arable land, mountain pastures with and without herdsman, mowing steep slopes with 30-50% and over 50% inclination, mowing humpy meadows, maintaining meadow orchards, rearing of indigenous and traditional domestic animal breeds, production of indigenous and traditional agricultural plant varieties, sustainable rearing of domestic animals, maintaining extensive grassland, maintaining animal husbandry in areas with large carnivores, preservation of special grassland habitats, preservation of grassland habitats for butterflies, preservation of litter meadows, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, maintaining cultivated and populated landscape on protected areas and permanent green cover on fallow land. The most complex measures are rated to be organic production activities, followed by integrated production (Appendix II, Figure 4).

The success of AEM also depends on how complex they are for the farmers. AEM have to be designed for easy realisation into practice by the farmers, which makes a great contribution to their acceptance and successful implementation. The ineffectivity of AEM is also sometimes linked to their complexity. A research in the UK (2012) points out that farmers "have, increasingly, to comply with complex rules and regulations" and "may lack enough knowledge or understanding to apply" them effectively. It is further noted that farmers may lack understanding of the relationship between "the instructions they are given and the expected outcome". In Italy (Defrancesco, et al. 2008) a survey showed that easy-to-apply AEM encouraged farmers to participate on agri-environmental schemes. This problem can be alleviated by offering training courses and information sessions with the aim of giving the farmers a new awareness of which responsibility they have towards the natural resources they exploit and to help them understand the legislation.

There are only two weights distributed among the 29 measures: 0,106 for organic crop, fruit, vine and horticultural production, 0,023 for the rest: reduction of soil erosion in fruit and wine growing, preservation of crop rotation, greening of arable land, integrated crop, fruit, vine and horticultural production, mountain pastures with and without herdsman, mowing steep slopes with 30-50% and over 50% inclination, mowing humpy meadows,

maintaining meadow orchards, rearing of indigenous and traditional domestic animal breeds, production of indigenous and traditional agricultural plant varieties, sustainable rearing of domestic animals, maintaining extensive grassland, maintaining animal husbandry in areas with large carnivores, preservation of special grassland habitats, preservation of grassland habitats for butterflies, preservation of litter meadows, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, maintaining cultivated and populated landscape on protected areas and permanent green cover on fallow land (Appendix II, Figure 5).

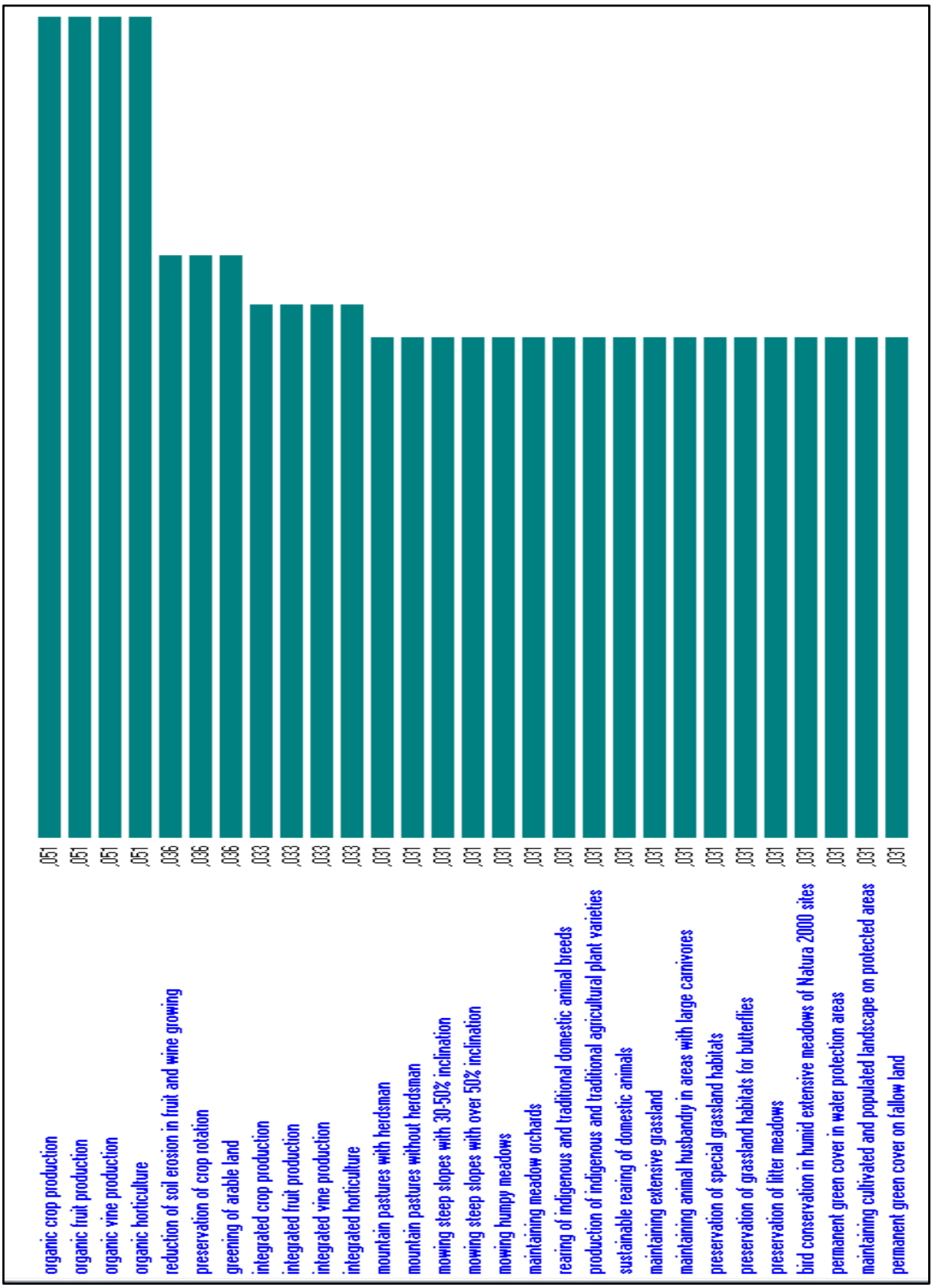
The successful implementation of AEM leads to high quality and healthier food products which have to be placed on the market. To place the high quality agricultural and forestry products on the market requires a reliable marketing infrastructure. The efforts invested in adopting environment friendly agricultural practices are enormous. Small farmers who are usually not very well organized need the help of marketing experts and a strong financial backing to place their produce on the highly competitive market. Organic products have to have a guaranteed channel to the markets to ensure that they reach the consumer with the maximum freshness. This will avoid wasted efforts. If the risks taken in the course of production are in vain, this might discourage the farmers from proceeding with this way of agricultural production.

Figure 6 in Appendix II shows no distinct measure towards the attribute, yield reduction due to changing method of production. All measures were assigned the weight 0,034. Decrease of yield farmers face, especially by changing to organic production, will be compensated by high market prices for their high quality agricultural products. Yield reduction as a result of AEM is therefore taken for granted.

The overall weights of measures towards production and economic consequences in figure 3 show that the biggest consequences come from all organic production activities (0,051). Reduction of soil erosion in fruit and vine growing, preservation of crop rotation, greening of arable land (0,036) are the next group of measures with an substantial influence on the production and economic consequences. Integrated agriculture (0,033) also has

considerable influence. The rest of the measures, mountain pastures with herdsman, mountain pastures without herdsman, mowing steep slopes with 30-50% inclination, mowing steep slopes with over 50% inclination, mowing humpy meadows, maintaining meadow orchards, rearing of indigenous and traditional domestic animal breeds, production of indigenous and traditional agricultural plant varieties, sustainable rearing of domestic animals, maintaining extensive grassland, maintaining animal husbandry in areas with large carnivores, preservation of special grassland habitats, preservation of grassland habitats for butterflies, preservation of litter meadows, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, maintaining cultivated and populated landscape on protected areas and permanent green cover on fallow land, all with the weight 0,031, also have production and economic consequences not much less significant than integrated production.

Figure 3: Weights of measures with respect to criteria "production and economic consequences"



4.2 Environmental friendly agriculture

The level of contribution of the attributes towards promoting environmental friendly agricultural practices is nearly the same according to the judgements in Table 10. The weights are 0,297 for stopping the decline of biodiversity, 0,266 for reducing discharging of chemicals into the environment, 0,251 for preventing pollution of drinking water and its sources and 0,186 for improving soil quality and fertility.

Stopping the decline of biodiversity is seen as the best indicator for good agricultural practices. Reducing discharging of chemicals into the environment and preventing pollution of drinking water and its sources are rated as the next important attributes towards environmental friendly agricultural practices. Preventing pollution of drinking water and its sources as well as improving soil quality and fertility are measures which also help to promote environmental friendly agricultural practice.

Table 10: Weights of attributes towards promoting environmental friendly agricultural practices

Attribute	Weight
Stop the decline of biodiversity	0,297
Reduce discharging of chemicals into the environment	0,266
Prevent pollution of drinking water and its sources	0,251
Improve soil quality and fertility	0,186

Of the proposed 29 agri-environmental measures, organic fruit, vine and horticultural production have the weight of 0,105; integrated crop, fruit, vine and horticultural production, organic crop production, mountain pastures without herdsman, mowing steep slopes with 30-50% inclination, mowing steep slopes with over 50% inclination, mowing humpy meadows and maintaining meadow orchards all have a weight of 0,039; preservation of crop rotation, greening of arable land, sustainable rearing of domestic

animals, maintaining extensive grassland, maintaining animal husbandry in areas with large carnivores, preservation of special grassland habitats, preservation of grassland habitats for butterflies, preservation of litter meadows, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, maintaining cultivated and populated landscape in protected areas and permanent green cover on fallow land all have a weight of 0,021; reduction of soil erosion in fruit and wine growing, mountain pastures with herdsman, rearing of indigenous and traditional domestic animal breeds and production of indigenous and traditional agricultural plant varieties have a weight of 0,011 towards stopping the decline of biodiversity (Appendix II, Figure 7). Organic and integrated production methods help to protect all living organisms of the agro-ecosystems from being harmed by agricultural chemicals; mountain pastures without herdsman, mowing steep slopes with 30-50% and with over 50% inclination, mowing humpy meadows and maintenance of meadow orchards are activities to manage, protect and maintain the landscape and hence the creation and preservation of special habitats. These measures help most to stop the decline of biodiversity.

Towards reducing discharging chemicals into the environment, the measures were allocated the following weights: organic fruit, vine and horticultural production 0,120; greening of arable land, integrated crop, fruit, vine and horticultural production, organic crop production 0,045; preservation of crop rotation, greening of arable land, sustainable rearing of domestic animals, maintaining extensive grassland, maintaining animal husbandry in areas with large carnivores, preservation of special grassland habitats, preservation of grassland habitats for butterflies, preservation of litter meadows, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, maintaining cultivated and populated landscape in protected areas and permanent green cover on fallow land 0,024; reduction of soil erosion in fruit and wine growing, mountain pastures with and without herdsman, mowing steep slopes with 30-50% and with over 50% inclination, mowing humpy meadows, maintenance of meadow orchards, rearing of indigenous and traditional domestic animal breeds and production of indigenous and traditional agricultural plant varieties 0,012 (Appendix II, Figure 8).

Organic production is rated as the best tool towards reducing discharging of chemicals into the environment, followed by integrated production methods together with greening of arable land. Preservation of crop rotation, sustainable rearing of domestic animals, maintain extensive grassland, maintaining animal husbandry in in areas with large carnivores, preservation of special grassland habitats, preservation of grassland habitats for butterflies, preservation of litter meadows, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, maintaining cultivated and populated landscape on protected areas and permanent green cover on fallow land are seen to give essential support (Appendix II, Figure 8).

Towards preventing pollution of drinking water and its sources, the measures organic crop, fruit, vine and horticultural production, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas and permanent green cover on fallow land all received the weight 0,094; integrated crop, fruit, vine and horticultural production were allocated the weight 0,035; preservation of crop rotation greening of arable land, maintaining meadow orchards and sustainable rearing of domestic animals have the weight 0,018; reduction of soil erosion in fruit and wine growing, mountain pastures with and without herdsman, mowing steep slopes with 30-50% and with over 50% inclination, mowing humpy meadows, rearing of indigenous and traditional domestic animal breeds and production of indigenous and traditional agricultural plant varieties, maintain extensive grassland, maintaining animal husbandry in in areas with large carnivores, preservation of special grassland habitats, preservation of grassland habitats for butterflies, preservation of litter meadows and maintaining cultivated and populated landscape on protected areas all got the weight 0,009 (Appendix II, Figure 9).

Towards improving soil quality and fertility, organic crop, fruit, vine and horticultural production play the leading role with the weight 0,117. The next important measures are preservation of crop rotation, greening of arable land, integrated crop, fruit, vine and horticultural production with the weight 0,044. Reduction of soil erosion in fruit and vine growing, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas and permanent green cover on fallow land are in third

place with the weight 0,023. Last but not to be neglected are mountain pastures with and without herdsman, mowing steep slopes with 30-50% and with over 50% inclination, mowing humpy meadows, maintaining meadow orchards, rearing of indigenous and traditional domestic animal breeds and production of indigenous and traditional agricultural plant varieties, sustainable rearing of domestic animals, maintaining extensive grassland, maintaining animal husbandry in in areas with large carnivores, preservation of special grassland habitats, preservation of grassland habitats for butterflies, preservation of litter meadows and maintaining cultivated and populated landscape on protected areas with the weight 0,012 (Appendix II, Figure 10).

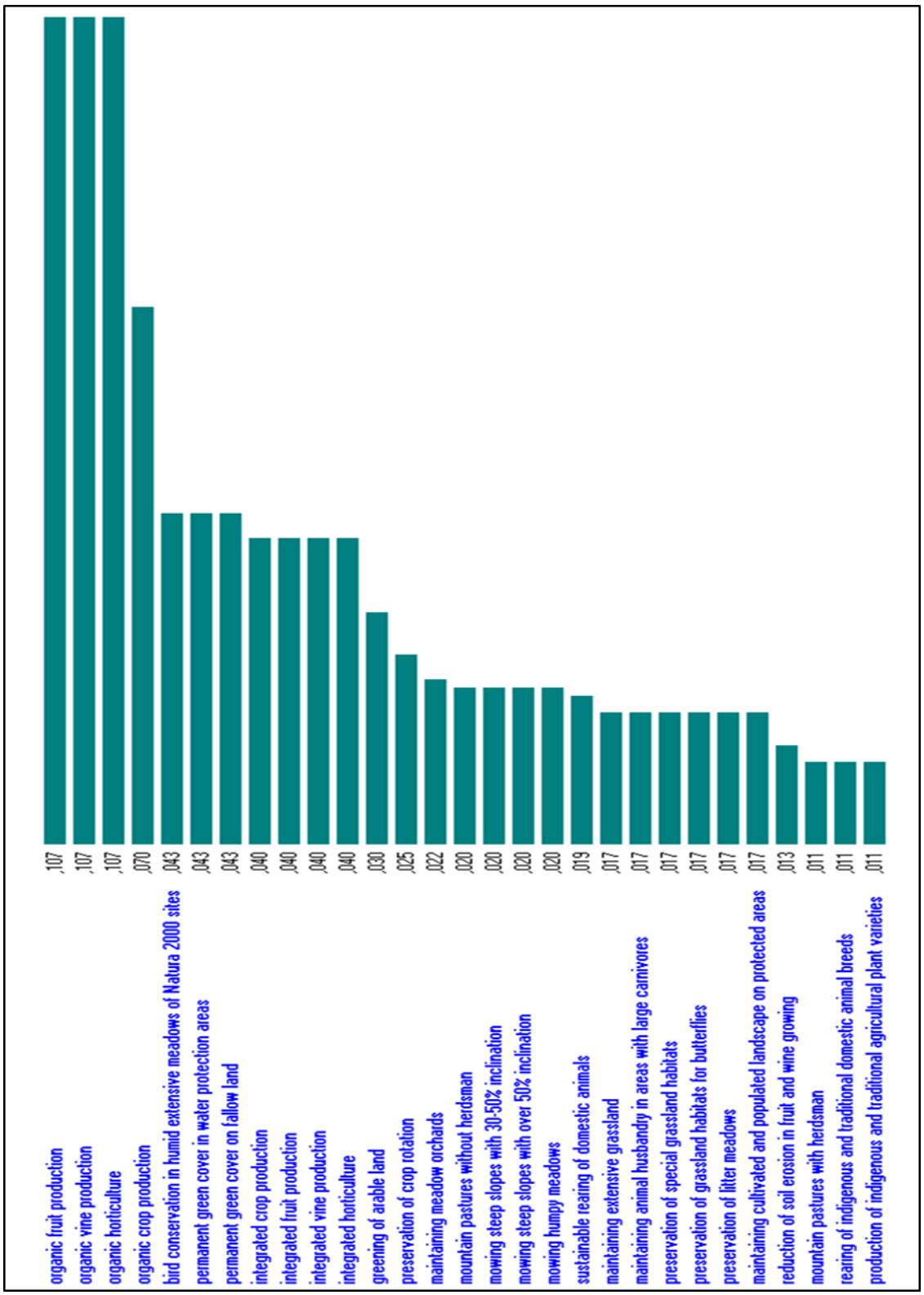
Although improving soil quality and fertility is rated last among the attributes towards promoting environmental friendly agricultural practices, it is by no means a sign that it should be neglected. Soil is a medium for plant growth. It is therefore important to ensure that the soil keeps its characteristics which aid plant growth. Improving soil quality and fertility is best supported by organic production, whereby integrated production, preservation of crop rotation and greening of arable land make a substantial contribution. Some help also comes from reduction of soil erosion in fruit and wine growing, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas and permanent green cover on fallow land (Appendix II, Figure 10).

Figure 4 shows the overall contribution of measures towards promoting environmental friendly agriculture. Organic fruit, vine and horticultural production make the best contribution with the weight 0,107, followed by organic crop production with the weight 0,070. Bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas and permanent green cover on fallow land are assigned the same weight 0,043 ranking third. On fourth place are integrated crop, fruit, vine and horticultural production with the weight 0,040. Greening of arable land was assigned the weight 0,030; preservation of crop rotation 0,025; maintaining meadow orchards 0,022. Pastures without herdsman, mowing steep slopes with 30-50% and with over 50% inclination and mowing humpy meadows got the weight 0,020; sustainable rearing of domestic animals 0,019. Maintaining extensive grassland, maintaining animal

husbandry in in areas with large carnivores, preservation of special grassland habitats, preservation of grassland habitats for butterflies, preservation of litter meadows and maintaining cultivated and populated landscape on protected areas have the common weight 0,017. Reduction of soil erosion in fruit and wine growing was allocated the weight 0,013. With a weight of 0,011, mountain pastures with herdsman, rearing of indigenous and traditional domestic animal breeds and production of indigenous and traditional agricultural plant varieties are seen to make the least contribution towards promoting environmental friendly agricultural practices.

Permanent green cover in water protection areas is a measure to reduce contamination of drinking water. Very supportive for protection of source water is integrated agricultural production. Figure 4 shows that integrated crop, fruit, vine production and horticulture, as a third important group of measures, are considered to have the same amount of contribution in promoting environmental friendly agricultural practices.

Figure 4: Weights of measures with respect to criteria “promote environmental friendly agricultural practises



4.3 Improvement of rural areas

The weights of attributes towards improving rural areas to prevent marginalisation, which resulted from AHP calculations are 0,251 for creating employment, 0,214 for conservation of utilised agricultural land, 0,163 for preservation of autochthonous and traditional domestic animal breeds, 0,146 for preservation of autochthonous and traditional domestic plant varieties, 0,115 for preservation of agriculture in less favoured areas and 0,112 for conservation of typical cultural landscape, specific features and natural habitats (Table 11).

The weights of measures towards creating employment are 0,040 for reduction of soil erosion in fruit and wine growing, preservation of crop rotation, greening of arable land, integrated crop, fruit, vine and horticultural production, organic crop, fruit, vine and horticultural production, mountain pastures with and without herdsman, mowing steep slopes with 30-50% and over 50% inclination, preservation of grassland habitats for butterflies, preservation of litter meadows, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, maintaining cultivated and populated landscape on protected areas and permanent green cover on fallow land and 0,021 for mowing humpy meadows, maintaining meadow orchards, rearing of indigenous and traditional domestic animal breeds, production of indigenous and traditional agricultural plant varieties, sustainable rearing of domestic animals, maintaining extensive grassland, maintaining animal husbandry in areas with large carnivores and preservation of special grassland habitats (Appendix II, Figure 11).

It is comprehensible to presume that job creation in the rural areas will help most to improve them and prevent marginalisation. Though Terluin´s (2003) desktop analysis of the economic development in the EU showed that the loss of population and jobs in the rural areas of the EU mainly due to decline of agricultural activities was partly compensated by manufacturing and services sectors, Halhead (2006) noted that "the rural areas of Europe have been experiencing often severe decline, resulting from the decreasing importance of agriculture in the rural economy in terms of employment, the forces of the EU internal market, the globalization of markets, increasing cultural and economic urbanization and trends in rural–urban migration, especially of young and educated

people". Karcagi-Kováts and Katona-Kovács (2012) still noted that "population decline in rural areas of the EU is one of the acute developments which still continues today". In some of the member states there are significant signs that rural areas are threatened by depopulation. Especially the younger generation is migrating to the conurbations and big cities where they have better employment opportunities. The main reasons this time for population decline in rural areas are ageing population and migration still, due to (Karcagi-Kováts and Katona-Kovács, 2012):

- unemployment or low wages,
- poverty and poor living conditions,
- declining agriculture,
- lack of social and public services (education, health facilities, shops, cultural facilities, transport, telecommunication)

The EU member states are therefore being urged to offer and support strategies for sustainable rural development which takes into consideration the economic, social and environmental potentials of rural areas. Figure 11 in Appendix II shows agricultural activities and activities for landscape management, maintenance and conservation as possible ways of creating employment in rural areas. As the rural areas are the place with the biggest amounts of natural resources, it gives the development and management of rural life tremendous significance.

Table 11: Weights of attributes towards improving the rural areas to prevent marginalisation

Attribute	Weight
Create employment	0,251
Conservation of utilized agricultural land	0,214
Preservation of autochthonous and traditional domestic animal breeds	0,163
Preservation of autochthonous and traditional domestic plant varieties	0,146
Preservation of agriculture in less favoured areas	0,115
Conservation of typical cultural landscape, specific features and natural habitats	0,112

Weights of measures with respect to conservation of utilised agricultural land were distributed as follows: 0,121 for organic fruit, vine and horticultural production, 0,046 for integrated crop, fruit, vine and horticultural production and organic crop production, 0,024 for preservation of crop rotation, greening of arable land, production of indigenous and traditional agricultural plant varieties, sustainable rearing of domestic animals, maintaining extensive grassland, maintaining animal husbandry in areas with large carnivores, preservation of special grassland habitats, preservation of grassland habitats for butterflies, preservation of litter meadows, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, maintaining cultivated and populated landscape on protected areas and permanent green cover on fallow land, 0,012 for reduction of soil erosion in fruit and wine growing, mountain pastures with and without herdsman, mowing step slopes with 30-50% and over 50% inclination, mowing humpy meadows, maintaining meadow orchards and rearing of indigenous and traditional domestic animal breeds (Appendix II, Figure 12).

Just as important for the rural areas is the conservation of utilized agricultural land. This requires measures and activities which lead to preserving and restoring agricultural land and preventing its deterioration. Keeping a high level of soil fertility is therefore vital, without which agricultural production and forestry would not be possible. Controlling soil erosion and restoring the nutrient content of soils are the major activities. Not only its

sustainable use and management are important, but also making sure that there is no significant loss of agricultural land in rural areas. This measure is important to keep the agriculturally productive areas big enough to meet the high food demands. Organic fruit, vine and horticultural production are seen as the best activities to reach this goal. Integrated production together with organic production is also seen to contribute substantially to the conservation of utilized agricultural land (Appendix I, Figure 12). Conservation of agricultural land is also backed by measures such as the preservation of crop rotation and litter meadows, the maintenance of cultivated and populated landscape in protected areas, besides organic and integrated agricultural production. The main target is the maintenance of agricultural activities and to make agricultural production the backbone of economic activities in rural areas. Maintaining agricultural activities in the rural areas with all their related projects is a direct way of creating and securing employment. Sustainability of these activities is therefore a vital component when planning and implementing them.

Preservation of autochthonous and traditional domestic animal breeds is supported by the rearing of indigenous and traditional domestic animal breeds as shown by its weight of 0,232. The weight of 0,046 was allocated to organic fruit, vine and horticultural production, mountain pastures with herdsman and sustainable rearing of domestic animals, measures which rank second to the preservation of autochthonous and traditional domestic animal breeds. With the weight of 0,023, reduction of soil erosion in fruit and wine growing, preservation of crop rotation, greening of arable land, integrated crop, fruit, vine and horticultural production, organic crop production, mountain pastures without herdsman, mowing step slopes with 30-50% and over 50% inclination, mowing humpy meadows, maintaining meadow orchards and production of indigenous and traditional agricultural plant varieties, maintaining extensive grassland, maintaining animal husbandry in areas with large carnivores, preservation of special grassland habitats, preservation of grassland habitats for butterflies, preservation of litter meadows, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, maintaining cultivated and populated landscape on protected areas and permanent green cover on fallow land rank third (Appendix II, Figure 13).

Maintaining agricultural activities in rural areas could also be assisted by rearing indigenous and traditional domestic animal breeds and producing indigenous and traditional agricultural plant varieties which make an enormous contribution to reducing the decline of agricultural biodiversity and biodiversity at large. In areas with harsh conditions for agriculture, traditional domestic animal breeds and plant varieties could play a significant role in preserving agriculture. With the changing climate that is causing floods and droughts, traditional animal breeds and plant varieties might get enough attention as genetic sources for resistant species. The significance of traditional animal breeds and plant varieties for breeding purposes has long been recognized. In developing countries domestic animal breeds and plant varieties may certainly be the answer to alleviating poverty and hunger. Organic agriculture, mountain pastures with herdsman, the sustainable rearing of domestic animals and rearing indigenous and traditional domestic animal breeds are seen as a means of improving rural areas.

The distribution of the weights of measures with respect to preservation of autochthonous and traditional domestic plant varieties has the production of indigenous of indigenous and traditional plant varieties with a weight of 0,218 as the most important measure, followed by organic fruit, vine and horticultural production, mountain pastures without herdsman, mowing steep slopes with 30-50% and over 50% inclination, mowing humpy meadows and maintaining meadow orchards with the weight 0,043 as auxiliary measures for the preservation of indigenous of indigenous and traditional plant varieties, targeting the maintenance and preservation of natural environment. The weight of 0,022 was allocated to reduction of soil erosion in fruit and wine growing, preservation of crop rotation, greening of arable land, integrated crop, fruit, vine and horticultural production, organic crop production, mountain pastures with herdsman, rearing of indigenous and traditional domestic animal breeds, sustainable rearing of domestic animals, maintaining extensive grassland, maintaining animal husbandry in areas with large carnivores, preservation of special grassland habitats, preservation of grassland habitats for butterflies, preservation of litter meadows, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, maintaining cultivated and populated

landscape on protected areas and permanent green cover on fallow land (Appendix II, Figure 14).

The weights of measures with respect to preservation of agriculture in less favoured areas are 0,112 for organic fruit, vine and horticultural production, 0,042 for integrated crop, fruit, vine, horticultural and organic crop production, 0,022 for reduction of soil erosion in fruit and wine growing, preservation of crop rotation, greening of arable land, mountain pastures without herdsman, mowing steep slopes with 30-50% and over 50% inclination, mowing humpy meadows and maintaining meadow orchards, rearing of indigenous and traditional domestic animal breeds, production of indigenous of indigenous and traditional plant varieties, sustainable rearing of domestic animals, maintaining extensive grassland, maintaining animal husbandry in areas with large carnivores, preservation of special grassland habitats, preservation of grassland habitats for butterflies, preservation of litter meadows, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, maintaining cultivated and populated landscape on protected areas and permanent green cover on fallow land and mountain pastures with herdsman (Appendix II, Figure 15).

The best way to preserve agriculture in less favoured areas (LFA) is shown to be through organic and integrated production methods (Appendix II, Figure 15). Less favoured areas are distinguished by their unfavourable conditions for agricultural activities. They are usually mountainous or their soils are poor and stony. In LFA, sustainability of agriculture and other land use forms resembles “struggle for survival”. It is therefore crucial to find suitable agricultural activities to prevent their abandonment. Rearing goats or sheep is an example of a very suitable activity for these areas owing to their undemanding nature with respect to feed. Čermák et al. (2013) state that “an important part of farming in less-favoured areas (LFA) is ruminant keeping”. Sossidou et al. (2013) observed that “sheep and goat farming is considered to be one of the most dynamic sectors of the rural economy in Greece, both in terms of employment and overall income. Majority (over 85%) of the sheep and goats flocks are being reared in mountainous and disadvantageous areas”. All agricultural activities that involve nature conservation and maintenance can help to raise

the economic, social and recreational value of LFA. Behind all these activities are three goals which should be achieved concurrently: environmental protection, profitability of activity and social accountability.

The weight of 0,04 was allocated to the following measures with respect to conservation of typical cultural landscape, specific features and natural habitats: reduction of soil erosion in fruit and wine growing, preservation of crop rotation, greening of arable land, integrated crop, fruit, vine and horticultural production, organic crop, fruit, vine and horticultural production, mountain pastures with and without herdsman, mowing steep slopes with 30-50% and over 50% inclination, preservation of grassland habitats for butterflies, preservation of litter meadows, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, maintaining cultivated and populated landscape on protected areas and permanent green cover on fallow land, 0,02 to mowing humpy meadows, maintaining meadow orchards, rearing of indigenous and traditional domestic animal breeds, production of indigenous and traditional agricultural plant varieties, sustainable rearing of domestic animals, maintaining extensive grassland, maintaining animal husbandry in areas with large carnivores and preservation of special grassland habitats (Appendix II, Figure 16). The same weight of 0,04 is given to 21 agricultural activities and activities that contribute to maintenance and protection of the landscape, thus stating that they are the best tools for conservation of typical cultural landscape, specific features and natural habitats. The other eight measures are considered to be half as effective, which does not completely take them out of consideration. Looking at the proposed measures mentioned in the European Landscape Convention (ELC), it is quite apparent that all the 29 agri-environmental measures are relevant to protecting and managing the agricultural landscape.

Agriculture directly influences the landscapes in rural areas around the world. Agricultural landscapes are cultural landscapes which are constantly changing. Rural landscapes change as a result of changing agricultural landscape, with “great implications for biodiversity, cultural heritage, recreation and other functions” (Primdahl et al. 2013). Farmers are in constant interaction with the landscape. For that reason, carrying out conservation of

typical cultural landscape, specific features and natural habitats is a logical activity which makes the farmer an environmental or ecological manager as well. Agricultural landscapes surely shelter many organisms; they also sometimes shelter valuable cultural heritage. The value of agricultural and other landscapes has long been realised in Europe which led to the signing of the ELC which "was opened for signature for the member states of the Council of Europe in Florence, Italy, on 20 October 2000 and came into force in 2004" (Jones et al. 2007). The ELC aims at management, protection and planning of European landscapes. Article 5 of the convention proposes general measures which could be harmonised with each member state´s policies. Each member state commits itself to (Council of Europe 2000):

- recognizing landscapes in law as an essential component of people's surroundings, an expression of the diversity of their shared cultural and natural heritage, and a foundation of their identity
- setting up and implementing landscape policies aimed at landscape protection, management and planning
- establishing procedures for the participation of the general public, local and regional authorities, and other parties with an interest in the definition and implementation of the landscape policies
- integrating landscape into its regional and town planning policies and in its cultural, environmental, agricultural, social and economic policies, as well as in any other policies with possible direct or indirect impact on landscape.

The general measures are facilitated by specific measures like (Council of Europe 2000):

- raising awareness among the local population, private organisations and public authorities of the value and role of landscapes,
- training for specialists, multidisciplinary training for professionals and offering school and university courses in landscape policy, management, protection and planning,

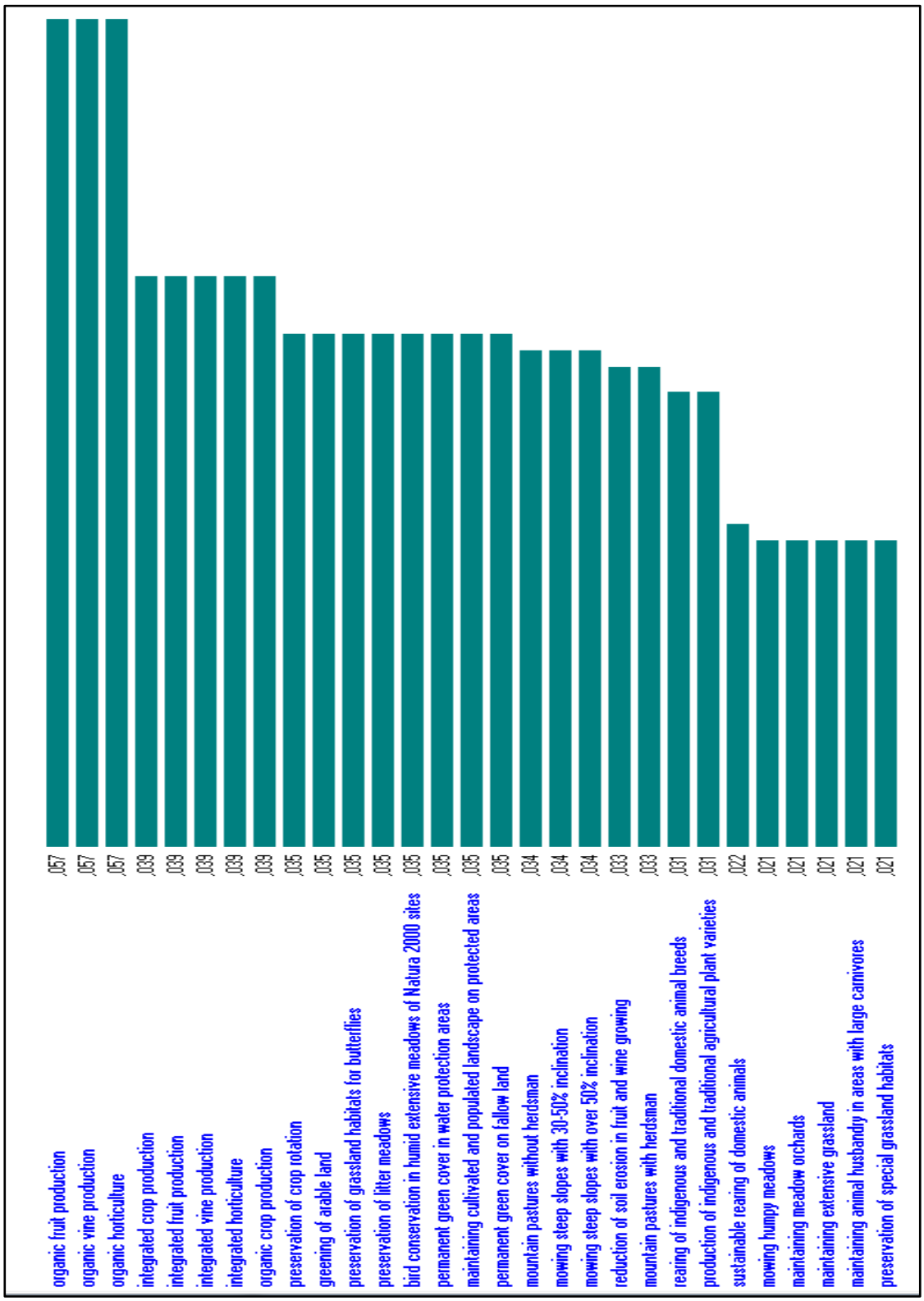
- identifying landscapes on the country´s territory, analysing their characteristics and taking note of changes that take place,
- defining landscape quality objectives
- establishing instruments which assist the execution of policies

With respect to criteria "improve the rural areas to prevent marginalisation", the weights of measures organic fruit, vine and horticultural production dominate over the others with 0,057. The weight 0,039 was assigned to integrated crop, fruit, vine, horticultural and organic crop production. 0,035 was assigned to preservation of crop rotation, greening of arable land, preservation of grassland habitats for butterflies, preservation of litter meadows, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, maintaining cultivated and populated landscape on protected areas and permanent green cover on fallow land, 0,034 to mountain pastures without herdsman, mowing steep slopes with 30-50% and with over 50% inclination, 0,033 to reduction of soil erosion in fruit and wine growing and mountain pastures with herdsman, 0,031 to rearing of indigenous and traditional domestic animal breeds as well as production of indigenous and traditional agricultural plant varieties, 0,022 to sustainable rearing of domestic animals, 0,021 to mowing humpy meadows, maintaining meadow orchards, maintaining extensive grassland, maintaining animal husbandry in areas with large carnivores and preservation of special grassland habitats (Figure 5).

Besides the measures organic fruit, vine and horticultural production with a distinct weight, integrated crop, fruit, vine and horticultural production, preservation of crop rotation, greening of arable land, preservation of grasslands habitats for butterflies, preservation of litter meadows, bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover on fallow land, and permanent green cover in water protection areas, maintaining cultivated and populated landscape in protected areas and permanent green cover on fallow land are also seen to make a considerable contribution to improve rural areas to prevent marginalisation. The rest of the measures should not be ignored as

they also contribute significantly to improving rural areas to prevent their marginalisation. As long as agricultural and other relevant activities in the rural areas are enhanced and sustained, there is due to be a creation of jobs which are crucial for the development of rural areas. Agricultural and forestry activities and all activities related to diversification of sources of income together with the provision of social and public services will upgrade rural areas.

Figure 5: Weights of measures with respect to criteria “improve the rural areas to prevent marginalisation”



4.4 Overall goal

Organic fruit, vine and horticultural production rank first among the 29 AEM, with the weight 0,071, with respect to the overall goal "assessment of agri-environmental measures". Organic crop production ranks second with the weight 0,054, followed by integrated crop, fruit, vine and horticultural production with the weight 0,037. Ranking fourth are bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, and permanent green cover on fallow land, with the weight 0,036. Greening of arable land was allocated the weight 0,034, followed by preservation of crop rotation with 0,032. The weight 0,028 is allocated to four measures, reduction of soil erosion in fruit and wine growing, mountain pastures without herdsman, mowing steep slopes with 30-50% and over 50% inclination, 0,027 to preservation of grassland habitats for butterflies, preservation of litter meadows and to maintaining cultivated and populated landscape in protected areas. Maintaining meadow orchards received the weight 0,026, mowing humpy meadows and sustainable rearing of domestic animals 0,025. Ranking last with the weight 0,024 are mountain pastures with herdsman, rearing of indigenous and traditional domestic animal breeds, production of indigenous and traditional agricultural plant varieties, maintaining extensive grassland, maintaining animal husbandry in areas with large carnivores and preservation of special grassland habitats. That some AEM have the same weight and ranking indicates that those AEM are considered to have the same amount of contribution towards assessment of agri-environmental measures.

There is a slight difference between the weights of measures obtained using Excel spreadsheets (Table 12) and those obtained in Expert Choice (Appendix II, Figure 17). The differences in weight between 0,001 and 0,006 are negligible. The measures in the first 3 ranks are identical. The following ranks have some displacements of measures. Rank four has three matching measures; greening of arable land is ranked 4^{th} in Expert Choice and 5^{th} in Excel. Preservation of crop rotation ranks 5^{th} in Expert Choice and 6^{th} in Excel. Reduction of soil erosion in fruit and wine growing ranks 6^{th} in Expert Choice and 7^{th} in Excel; rank 7 therefore has three matches. Rank 8 matches completely. Mountain pastures

with herdsman ranks 9th in Expert Choice and 11th in Excel. Rank 10 has two matches; maintaining meadow orchards ranks 10th in Expert Choice and 9th in Excel. Rearing of indigenous and traditional domestic animal breeds and production of indigenous and traditional agricultural plant varieties rank 10th in Expert Choice and 11th Excel; rank 11 therefore has three matches.

4.4.1 Organic agriculture

Organic fruit, vine and horticultural production are very highly rated towards the overall goal, assessment of agri-environmental measures (Table 10; Appendix II, Figure 17). Organic crop production ranks second. Organic agriculture is a way of production which puts the greatest emphasis on environmental protection and consideration of animal welfare (Răducuţă, 2011). Organic agriculture, organic farming or biological agriculture are terms which describe the same method of cultivation or animal husbandry which renounces the use of synthetic inputs. Organic agriculture has environmental protection, sustainable agricultural production and the production of healthy food products as targets. The International Federation of Organic Agriculture Movements (IFOAM) and Research Institute for Organic Agriculture (FiBL) define organic agriculture as "a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation and science to benefit the shared environment and to promote fair relationships and a good quality of life for all involved". Kaswan et al. (2012) expand the task of organic agriculture to "optimization of land use and crop structure; efficient use of available organic fertilizing resources; agro-technical methods to protect crops from weeds; crop rotation; soil-protecting technologies for planned chemical land reclamation; preservation of agricultural and biological diversity at farms and its efficient utilization; stabilization of agro-landscapes through a uniform system of field-protecting forest belts; facilitation of proper use and preservation of water

Table 12: Overall weights of measures with respect to main goal "assessment of agri-environmental measures" calculated by Microsoft Excel, arranged by ranking

Measure	Priority weight	ranking
Organic fruit production	0,071	1
Organic vine production	0,071	1
Organic horticulture	0,071	1
Organic crop production	0,054	2
Integrated crop production	0,037	3
Integrated fruit production	0,037	3
Integrated vine production	0,037	3
Integrated horticulture	0,037	3
Bird conservation in humid extensive meadows of Natura 2000 sites	0,036	4
Permanent green cover in water protection areas	0,036	4
Permanent green cover on fallow land	0,036	4
Greening of arable land	0,034	5
Preservation of crop rotation	0,032	6
Reduction of soil erosion in fruit and wine growing	0,028	7
Mountain pastures without herdsman	0,028	7
Mowing steep slopes with 30-50% inclination	0,028	7
Mowing steep slopes with over 50% inclination	0,028	7
Preservation of grassland habitats for butterflies	0,027	8
Preservation of litter meadows	0,027	8
Maintaining cultivated and populated landscape in protected areas	0,027	8
Maintain meadow orchards	0,026	9
Mowing humpy meadows	0,025	10
Sustainable rearing of domestic animals	0,025	10
Mountain pastures with herdsman	0,024	11
Rearing of indigenous and traditional domestic animal breeds	0,024	11
Production of indigenous and traditional agricultural plant varieties	0,024	11
Maintaining extensive grassland	0,024	11
Maintaining animal husbandry in areas with large carnivores	0,024	11
Preservation of special grassland habitats	0,024	11

resources; usage of renewable resources; harmonious balance between crop and animal production through integrated farming and utilization of indigenous technical knowledge". According to EU regulations, agricultural products are termed organic when they conform to the regulations on organic production and labelling of organic products[14] and the farmed animal directive[15]. In the EU it is expected that organic agriculture goes beyond providing organic products, environmental services and protecting animal welfare; organic agriculture is expected to contribute to rural development. An increased environmental awareness and demand for organic products has led to a changed attitude towards the conventional agricultural production methods. This is not only true for Europe, it is a global trend. This has led to an increase in the share of agricultural land used for organic production. IFOAM and FiBL collected statistics which show that in 2009 37.2 million hectares of agricultural land worldwide were used for organic production by more than 1.8 million producers, data which was still prevailing in 2011. This makes up a share of 0.9 percent of the agricultural land of the 160 countries covered by the survey. The organic area increased by two million hectares compared to the previous year (FiBL and IFOAM 2011). The largest areas of agricultural land under organic cultivation are found in Latin America, Oceania and Europe. Organic agriculture has been increasing rapidly in the EU and worldwide in the past years following the high demand for products produced under environmental friendly conditions and conditions which take animal welfare into consideration. In 2012, of the 174 million hectares utilised agricultural area[16] (UAA) in the EU-28, 9,6 million hectares was under organic farming (EC 2013), a share of just 5,5%. An ambitious goal could be to increase organic farming which contributes to:

- High quality agricultural products
- Clean drinking water
- Soils of good quality and fertility
- Non-polluted environment

[14] Regulation No 834/2007 and No 889/2008
[15] Directive 98/58/EC
[16] Utilised agricultural area is the total area used for farming; this includes arable land, permanent grassland, land under permanent crops (e.g. fruit and grapes), and other utilised agricultural areas (EC 2013).

- Enrichment of rural ecosystems by increasing biodiversity
- Sustainability of agricultural production and generation of income

4.4.2 Integrated agriculture

On the other hand food security is threatened by changing or unreliable weather conditions, social and economic turbulences (McLaughlin 2011). As a result, intensive agricultural production might still be practiced for a long time at the cost of the environment in which it is taking place; degradation of agro-ecosystems is the outcome, risking the loss of the ecological foundation upon which agriculture is based. Integrated agricultural production is a sustainable alternative. Table 63 shows integrated crop, fruit and vine production together with integrated horticulture ranking third, a significant contribution towards the assessment of agri-environmental measures as a whole. They are the second group of measures that are considered to make a considerable contribution.

The biggest challenge agriculture faces today is to maintain productivity with less external inputs and maximum sustainability. The world needs agricultural production methods which preserve soil fertility, include environmental aspects and at the same time ensure adequate food production. For all three aspects, integrated agriculture could therefore be a sustainable alternative to conventional farming. Integrated agriculture can be seen from the aspect of combining animal with crop production and aquaculture in a supplementary and complementary manner (Agbonlabor et al. 2003 cited by Dadabhau and Kisan 2013) or the combination of conventional with organic agricultural production methods. Integrated agriculture also means reducing the intensive use of one or several of the four main elements of agricultural production: soil tillage, nutrient input, pesticides and crop rotation, a big step towards sustainable agricultural production (Hiltbrunner et al. 2008). A decade ago Hall (2004, cited by Hiltbrunner et al. 2008) stated that “the long-term (economic) practicability of any less intensive cropping system largely depends on successful weed control” because “at present, herbicides account for the highest percentage of pesticides used in agriculture worldwide". Today, scientists endeavour to find methods of pest control which conform to today´s environmental standards.

Despite the global environmental awareness, it cannot be disputed that the overall use of pesticides has increased at an alarming pace though a significant reverse in the consumption structure since the 1960s has been observed (Longo and York 2008, Zhang et al. 2011). Today more herbicides are being used than insecticides, fungicides and other pesticides.

The International Organisation for Biological and Integrated Control (IOBC) has been devoted to environmentally safe methods of pest and disease control since 1955, the idea of integrated plant protection was born in 1977 (www.iobc-global.org, Boller et al. 1998 and 2004, Lopes et al. 2009). IOBC has a holistic approach to pest and disease control today, their guidelines and proposals have found use worldwide. IOBC defines integrated production or integrated farming (IP or IF) as "a farming system that produces high quality food and other products by using natural resources and regulating mechanisms to replace polluting inputs and to secure sustainable farming with emphasis on:

• a holistic systems approach involving the entire farm as the basic unit,
• the central role of agro-ecosystems,
• balanced nutrient cycles, and
• the welfare of all species in animal husbandry" (Boller et al. 2004).

The objectives of IF set by IOBC decades ago are still valid today (Boller et al. 2004):

- Incorporating natural resources and regulating mechanisms into agricultural activities to attain the maximum reduction of external inputs. Rational and indulgent use of natural resources might be the key to replacing external inputs like fertilisers and pesticides. Reducing or abandoning them is not only helpful for environmental protection; it also helps to reduce production costs thus improving the financial status of the farm.
- Safeguarding sustainable production of healthy and high quality food and other agricultural products using environmentally sound methods. The quality of agricultural products is not only judged by their external or internal characteristics. It also includes conditions under which they are produced: all sustainable production techniques, ethics in animal husbandry and fair treatment of farm workers.

- Sustaining farm income by practising fair trade as much as possible. High quality and safe farm products originating from ecologically, ethically and socially sound production practices must be able to ensure at least basic income for the farmer.
- Eradicating or curtailing the sources of pollution caused by agriculture.
- Sustaining the multiple function of agriculture especially in the rural areas. Agricultural activities are not just limited to food and fibre production. Agriculture takes up tasks like wildlife conservation (see p. 22, Footnote 2), landscape management and management of agricultural and non-agricultural recreational areas with the environmental aspect as the driving force (ecotourism, agrotourism).

4.4.3 Biological diversity or Biodiversity

Bird conservation in humid extensive and meadows of Natura 2000 sites is also highly rated, a nature conservation measure which contributes to stopping the decline of biological diversity. The Convention on Biological Diversity[17] (CBD) defines biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems". Biodiversity is not just about animals, plants, microorganisms and their ecosystems; it is also about human beings and their need for food security, medicines, fresh air and water, shelter and clean and healthy surroundings in which to live. "Biodiversity is therefore crucial for the production of marketed and non-marketed ecosystem goods and services" (Palmer and Di Falco 2012). The global concern about declining biodiversity is justified considering the development of agriculture since the 1960s and its contribution to the rapid deterioration of conditions for living organisms and their ecosystems. Since then, the global population has more than doubled, which has led to an increased demand for agricultural goods and services. The Growing population has been faced with a stagnant amount of agricultural land so far. Demand to change natural land cover to agricultural land will keep increasing.

[17] CBD was introduced at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro and opened for signature. It came into force on 29 December 1993.

Thus, the decline of biodiversity might be associated with the decrease of the space in which flora and fauna naturally exist. With the habitats[18] and birds directive[19] the EU compiled two sets of regulations aiming at the conservation, protection and improvement of species and their habitats, therefore stopping the dwindling away of biodiversity. The two directives are implemented taking into consideration the economic, social, cultural and regional requirements as well as capabilities and may need the maintenance and encouragement of human activities (EC 2009). The habitats directive targets wild species of fauna and flora threatened by deteriorating habitats and contributes to the conservation and maintenance of their natural habitats. In turn, this ensures biodiversity (EC 1992). Farmers and their agricultural activities can be well integrated into this project. The UAA and the space within its range is an ecosystem which needs to be taken care of and maintained to keep it close to its natural condition where it is possible.

Preservation of grassland habitats for butterflies might seem to have no direct link to agriculture but the contrary is true. Loss, degradation, disturbance and fragmentation of habitats for butterflies are possible results of agricultural and forestry activities. Conservation efforts on the field margins could be an act to show appreciation of biodiversity, respect of habitats and willingness to contribute to stable agro-ecosystems. Field margins and their conservation are widely accepted "as a means of promoting conservation value of arable land" (Cole et al. 2012); they help to enhance heterogeneity of landscape and wildlife populations around intensively cultivated agricultural land.
Farmers in the EU are already following the general practice of establishing green field margins (GFM) around their cultivated land which are also welcome habitats for butterflies, as recommended by the habitats directive[20]. The habitats directive gives guidelines on the preservation of habitats and the protection of endangered species. In Annex II of the directive "animal and plant species of community interest whose conservation requires the designation of special areas of conservation" are listed and in Annex IV those that need strict protection. Among the animal species mentioned are 29

[18] Directive 92/43/EEC
[19] Directive 2009/147/EC
[20] Directive 92/43/EEC

butterfly species (van Swaay et al. 2012). To give further help to everyone who wishes or intends to take action for one of the listed butterfly species, van Swaay et al. (2012) "compiled an overview of the habitat requirements and ecology of each species, as well as information on their conservation status in Europe".

4.4.4 Land conservation and water protection

Measures of land conservation and water protection are also highly rated and they go hand in hand: permanent green cover on fallow land, greening of arable land, preservation of crop rotation and permanent green cover in water protection areas. The degradation of agro-ecosystems is mostly caused by the discharging of chemicals into the air, soil and water, thus contaminating them.

Permanent green cover on fallow land and greening of arable land do not only contribute to creating more habitats for wild fauna and flora but are also a significant contribution to combat soil erosion and leaching. The persistent transfer of nutrients from agricultural land to watersheds is still prevailing and still a global problem. Great effort has therefore been directed at reducing this agricultural nutrient leakage, the so called agricultural non-point source (ANPS) pollution, through regulations and incentives (Winsten et al. 2011, Fu et al. 2012). The role of farmers is self-evident and involves adoption of measures aiming at the protection, conservation and restoration of waterways and water bodies, for example (also see Shepheard and Norer, 2013):

- Reasonable use of fertiliser
- Prudent and specific use of pesticides
- Suitable crop rotation
- Appropriate soil protection measures
- Environmental oriented animal husbandry

Watershed management or watershed stewardship therefore has also come into focus in many parts of the world to help reduce ANPS pollution (Kang and Lee 2011, Zarkesh et al. 2011, Lin and Ueta 2012, Udias et al. 2012, Nerkar et al. 2013). As a consequence, researchers from various countries attempt to scientifically derive feasible water

management tools. Management of terrestrial water bodies, waterways and coastal areas is a great challenge and therefore calls for collaboration of national and local authorities, non-governmental organizations (NGO), farm and other land owners to have the best outcome. There has been an increased formation of community-based watershed organisations in the USA to enhance water quality, supported by state and federal government agencies as documented by Stedman et al. (2009). Winsten et al. (2011) on the other hand question the "current federal and state soil and water conservation programs which consist primarily of cost-sharing or compensating farmers for implementing a set of pre-defined best management practices" but do "not consider specific environmental outcomes or the cost-effectiveness of the program at the farm or watershed level". Hibbard and Lurie (2012) describe concerted efforts of community-based natural resources management (CBNRM) in the USA by forming watershed stewardship organisations on a collaborative basis, "typically involving local, state and federal agencies, private firms and landowners, non-governmental organisations such as environmental and economic development groups and watershed councils". A positive implication is the reduction of the contamination of drinking water.

Permanent green cover in water protection areas is a measure to reduce the contamination of drinking water and its sources. Water is a valuable resource which is "not a commercial product but a heritage and should be protected, defended and treated as such" as stated by the Water Framework Directive[21] (WFD) of the EU (EC, 2000). Drinking water has its sources on the surface and underground, which leads to the necessity to protect both run-off and groundwater from contamination, through "the prevention of sediment, nutrient and pesticide-laden runoff from entering waterways and greater habitat provision along riparian corridors[22]" (Shepheard and Norer, 2013). The important role of watersheds and catchments which also have to get special attention and their management stringently organised was elaborated in the previous paragraph. Besides recommendations and

[21] Directive 2000/60/EC
[22] Riparian corridors are areas around riverbanks and lakes (see Naiman and Decamps 1997).

opinions, legal instruments were put into place by the EU, to help attain a reasonable and effective contribution from the farmers and other land owners,.

WFD and environmental quality standards directive[23] (EQSD) provide a basis with the main objectives set towards a sustainable water policy in the EU, addressing qualitative and quantitative community water protection. Additional clear-cut directives target specific areas of water protection. The groundwater directive[24] (GWD) seeks to protect groundwater from degradation and chemical pollution, achieved by avoiding, preventing or reducing adverse amounts of hazardous pollutants from reaching groundwater. This includes regular control of the chemical status of ground water bodies with the help of a proposed list of hazardous chemicals and if essential, the enforcement of appropriate measures. To ensure clean and hygienic water meant for human consumption, the EU specified quality parameters in the drinking water directive[25] (DWD), which are essential to prevent health risks. To make sure that member states meet the requirements of the DWD, a monitoring of the drinking water quality is strongly recommended. The waste water directive[26] (WWD) and its annex regulate the management of domestic and industrial waste water which is a considerable problem in regard to eutrophication of water bodies, especially at the coastal areas. The primary objective of EU legislation on water is therefore the protection of source water.

4.5 Sensitivity analysis

The last step of AHP, sensitivity analysis, has been described in the previous sections of this work (see p 51). Figures 6, 7, 8 and 9 show sensitivity analyses in the dynamic presentation form. By moving the bars of one of the criteria back and forth, the values of all criteria and the weights of the measures are automatically adjusted accordingly.

Figure 6 shows the original ranking of the measures before varying the weights of the criteria (sub-objectives). The criteria weights are 33,3% for promoting environmental

[23]Directive 2008/105/EC
[24] Directive 2006/118/EC
[25] Directive 98/83/EC
[26] Directive 91/271/EEC

friendly agricultural practices, 24,1% for improving the rural areas to prevent marginalisation and 42,5% for production and economic consequences. The Organic fruit and vine production and organic horticulture are the most important measures with 6,5% each, followed by organic crop production with 5,2%, integrated crop, fruit, vine production and integrated horticulture with 3,6% each. Bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, and on fallow land and greening of arable land received 3,4% each. Preservation of crop rotation was allocated a weight of 3,3% and reduction of soil erosion in fruit and wine growing 3,0%.

By changing the priority weight of the criterion "promote environmental friendly agricultural practices" to 49,0% as shown in figure 7, organic fruit and vine production, organic horticulture kept their leading position as most important measures. Their weights increased to 7,5% each, followed by organic crop production which also got a bigger weight of 5,6%. Integrated crop, fruit, vine production and integrated horticulture each got 3,7%, a weight bigger than in figure 3. Bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, and on fallow land each have a weight of 3,6%. Greening of arable land went down to 3,3%, whereas preservation of crop rotation was reduced to 3,1% and reduction of soil erosion in fruit and wine growing was reduced to 2,6%.

By changing the priority weight of the criterion "improve the rural areas to prevent marginalisation" to 49,0% (figure 8), the ranking of the measures still stayed the same. Organic fruit and vine production, organic horticulture kept their leading position as most important measures but their weights were 6,3% each, less than in figure 7. They were followed by organic crop production with 4,8%. Integrated crop, fruit, vine production and integrated horticulture kept their weights of 3,7%, a weight slightly bigger than in figure 6. Bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas and on fallow land, greening of arable land and preservation of crop rotation each got a weight of 3,4%, reduction of soil erosion in fruit and wine growing 3,1%.

By changing the priority weight of the criterion "production and economic consequences" to 49,0% (figure 9), the there was no significant change in the weights of the measures

compared to figure 6. Organic fruit, vine and horticultural production kept their leading position as most important measures with weights of 6,4% each, less than in figure 7 but more than in figure 8. They were followed by the organic crop production with the weight of 5,2%. Integrated crop, fruit, vine production and integrated horticulture kept their weights of 3,6% each, compared to figure 6. Greening of arable land shows a weight of 3,5%. Bird conservation in humid extensive meadows of Natura 2000 sites, permanent green cover in water protection areas, permanent green cover on fallow land and preservation of crop rotation show weights of 3,4% each. The reduction of soil erosion in fruit and wine growing a weight of 3,1%.

The sensitivity graphs in figures 7-9 show changes in weights for the measures after altering the weights of the criteria but the measures kept their rankings. Since the AHP model used has more than three levels (see step 6 on p. 39), it was also possible to make a sensitivity test for the criteria (Appendix III).

Figure 6: Default sensitivity analysis

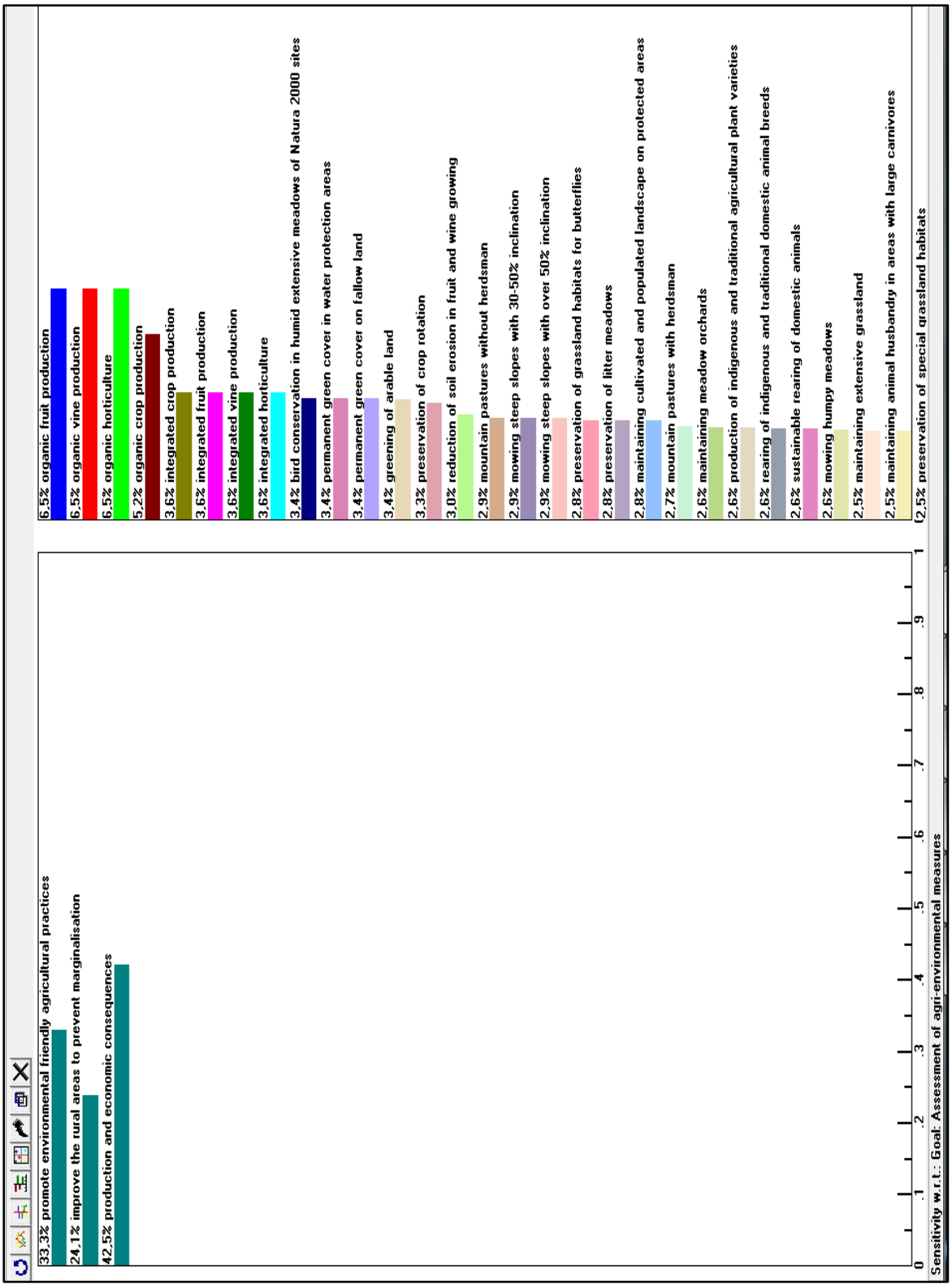


Figure 7: Sensitivity analysis with varied weight of the objective: promote environmental friendly agricultural practices

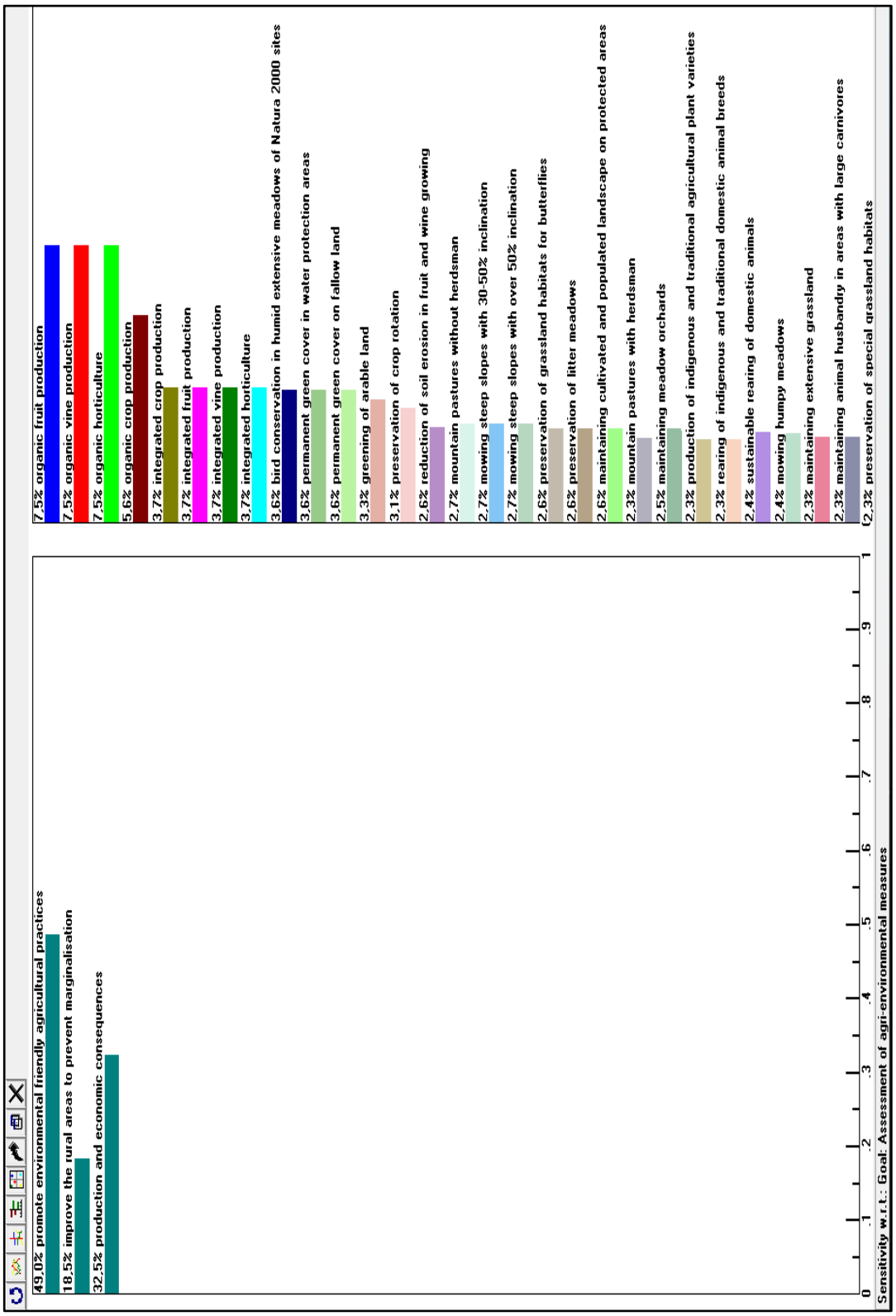


Figure 8: Sensitivity analysis with varied weight of the objective: improve the rural areas to prevent marginalisation

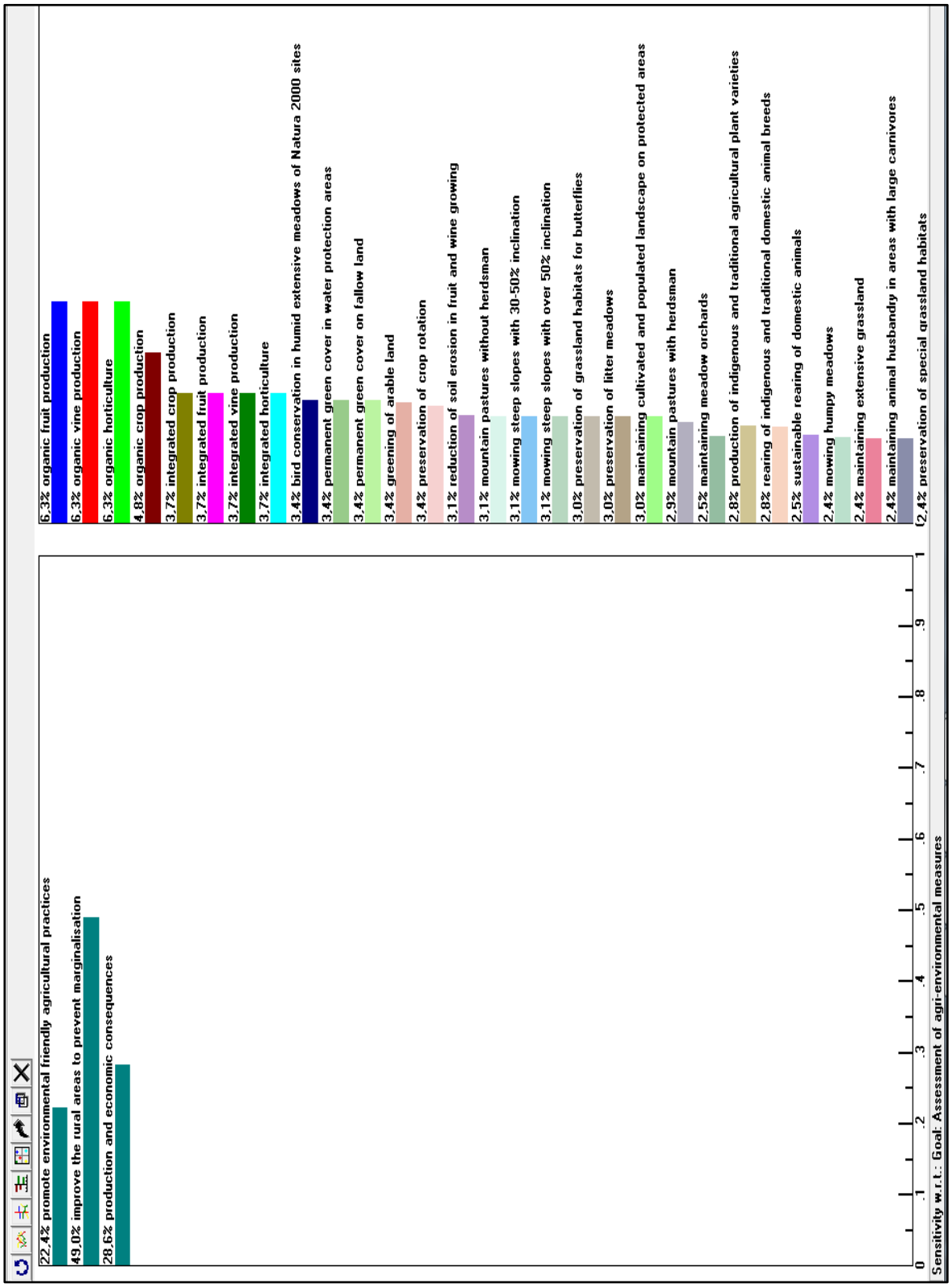
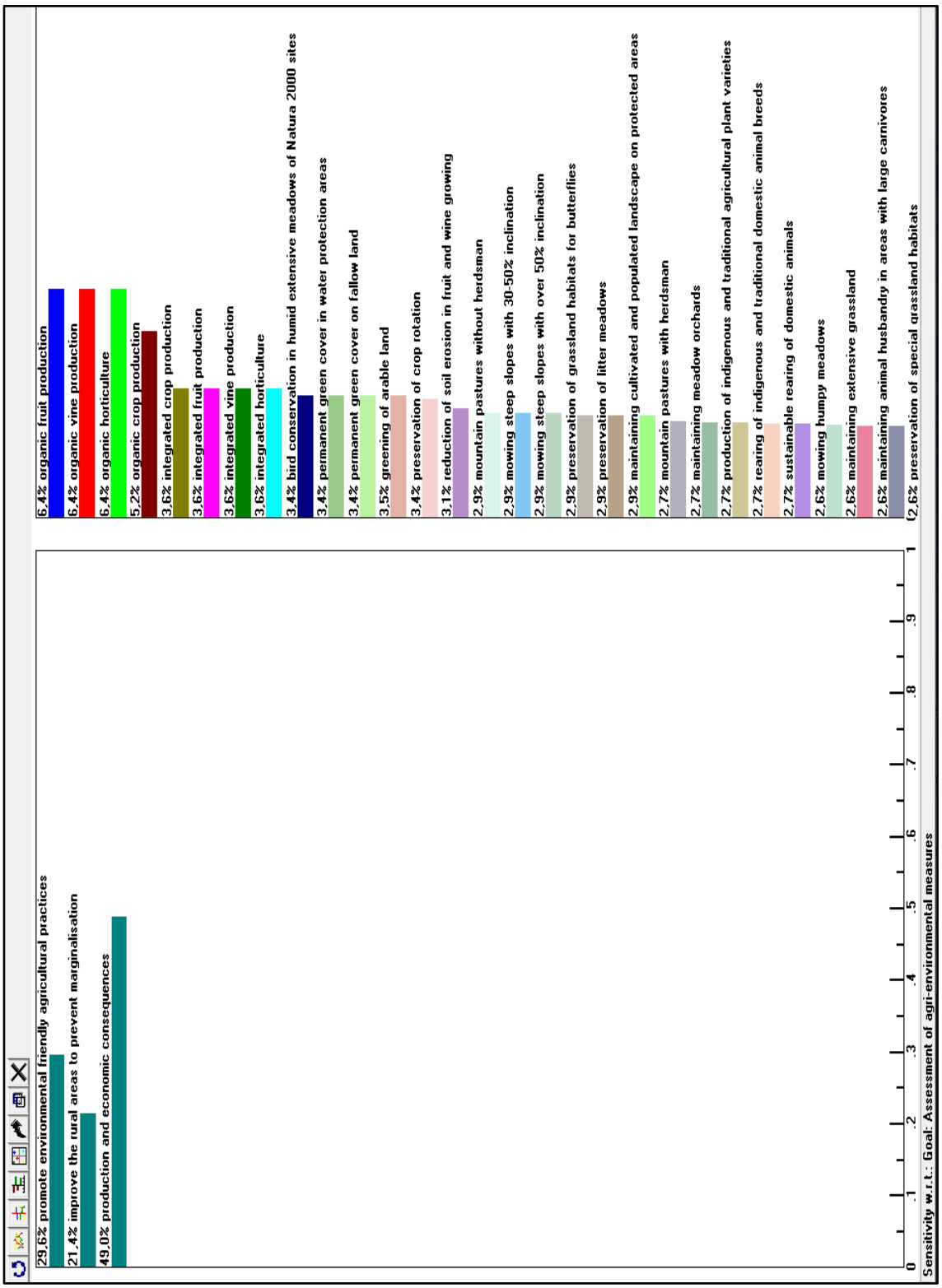


Figure 9: Sensitivity analysis with varied weight of the objective: production and economic consequences



5. CONCLUSIONS

In the hypothesis, a precise ranking of the measures was expected. Precise ranking means the single measures would have received weights which are only allocated to them individually, clearly distinguishing each measure. These weights would have led to individual ranks for each measure. This was not achieved because there are several measures with the same weight throughout the ranking. This does not have a negative impact on the interpretation of the results.

More than half of the work has been done in decision making procedures, when the problem has been well formulated (Meixner and Haas, 2010). This helps to get to the core of the problem. Determining the factors influencing the problem, which are required to build the hierarchy in AHP, is made easier. It is indisputable that AHP produces precise results. On the other hand it also requires precise handling of data and facts. AHP has been successfully used in organisational sciences, economics, the medical branch, industry, the energy branch, in business management or legal questions, to mention only a few (Saaty, 1990). "The Hierarchon", a dictionary of hierarchies compiled by Saaty and Forman (2003) with examples of how to structure decision problems, backs up the assumption that AHP has not been widely used in agriculture.

The attempt in this dissertation was to show how AHP can successfully be employed in agriculture by assessing the role of agri-environmental measures to improve agriculture and the countryside. The data for criteria and their attributes was extracted from the rural development programme (RDP) of the Republic of Slovenia. Arranging them in a hierarchy helped to analyse their interactions within the hierarchy and with respect to the main goal. Pairwise comparisons for this dissertation were done by experts, the data which was then successfully made AHP compatible using Microsoft Excel spreadsheets. The correct implementation of the next steps clearly set for AHP resulted in very comprehensive and reliable matrices which were used to calculate the weights at all levels of the hierarchy. Since the pairwise comparisons were done by several experts, the data had to be compressed by building the geometric mean using Microsoft Excel spreadsheets. This step was successfully carried out. Though it is time consuming, it is the best way to

take the different opinions involved in the assessment procedure into consideration. Compressing the data was necessary to be able to feed the information into the computer software programme Expert Choice.

Although AHP was originally designed for choosing one from numerous alternatives, it can also be successfully used to evaluate or assess problems. In group decisions, as it was in this dissertation, AHP can combine different interests, expertise and opinions of individuals. The results generated by AHP do not end debates on further action; they are a good basis for further discussion.

Looking at it strictly from a user´s and excluding the mathematical point of view, some of the constraints AHP has are:

- Expenses. Decision procedures usually affect many participants of different professions and educational levels, with different responsibilities and requirements. Using AHP at government, company or other administration levels is therefore very expensive because each of the stakeholders involved in the decision procedure should have a group decision version of EC and/or remote control voting boxes to enable performance of group decision without them having to convene.

- Time. Formulation of the problem and decomposing it into its smallest components and building the model is very time consuming. This needs long discussions to take the proposals, ideas and interests of all stakeholders involved into consideration and to select the best suitable components for the model. How well formulated a problem is and how well the model is built determines how realistic and applicable the outcome of the decision model is in practice. It also determines how fast a result is reached. In case the result is conflicting or illogical (inconsistent), pair-wise comparisons have to be repeated.

To be able to feed the growing world population and to have consideration for the environment at the same time, there is no way around integrated and organic agricultural production as parallel systems. Organic agriculture contributes to high quality, secure and healthy food as well as by-products, but not necessarily to the quantity needed to feed the

global population. It cannot keep pace with the fast growing world population. The results achieved in the assessment of agri-environmental measures show that this tendency has already been perceived. Promoting and supporting both integrated and organic agricultural production should therefore be given priority in the next programming periods with more emphasis on organic agriculture.

Rural areas and agricultural production are closely associated; rural areas are the only place with the natural resources which make agricultural production possible. Making rural areas attractive places to live is therefore vital. Provision of funds and the necessary infrastructures are therefore one of the major prerequisites to prevent the abandonment of farms. Farmers render services for humankind by taking care of the environment in which they produce their goods.

Rural areas also have recreational functions for the part of the population which lives in conurbations and big cities. Rural areas are also a repository for traditions and cultural heritage which need to be preserved.

That organic fruit, vine and horticultural production are the best measures towards agri-environmental measures is specific for Slovenia. Besides animal husbandry, fruit production and horticulture are the most important agricultural activities. Majkovic et al. (2005) still note that fruit production is the most thriving agricultural activity in Slovene agriculture. This fact is backed by Sušnik et.al, (2006) who state that in Slovenia fruit growing is a traditional agricultural practice. Vrišer (2002) stated that 2,6% of the agricultural area were used for fruit production. In 2006 Sušnik et.al still noted that “fruit is grown on 2–3% of all agricultural land in Slovenia”. This shows no increase in the fruit growing area. Crop production in Slovene agriculture has great significance in combination with animal production. This is because of Slovenia´s geographical features. Almost 500,000 hectares of land within Slovene boundaries are defined as less favoured areas (LFA). Vrišer (2002) states that in the census of the agricultural sector made in 2000 the proportion of Slovenia's total surface area of plains and low hills amounts to 36.4%, on which 54.5% of the utilized agricultural area is found, whereas on the karst regions that occupy about 25.3% of the total surface area, there is only 17.5% of utilized agricultural area, and in the high mountains (10.8%), only 3.5%. Agriculture together with forestry,

hunting and fishing contributed 2,06% to Slovenia´s GDP in 2008 (Esselink, 2009). Utilised agricultural area in Slovenia was 488.774 ha in 2009, 25 % of the country´s total surface area. 60% of the UAA is permanent grassland; more than 20% of the arable land are mostly used for gardens and to produce animal feed. The rest is used for orchards, olive groves and vineyards (Esselink, 2009).

6. SUMMARY

The objective of this dissertation was to apply the Analytic Hierarchy Process (AHP) to assess the agri-environmental measures showing at the same time how this most used multicriteria decision method can also be used for agricultural problems. As it can yield reliable results, AHP can be of great value when it comes to analysing or evaluating complex agricultural problems.

The intention of the assessment of agri-environmental measures was to get their precise ranking, which could be a basis for further discussions about the question which of the AEM are considered most useful and feasible. This information could also give an insight into the acceptability of the measures.

The most important step in AHP is formulation of the problem and determination of its components. AHP uses the principle of decomposition and aggregation. The formulated problem to be analysed or evaluated is decomposed into its smaller components. Arranging these components in a hierarchy makes the problem more comprehensible. The hierarchical structure of AHP consists of a main goal at the top, followed by criteria or sub-goals right below the main goal. The levels that follow can consist of stakeholders or attributes which contribute to the criteria. The last level at the bottom of the hierarchy consists of the alternatives, the tools one can choose from to reach the formulated main goal. AHP can have as many levels as necessary to simplify the problem.

The next step in AHP is the pairwise comparison of the elements at each level of the hierarchy to determine their weights which are necessary to get the priority weights of the alternatives. Pairwise comparison can be done with the help of Microsoft Excel spreadsheets or Expert Choice, a software programme developed to implement AHP. Control of the consistency of pairwise comparisons is necessary throughout the whole procedure by either calculating the Consistency Index in Microsoft Excel or by observing the Consistency Index calculated by Expert Choice. A consistency Index of 0,1 or 10% is

acceptable, a little more than 10% is also not a problem. Inconsistency means that pairwise comparisons should be repeated until a better result is achieved.

The advantages of hierarchies are (Saaty and Vargas, 2001):

- Hierarchies give very detailed information on the structure and functionality of a formulated problem. They show an outline of the stakeholders and all important factors that influence the functioning of the formulated problem
- The help to show the interactions of the identified components os a formulated problem. The effect of changes in values of components at the upper levels of the hierarchy on the ones at the lower levels can be clearly traced and understood.
- Hierarchies are stable and flexible. Small changes in a well-structured hierarchy will have little impact and additions will not disrupt its performance.

In many cases in the results obtained in this dissertation, one priority weight was assigned to several AEM towards the main goal, assessment of agri-environmental measures. This proved that those measures made an equal contribution to achieve the main goal. The results obtained in our assessment clearly show that organic and integrated production methods are seen to contribute most to achieving the set environmental goals and enhancing sustainable agricultural production. At the same time measures which contribute to stopping the decline of biodiversity and preventing contamination of drinking water and its sources are also seen as an integral part of agricultural activities.
That organic fruit, vine and horticultural production are seen as the most important AEM is specific for the Republic of Slovenia because of its large amount of area designated as Least Favoured Areas which are not suitable for arable farming.

6. POVZETEK

Cilj pričujoče doktorske disertacije je bila uporaba analitičnega hierarhičnega procesa (AHP) za ocenjevanje kmetijsko-okoljskih ukrepov, obenem pa smo želeli predstaviti, kako je to večkriterijsko metodo odločanja mogoče uporabiti pri vprašanjih na področju kmetijstva. Ker AHP zagotavlja zanesljive rezultate, je zelo pomemben pri analizi ali ocenjevanju kompleksnih vprašanj na področju kmetijstva.

Namen ocenjevanja kmetijsko-okoljskih ukrepov je bila njihova natančna razvrstitev, ki bi lahko predstavljala osnovo za nadaljnje razprave o tem, kateri kmetijsko-okoljski ukrepi so najbolj uporabni in izvedljivi. To informacijo bi prav tako lahko uporabili za ugotavljanje sprejemljivosti teh ukrepov ter načrtovanje politike v prihodnje.

Najpomembnejši korak pri AHP je oblikovanje hierarhije in določanje njenih sestavnih delov. AHP deluje po principih razčlenjevanja in združevanja. Oblikovano vprašanje, ki ga je potrebno analizirati ali oceniti, se razčleni v manjše sestavne dele. Za razumevanje vprašanja je potrebno te sestavne dele hierarhično razvrstiti. Hierarhična struktura AHP je sestavljena iz osrednjega cilja na vrhu, ki mu sledijo merila ali vmesni cilji, ki se nahajajo pod njim. Ravni, ki sledijo, so lahko sestavljene iz deležnikov ali atributov, ki vplivajo na merila. Zadnji nivo na dnu hierarhije je sestavljen iz alternativ, orodij, ki jih posameznik lahko izbere in s pomočjo katerih lahko oblikuje osrednji cilj. AHP lahko ima toliko nivojev, kot jih je potrebnih za razčlenitev vprašanja.

Naslednji korak pri AHP je parna primerjava teh sestavnih delov na vsakem hierarhičnem nivoju in določitev njihove učinkovitosti, ki so potrebne za določanje prioritetne učinkovitosti alternativ. Parno primerjavo je mogoče izvesti s pomočjo elektronske tabele v Microsoft Excelu ali v specialnem programu Expert Choice, ki je bil razvit za implementacijo AHP. Doslednost parnih primerjav je potrebno preverjati skozi celoten postopek, in sicer z izračunavanjem kazalnika doslednosti (ang. Consistency Index).

Kazalnik doslednosti vrednosti 0,1 oz. 10 % je sprejemljiv. Prav tako večjih težav ne predstavlja nekoliko povišana vrednost nad 10 %. Nedoslednost pomeni, da je parno primerjavo potrebno ponavljati, dokler ne dosežemo boljših rezultatov.

Prednosti hierarhične ureditve so (Saaty in Vargas 2001):

- Hierarhične ureditve dajejo zelo natančne podatke o strukturi in funkcionalnosti oblikovanega vprašanja. Prikazujejo oris deležnikov in vseh pomembnih faktorjev, ki vplivajo na delovanje oblikovanega vprašanja.
- Pomaga pri prikazovanju medsebojnega vpliva identificiranih sestavnih delov ali oblikovanega vprašanja. Tako je mogoče natančno izslediti in razumeti učinke sprememb na vrednosti sestavnih delov v zgornjih nivojih hierarhije na tiste v spodnjih nivojih.
- Hierarhije so nespremenljive in obenem fleksibilne. V dobro strukturiranih hierarhijah bodo imele majhne spremembe neznaten vpliv in dodatki ne bodo vplivali na učinkovitost.

V številnih primerih in rezultatih, ki smo jih pridobili v pričujoči doktorski disertaciji, smo eno prioritetno učinkovitost dodelili številnim kmetijsko-okoljskim ukrepom za doseganje osrednjega cilja, za ocenjevanje kmetijsko-okoljskih ukrepov. S tem smo dokazali, da so ti ukrepi enakovredno prispevali k doseganju osrednjega cilja. Rezultati, ki smo jih pridobili pri ocenjevanju, jasno kažejo, da ekološke in integrirane metode kmetijske pridelave najpomembneje prispevajo k doseganju zastavljenih okoljskih ciljev in izboljšujejo sonaravno kmetijsko pridelavo. Obenem pa so ukrepi, ki preprečujejo nadaljnje zmanjševanje biotske raznovrstnosti in kontaminiranosti pitne vode ter njenih virov, neločljiv sestavni del aktivnosti na področju kmetijstva.

Za Republiko Slovenijo je specifično, da ekološka pridelava sadja, vina in vrtnin spada med najpomembnejše kmetijsko-okoljske ukrepe.

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9. APPENDIX

APPENDIX I: Results of data acquisition, transformation of the collected data to pairwise matrices, calculation of priority weights and aggregation of expert judgements

The data collected via questionnaires was arranged in tables for a better view during the following steps.

Table 1: Assessment of the importance of criteria with respect to the main goal

	Criterion	Expert1	Expert2	Expert3	Expert4	Expert5
A	Promote environmental friendly agricultural production practices	7	8	5	8	7
B	Improve rural areas to prevent marginalisation	7	8	6	3	7
C	production and economic consequences	6	9	7	9	7

Table 2: Assessment of the importance of attributes with respect to "Promote environmental friendly agricultural production practices"

	Attribute	Expert1	Expert2	Expert3	Expert4	Expert5
A	Improve soil quality and fertility	7	8	4	8	7
B	Prevent pollution of drinking water and its sources	6	8	7	9	7
C	Reduce discharging of chemicals into the environment	9	7	6	9	7
D	Stop the decline of biodiversity	9	7	8	7	8

Table 3: Assessment of the importance of attributes with respect to "Improve the rural areas to prevent marginalization"

	Attribute	Expert1	Expert2	Expert3	Expert4	Expert5
A	Conservation of agricultural land	9	8	7	9	6
B	Preservation of autochthonous and traditional domestic animal breeds	7	7	8	7	7
C	Preservation of autochthonous and traditional domestic plant varieties	7	7	8	6	7
D	Preserve agriculture in less favoured areas	7	7	8	5	6
E	Conserve typical cultural landscape, specific features and natural habitats	7	7	7	6	6
F	Create employment	8	9	9	8	6

Table 4: Assessment of the importance of attributes with respect to "Production and economic consequences"

	Attribute	Expert1	Expert2	Expert3	Expert4	Expert5
A	Cost of measures	9	8	7	9	6
B	Complexity of the measures for the farmer	7	7	8	8	7
C	Create reliable conditions for marketing	7	6	7	8	8
D	Economic profitability for the farmer	7	8	8	7	9
E	Yield reduction due to change of production method	9	7	8	5	6
F	High quality and healthier agricultural food products	9	7	8	7	7

Steps 1-3 for turning questionnaire data (Table 1-4) into AHP compatible matrices are shown taking Table 2 as an example and using the letters A, B, C and D to represent the attributes. The following results are obtained:

Step 1: Raw pairwise comparisons

Expert1: A-B=1; A-C=-2; A-D=-2; B-C=-3; B-D=-3; C-D=0 (Table 15)
Expert2: A-B=0; A-C=1; A-D=1; B-C=1; B-D=1; C-D=0 (Table 17)
Expert3: A-B=-3; A-C=-2; A-D=-4; B-C=1; B-D=-1; C-D=-2 (Table 19)
Expert4: A-B=-1; A-C=-1; A-D=1; B-C=0; B-D=2; C-D=2 (Table 21)
Expert5: A-B=0; A-C=0; A-D=-1; B-C=0; B-D=-1; C-D=-1 (Table 23)

Step 2: Values for area above the diagonal of matrix, obtained by using the Microsoft Excel If-Function:

Expert1: 1+1=2; 1/(2+1)=1/3; 1/(2+1)=1/3; 1/(3+1)=1/4; 1/(3+1)=1/4, 0+1=1 (Table 16)
Expert2: 0+1=1; 1+1=2; 1+1=2; 1+1=2; 1+1=2; 0+1=1 (Table 18)
Expert3: 1/(3+1)=1/4; 1/(2+1)=1/3; 1/(4+1)=1/5; 1+1=2; 1/(1+1)=1/2; 1/(2+1)=1/3 (Table 20)
Expert4: 1/(1+1)=1/2; 1/(1+1)=1/2; 1+1=2; 0+1=1; 2+1=3; 2+1=3 (Table 22)
Expert5: 0+1=1; 0+1=1; 1/(1+1)=1/2; 0+1=1; 1/(1+1)=1/2; 1/(1+1)=1/2 (Table 24)

Step 3: Values for the area below the diagonal of matrix (reciprocals of values from step 2)

Expert1: 1/2; 1/(1/3)=3; 1/(1/3)=3; 1/(1/4)=4; 1/(1/4)=4, 1/1=1 (Table 16)
Expert2: 1/1=1; 1/2; 1/2; 1/2; 1/2; 1/1=1 (Table 18)
Expert3: 1/(1/4)=4; 1/(1/3)=3; 1/(1/5)=5; 1/2; 1/(1/2)=2; 1/(1/3)=3 (Table 20)
Expert4: 1/(1/2)=2; 1/(1/2)=2; 1/2; 1/1=1; 1/3; 1/3 (Table 22)
Expert5: 1/1=1; 1/1=1; 1/(1/2)=2; 1/1=1; 1/(1/2)=2; 1/(1/2)=2 (Table 24)

Step 1, level 2: Raw pairwise comparisons of criteria

Table 5: Expert 1

	A	B	C
A	1	0	1
B		1	1
C			1

Step 2 and step 3, Level 2: AHP compatible comparisons

Table 6: Expert 1

	A	B	C
A	1	1	2
B	1	1	2
C	1/2	1/2	1

Table 7: Expert 2

	A	B	C
A	1	0	-1
B		1	-1
C			1

Table 8: Expert 2

	A	B	C
A	1	1	1/2
B	1	1	1/2
C	2	2	1

Table 9: Expert 3

	A	B	C
A	1	-1	-2
B		1	-1
C			1

Table 10: Expert 3

	A	B	C
A	1	1/2	1/3
B	2	1	1/2
C	3	2	1

Table 11: Expert 4

	A	B	C
A	1	5	-1
B		1	-6
C			1

Table 12: Expert 4

	A	B	C
A	1	6	1/2
B	1/6	1	1/7
C	2	7	1

Table 13: Expert 5

	A	B	C
A	1	0	0
B		1	0
C			1

Table 14: Expert 5

	A	B	C
A	1	1	1
B	1	1	1
C	1	1	1

Step 1, Level 3: raw pairwise comparisons **of attributes to criteria 1**

Table 15: Expert 1

	A	B	C	D
A	1	1	-2	-2
B		1	-3	-3
C			1	0
D				1

Table 17: Expert 2

	A	B	C	D
A	1	0	1	1
B		1	1	1
C			1	0
D				1

Table 19: Expert 3

	A	B	C	D
A	1	-3	-2	-4
B		1	1	-1
C			1	-2
D				1

Table 21: Expert 4

	A	B	C	D
A	1	-1	-1	1
B		1	0	2
C			1	2
D				1

Table 23: Expert 5

	A	B	C	D
A	1	0	0	-1
B		1	0	-1
C			1	-1
D				1

Step 2 and step 3, Level 3: AHP compatible comparisons

Table 16: Expert 1

	A	B	C	D
A	1	2	1/3	1/3
B	1/2	1	1/4	1/4
C	3	4	1	1
D	3	4	1	1

Table 18: Expert 2

	A	B	C	D
A	1	1	2	2
B	1	1	2	2
C	1/2	1/2	1	1
D	1/2	1/2	1	1

Table 20: Expert 3

	A	B	C	D
A	1	1/4	1/3	1/5
B	4	1	2	1/2
C	3	1/2	1	1/3
D	5	2	3	1

Table 22: Expert 4

	A	B	C	D
A	1	1/2	1/2	2
B	2	1	1	3
C	2	1	1	3
D	1/2	1/3	1/3	1

Table 24: Expert 5

	A	B	C	D
A	1	1	1	1/2
B	1	1	1	1/2
C	1	1	1	1/2
D	2	2	2	1

Step 1, Level 3: raw pairwise comparisons **of attributes to criteria 2**

Table 25: Expert 1

	A	B	C	D	E	F
A	1	2	2	2	2	1
B		1	0	0	0	-1
C			1	0	0	-1
D				1	0	-1
E					1	-1
F						1

Table 27: Expert 2

	A	B	C	D	E	F
A	1	1	1	1	1	-1
B		1	0	0	0	-2
C			1	0	0	-2
D				1	0	-2
E					1	-2
F						1

Table 29: Expert 3

	A	B	C	D	E	F
A	1	-1	-1	-1	0	-2
B		1	0	0	1	-1
C			1	0	1	-1
D				1	1	-1
E					1	-2
F						1

Table 31: Expert 4

	A	B	C	D	E	F
A	1	2	3	4	3	1
B		1	1	2	1	-1
C			1	1	0	-2
D				1	-1	-3
E					1	-2
F						1

Table 33: Expert 5

	A	B	C	D	E	F
A	1	-1	-1	0	0	0
B		1	0	1	1	1
C			1	1	1	1
D				1	0	0
E					1	0
F						1

Step 2 and step 3, Level3: AHP compatible comparisons

Table 26: Expert 1

	A	B	C	D	E	F
A	1	3	3	3	3	2
B	1/3	1	1	1	1	1/2
C	1/3	1	1	1	1	1/2
D	1/3	1	1	1	1	1/2
E	1/3	1	1	1	1	1/2
F	1/2	2	2	2	2	1

Table 28: Expert 2

	A	B	C	D	E	F
A	1	2	2	2	2	1/2
B	1/2	1	1	1	1	1/3
C	1/2	1	1	1	1	1/3
D	1/2	1	1	1	1	1/3
E	1/2	1	1	1	1	1/3
F	2	3	3	3	3	1

Table 30: Expert 3

	A	B	C	D	E	F
A	1	1/2	1/2	1/2	1	1/3
B	2	1	1	1	2	1/2
C	2	1	1	1	2	1/2
D	2	1	1	1	2	1/2
E	1	1/2	1/2	1/2	1	1/3
F	3	2	2	2	3	1

Table 32: Expert 4

	A	B	C	D	E	F
A	1	3	4	5	4	2
B	1/3	1	2	3	2	1/2
C	1/4	1/2	1	2	1	1/3
D	1/5	1/3	1/2	1	1/2	1/4
E	1/4	1/2	1	2	1	1/3
F	1/2	2	3	4	3	1

Table 34: Expert 5

	A	B	C	D	E	F
A	1	1/2	1/2	1	1	1
B	2	1	1	2	2	2
C	2	1	1	2	2	2
D	1	1/2	1/2	1	1	1
E	1	1/2	1/2	1	1	1
F	1	1/2	1/2	1	1	1

Step 1, Level 3: raw pairwise comparisons **of attributes to criteria 3**

Table 35: Expert 1

	A	B	C	D	E	F
A	1	2	2	2	0	0
B		1	0	0	-2	-2
C			1	0	-2	-2
D				1	-2	-2
E					1	0
F						1

Table 37: Expert 2

	A	B	C	D	E	F
A	1	1	2	0	1	1
B		1	1	-1	0	0
C			1	-2	-1	-1
D				1	1	1
E					1	0
F						1

Table 39: Expert 3

	A	B	C	D	E	F
A	1	-1	0	-1	-1	-1
B		1	1	0	0	0
C			1	-1	-1	-1
D				1	0	0
E					1	0
F						1

Table 41: Expert 4

	A	B	C	D	E	F
A	1	1	1	2	4	2
B		1	0	1	3	1
C			1	1	3	1
D				1	2	0
E					1	-2
F						1

Table 43: Expert 5

	A	B	C	D	E	F
A	1	-1	-2	-3	0	-1
B		1	-1	-2	1	0
C			1	-1	2	1
D				1	3	2
E					1	-1
F						1

Step 2 and step 3, Level3: AHP compatible comparisons

Table 36: Expert 1

	A	B	C	D	E	F
A	1	3	3	3	1	1
B	1/3	1	1	1	1/3	1/3
C	1/3	1	1	1	1/3	1/3
D	1/3	1	1	1	1/3	1/3
E	1	3	3	3	1	1
F	1	3	3	3	1	1

Table 38: Expert 2

	A	B	C	D	E	F
A	1	2	3	1	2	2
B	1/2	1	2	1/2	1	1
C	1/3	1/2	1	1/3	1/2	1/2
D	1	2	3	1	2	2
E	1/2	1	2	1/2	1	1
F	1/2	1	2	1/2	1	1

Table 40: Expert 3

	A	B	C	D	E	F
A	1	1/2	1	1/2	1/2	1/2
B	2	1	2	1	1	1
C	1	1/2	1	1/2	1/2	1/2
D	2	1	2	1	1	1
E	2	1	2	1	1	1
F	2	1	2	1	1	1

Table 42: Expert 4

	A	B	C	D	E	F
A	1	2	2	3	5	3
B	1/2	1	1	2	4	2
C	1/2	1	1	2	4	2
D	1/3	1/2	1/2	1	3	1
E	1/5	1/4	1/4	1/3	1	1/3
F	1/3	1/2	1/2	1	3	1

Table 44: Expert 5

	A	B	C	D	E	F
A	1	1/2	1/3	1/4	1	1/2
B	2	1	1/2	1/3	2	1
C	3	2	1	1/2	3	2
D	4	3	2	1	4	3
E	1	1/2	1/3	1/4	1	1/2
F	2	1	1/2	1/3	2	1

The aggregation of the expert assessment values from the pairwise comparison matrices yielded the matrices in tables 45-48.

Table 45: Aggregated pairwise values of criteria, Level 2

	A	B	C
A	1	1,43	0,76
B	0,70	1	0,59
C	1,32	1,70	1

Table 46: Aggregated pairwise values of attributes to criterion 1, Level 3

	A	B	C	D
A	1	0,76	0,64	0,67
B	1,32	1	1	0,82
C	1,55	1,00	1	0,87
D	1,50	1,22	1,15	1

Table 47: Aggregated pairwise values of attributes to criterion 2, Level 3

	A	B	C	D	E	F
A	1	1,35	1,43	1,72	1,89	0,92
B	0,74	1	1,15	1,43	1,52	0,61
C	0,70	0,87	1	1,32	1,32	0,56
D	0,58	0,70	0,76	1	1	0,46
E	0,53	0,66	0,76	1	1	0,45
F	1,08	1,64	1,78	2,17	2,22	1

Table 48: Aggregated pairwise values of attributes to criterion 3, Level 3

	A	B	C	D	E	F
A	1	1,25	1,43	1,02	1,38	1,08
B	0,80	1	1,15	0,80	1,22	0,92
C	0,70	0,87	1	0,70	1	0,80
D	0,98	1,25	1,43	1	1,52	1,15
E	0,72	0,82	1	0,66	1	0,70
F	0,92	1,08	1,25	0,87	1,43	1

Taking the aggregated values in table 47, one of four methods of determining priority weights is shown in table 49.

Table 49: Calculation of priority weights

	A	B	C	D	E	F	A[27]	B	C	D	E	F	Sum of row[28]	Sum of row/6[29] (priority weights)	Sum of rows/diagonal
A	1	1,35	1,43	1,72	1,89	0,92	0,216	0,217	0,208	0,199	0,211	0,230	1,281	0,214	5,931
B	0,74	1	1,15	1,43	1,52	0,61	0,160	0,161	0,167	0,166	0,170	0,153	0,977	0,163	6,068
C	0,70	0,87	1	1,32	1,32	0,56	0,151	0,140	0,145	0,153	0,148	0,140	0,877	0,146	6,048
D	0,58	0,70	0,76	1	1	0,46	0,125	0,113	0,111	0,116	0,112	0,115	0,692	0,115	5,966
E	0,53	0,66	0,76	1	1	0,45	0,114	0,106	0,111	0,116	0,112	0,113	0,672	0,112	6,000
F	1,08	1,64	1,78	2,17	2,22	1	0,233	0,264	0,259	0,251	0,248	0,250	1,505	0,251	6,020
Sum of column	4,63	6,22	6,88	8,64	8,95	4,00	0,999	1,001	1,001	1,001	1,001	1,001	6,004	1,001	36,033

[27] Grey matrix…….normalised matrix
[28] Sum of row of normalised matrix
[29] Sum of row of normalised matrix divided by the size of matrix. Please note that AHP matrices are usually square matrices

Table 50: Aggregated expert judgements for measures

	Attributes → / Measures ↓	improve soil quality and fertility	prevent pollution of drinking water and its sources	reduce the dischargi ng of chemicals into the environm ent	stop the decline of biodiver sity	conservat ion of utilised agricultu ral land	preserva tion of autocht honous and tradition al domesti c animal breeds	preserva tion of autocht honous and tradition al domesti c plant varieties	preserv e agricul ture in less favour ed areas	conserv e typical cultural landsca pe, specific features and natural habitats	create emplo yment	cost of meas ures	comple xity of the measur es for the farmer	create reliable conditi ons for marketi ng	econom ic profitab ility of the measur es for the farmer	yield reducti on by changi ng metho d of produc tion	high quality and healthi er agricul tural food produc ts
1	reduction of soil erosion in fruit and wine growing	3	4	4	4	4	4	4	3	3,30	3,30	2	3	3	3	3	3
2	preservation of crop rotation	2	3	3	3	3	4	4	3	3,30	3,30	2	3	3	3	3	3
3	greening of arable land	2	3	2	3	3	4	4	3	3,30	3,30	2	3	3	3	3	3
4	integrated crop production	2	2	2	2	2	4	4	2	3,30	3,30	3	2	3	3	3	3
5	integrated fruit production	2	2,29	2,29	2,29	2,29	4	4	2	3,30	3,30	3	2	3	3	3	3
6	integrated vine production	2	2,29	2,29	2,29	2,29	4	4	2	3,30	3,30	3	2	3	3	3	3
7	integrated horticulture	2	2	2	2	2	4	4	2	3,30	3,30	3	2	3	3	3	3
8	organic crop production	1	1	2	2	2	4	4	2	3,30	3,30	4	1	1	1	3	3
9	organic fruit production	1	1,26	1,26	1,26	1,26	3	3	1	3,30	3,30	4	1	1	1	3	3

Table 50 continued: Aggregated expert judgements for alternatives

	Attributes → / Measures ↓	improve soil quality and fertility	prevent pollution of drinking water and its sources	reduce the dischargi ng of chemicals into the environm ent	stop the decline of biodivers ity	conservation of utilised agricultu ral land	preserva tion of autocht honous and tradition al domesti c animal breeds	preserva tion of autocht honous and tradition al domesti c plant varieties	preserv e agricul ture in less favour ed areas	conserv e typical cultural landsca pe, specific features and natural habitats	create emplo yment	cost of meas ures	comple xity of the measur es for the farmer	create reliabl e conditi ons for market ing	econom ic profitab ility of the measur es for the farmer	yield reducti on by changi ng metho d of produc tion	high quality and healthi er agricul tural food produc ts
10	organic vine production	1	1,26	1,26	1,26	1,26	3	3	1	3,30	3,30	4	1	1	1	3	3
11	organic horticulture	1	1,26	1,26	1,26	1,26	3	3	1	3,30	3,30	4	1	1	1	3	3
12	mountain pastures with herdsman	4	4	4	4	4	3	4	4	3,30	3,30	3	3	3	3	3	3
13	mountain pastures without herdsman	4	4	4	2	4	4	3	3	3,30	3,30	3	3	3	3	3	3
14	mowing steep slopes with 30-50% inclination	4	4	4	2	4	4	3	3	3,30	3,30	3	3	3	3	3	3
15	mowing steep slopes with over 50% inclination	4	4	4	2	4	4	3	3	3,30	3,30	3,30	3,30	3	3	3	3
16	mowing humpy meadows	4	4	4	2	4	4	3,30	3,30	3,63	3,63	3,30	3,30	3,30	3,30	3,30	3,30
17	maintaining meadow orchards	4	3	4	2	4	4	3,30	3,30	3,63	3,63	3,30	3,30	3,30	3,30	3,30	3,30
18	rearing indigenous traditional domestic animal breeds	4	4	4	4	4	1	4	3,30	3,63	3,63	3,30	3,30	3,30	3,30	3,30	3,30

Table 50 continued: Aggregated expert judgements for alternatives

	Attributes / Measures	improve soil quality and fertility	prevent pollution of drinking water and its sources	reduce the discharging of chemicals into the environment	stop the decline of biodiversity	conservation of utilised agricultural land	preservation of autochthonous and traditional domestic animal breeds	preservation of autochthonous and traditional domestic plant varieties	preserve agriculture in less favoured areas	conserve typical cultural landscape, specific features and natural habitats	create employment	cost of measures	complexity of the measures for the farmer	create reliable conditions for marketing	economic profitability of the measures for the farmer	yield reduction by changing method of production	high quality and healthier agricultural food products
19	production of indigenous and traditional agricultural plant varieties	4	4	4	4	3,30	4	1	3,30	3,63	3,63	3,30	3,30	3,30	3,30	3,30	3,30
20	sustainable rearing of domestic animals	4	3	3	3	3,30	3,30	4	3,30	3,63	3,63	3,30	3,30	3,30	3,30	3,30	3,30
21	maintaining extensive grassland	4	4	3	3	3,30	4	4	3,30	3,63	3,63	3,30	3,30	3,30	3,30	3,30	3,30
22	maintaining animal husbandry in areas with large carnivores	4	4	3	3	3,30	4	4	3,30	3,63	3,63	3,30	3,30	3,30	3,30	3,30	3,30
23	preservation of special grassland habitats	4	4	3	3	3,30	4	4	3,30	3,63	3,63	3,30	3,30	3,30	3,30	3,30	3,30
24	preservation of grassland habitats for butterflies	4	4	3	3	3	4	4	3	3,30	3,30	3	3	3	3	3	3

Table 50 continued: Aggregated expert judgements for alternatives

	Attributes / Measures	improve soil quality and fertility	prevent pollution of drinking water and its sources	reduce the discharging of chemicals into the environment	stop the decline of biodiversity	conservation of utilised agricultural land	preservation of autochthonous and traditional domestic animal breeds	preservation of autochthonous and traditional domestic plant varieties	preserve agriculture in less favoured areas	conserve typical cultural landscape, specific features and natural habitats	create employment	cost of measures	complexity of the measures for the farmer	create reliable conditions for marketing	economic profitability of the measures for the farmer	yield reduction by changing method of production	high quality and healthier agricultural food products
25	preservation of litter meadows	4	4	3	3	3	4	4	3	3,30	3,30	3	3	3	3	3	3
26	bird conservation in humid extensive meadows of natura 200 sites	3	1	3	3	3	4	4	3	3,30	3,30	3	3	3	3	3	3
27	permanent green cover in water protection areas	3	1	3	3	3	4	4	3	3,30	3,30	3	3	3	3	3	3
28	maintaining cultivated and populated landscape on protected areas	4	4	3	3	3	4	4	3	3,30	3,30	3	3	3	3	3	3
29	permanent green cover on fallow land	3	1	3	3	3	4	4	3	3,30	3,30	3	3	3	3	3	3

Synthesis of priority weights of measures to obtain the overall priority weight for each measure using Microsoft Excel spreadsheet was done by determining the sum of the product of criteria weights and measure weights with respect to criteria[30] (Table 51). Taking an example of the measures "Reduction of soil erosion in fruit and wine growing": 0,333*0,013+0,241*0,033+0,425*0,036 = 0,027578 and "Preservation of crop rotation": 0,333*0,025+0241*0,035+0,425*0,036 = 0,03206.

Table 51: Aggregation of priority weights of measures using Microsoft Excel spreadsheet

	promote environmental friendly agricultural practice	improve rural areas to prevent marginalisation	production and economic consequences	**priority weigh w. r. t. goal**	**ranking**
criteria weight with respect to goal →	0,333	0,241	0,425		
↓ priority weight of measure w. r. t. criteria ↓					
Reduction of soil erosion in fruit and wine growing	0,013	0,033	0,036	**0,028**	**7**
Preservation of crop rotation	0,025	0,035	0,036	**0,032**	**6**
Greening of arable land	0,03	0,035	0,036	**0,034**	**5**
Integrated crop production	0,04	0,039	0,033	**0,037**	**3**
Integrated fruit production	0,04	0,039	0,033	**0,037**	**3**
Integrated vine production	0,04	0,039	0,033	**0,037**	**3**
Integrated horticulture	0,04	0,039	0,033	**0,037**	**3**
Organic crop production	0,07	0,039	0,05	**0,054**	**2**
Organic fruit production	0,107	0,057	0,05	**0,071**	**1**
Organic vine production	0,107	0,057	0,05	**0,071**	**1**
Organic horticulture	0,107	0,057	0,05	**0,071**	**1**
Mountain pastures with herdsman	0,011	0,033	0,031	**0,025**	**11**
Mountain pastures without herdsman	0,02	0,034	0,031	**0,028**	**7**
Mowing steep slopes with 30-50% inclination	0,02	0,034	0,031	**0,028**	**7**
Mowing steep slopes with over 50% inclination	0,02	0,034	0,031	**0,028**	**7**
Mowing humpy meadows	0,02	0,021	0,031	**0,025**	**10**
Maintain meadow orchards	0,022	0,021	0,031	**0,026**	**9**
Rearing of indigenous and traditional domestic animal breeds	0,011	0,031	0,031	**0,024**	**11**

[30] Obtained from Expert Choice

Table 51 continued: Aggregation of priority weights of measures

	promote environmental friendly agricultural practice	improve rural areas to prevent marginalisation	production and economic consequences	**priority weight towards goal**	**ranking**
criteria weight with respect to goal →	0,333	0,241	0,425		
↓ priority weight of measure w. r. t. criteria ↓					
Production of indigenous and traditional agricultural plant varieties	0,011	0,031	0,031	**0,024**	**11**
Sustainable rearing of domestic animals	0,019	0,022	0,031	**0,025**	**10**
Maintaining extensive grassland	0,017	0,021	0,031	**0,024**	**11**
Maintaining animal husbandry in areas with large carnivores	0,017	0,021	0,031	**0,024**	**11**
Preservation of special grassland habitats	0,017	0,021	0,031	**0,024**	**11**
Preservation of grassland habitats for butterflies	0,017	0,035	0,031	**0,027**	**8**
Preservation of litter meadows	0,017	0,035	0,031	**0,027**	**8**
Bird conservation in humid extensive meadows of natura 200 sites	0,043	0,035	0,031	**0,036**	**4**
Permanent green cover in water protection areas	0,043	0,035	0,031	**0,036**	**4**
Maintaining cultivated and populated landscape in protected areas	0,017	0,035	0,031	**0,027**	**8**
Permanent green cover on fallow land	0,043	0,035	0,031	**0,036**	**4**

In this work, priority weights of criteria and attributes in Expert Choice were generated with respect to their importance. The priority weights of measures obtained in Table 51 make it possible to make a ranking of the measures with respect to their importance, preference or likelihood. The chronological ranking of agri-environmental measures with respect to their importance is shown in Table 12. We also had the option of extracting the global priority weights of measures from Expert Choice but chose to use the ones calculated by Microsoft Excel for this dissertation.

APPENDIX II: Weights of measures with respect to attributes and main global (Expert Choice)

Figure 1: Weights with respect to "Economic profitability for the farmer"

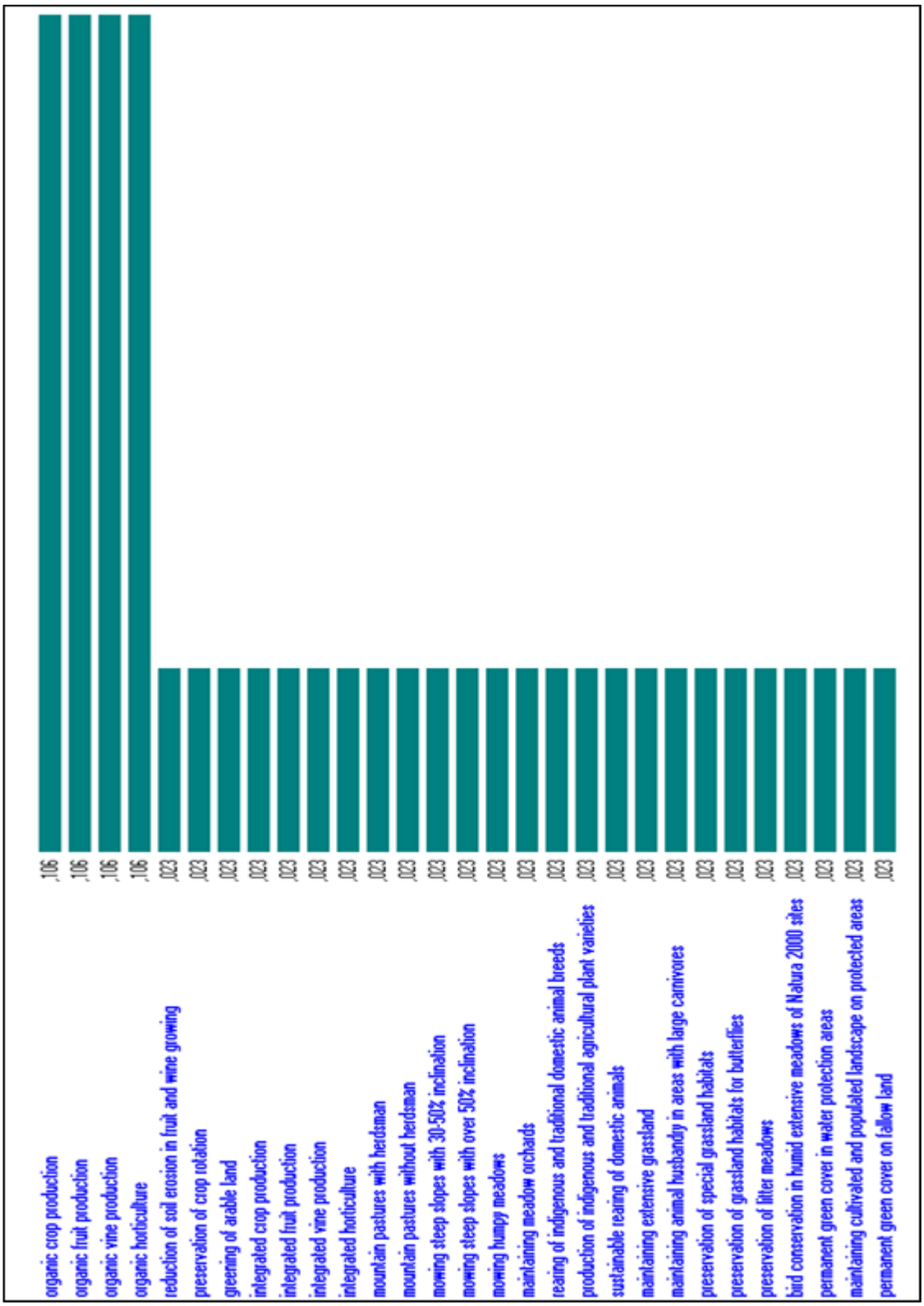


Figure 2: Weights of measures with respect to “cost of measures”

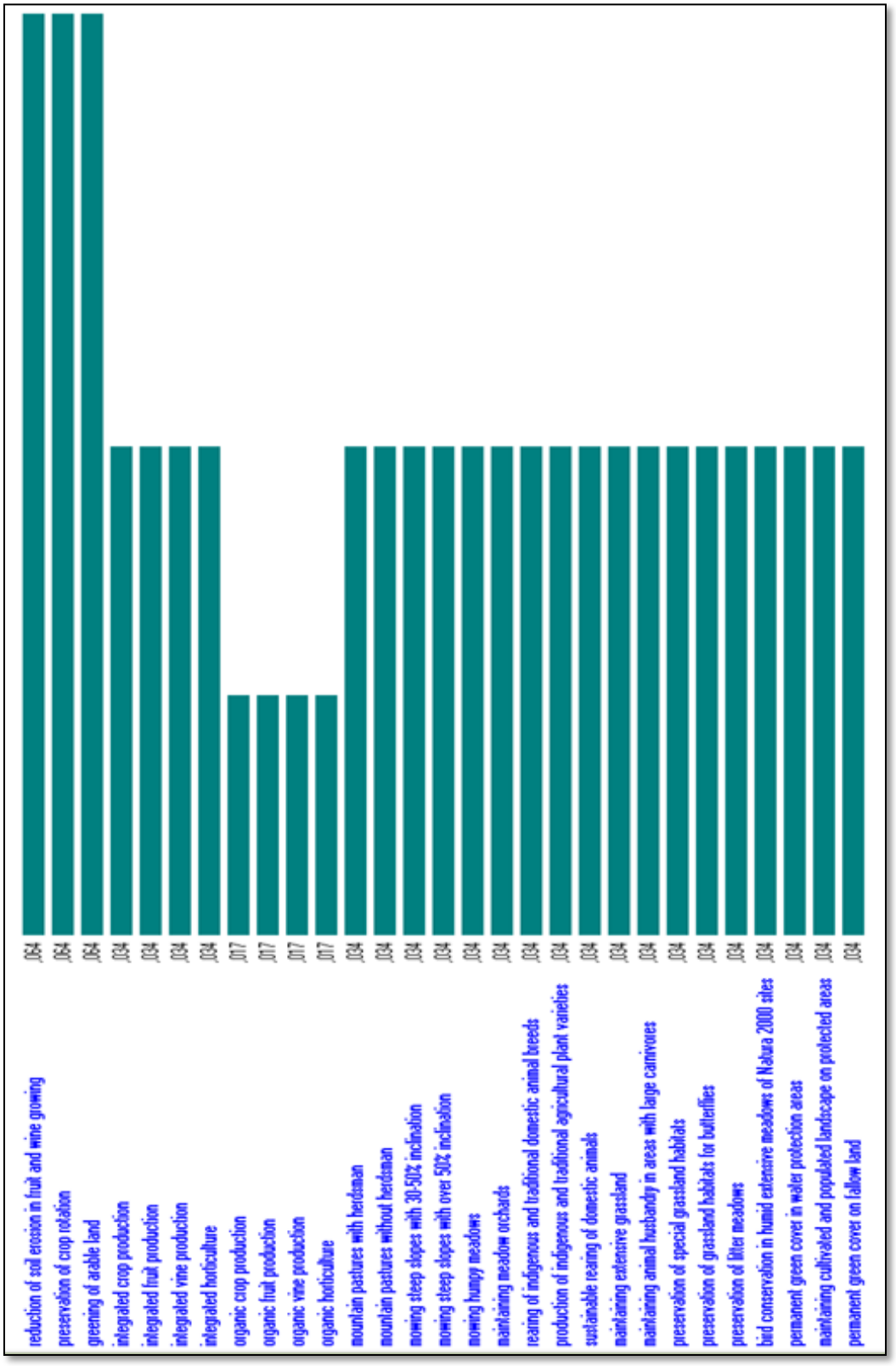


Figure 3: Weights of measures with respect to “high quality and healthier agricultural food products”

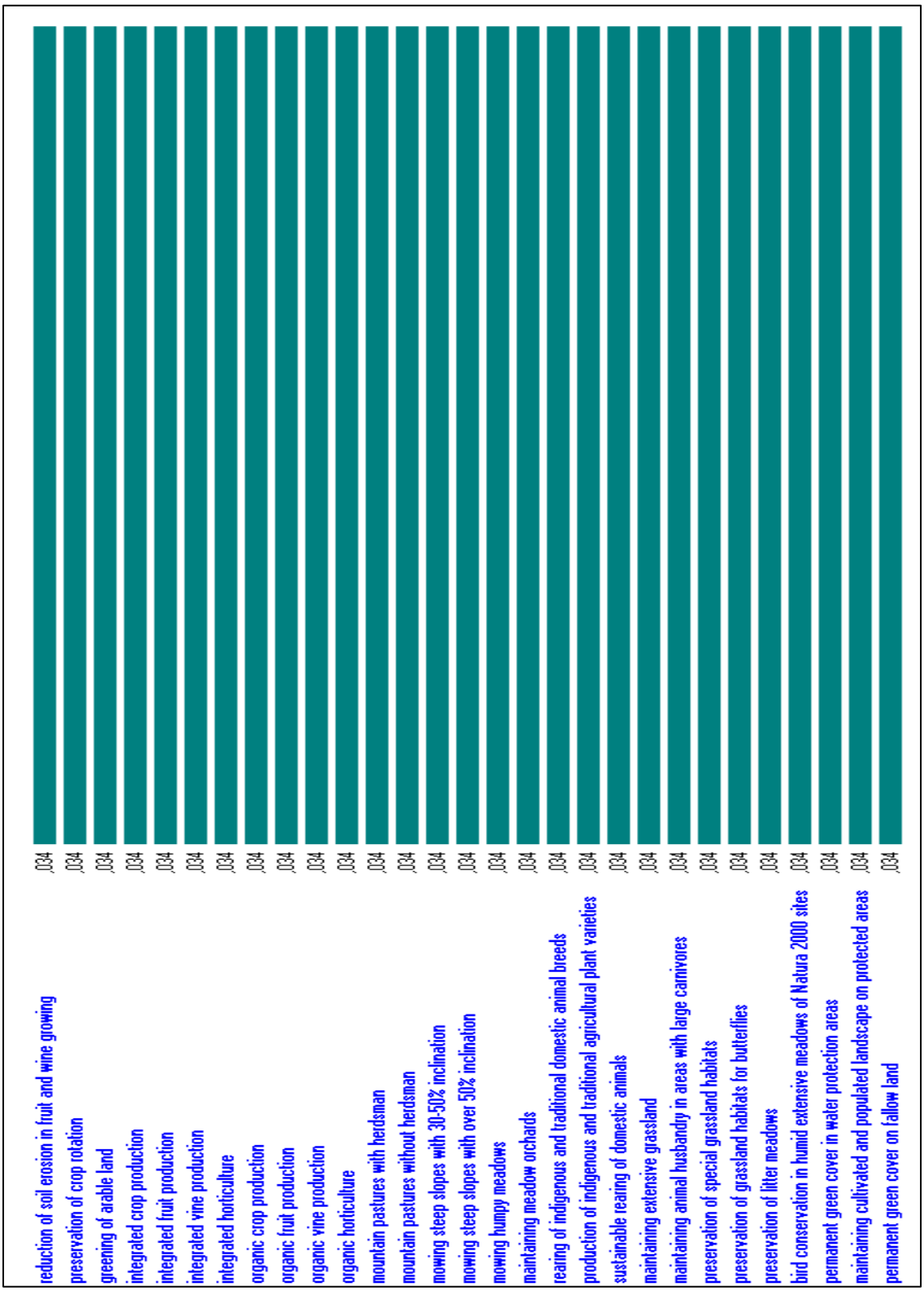


Figure 4: Weights of measures with respect to "complexity of the measures for the farmer"

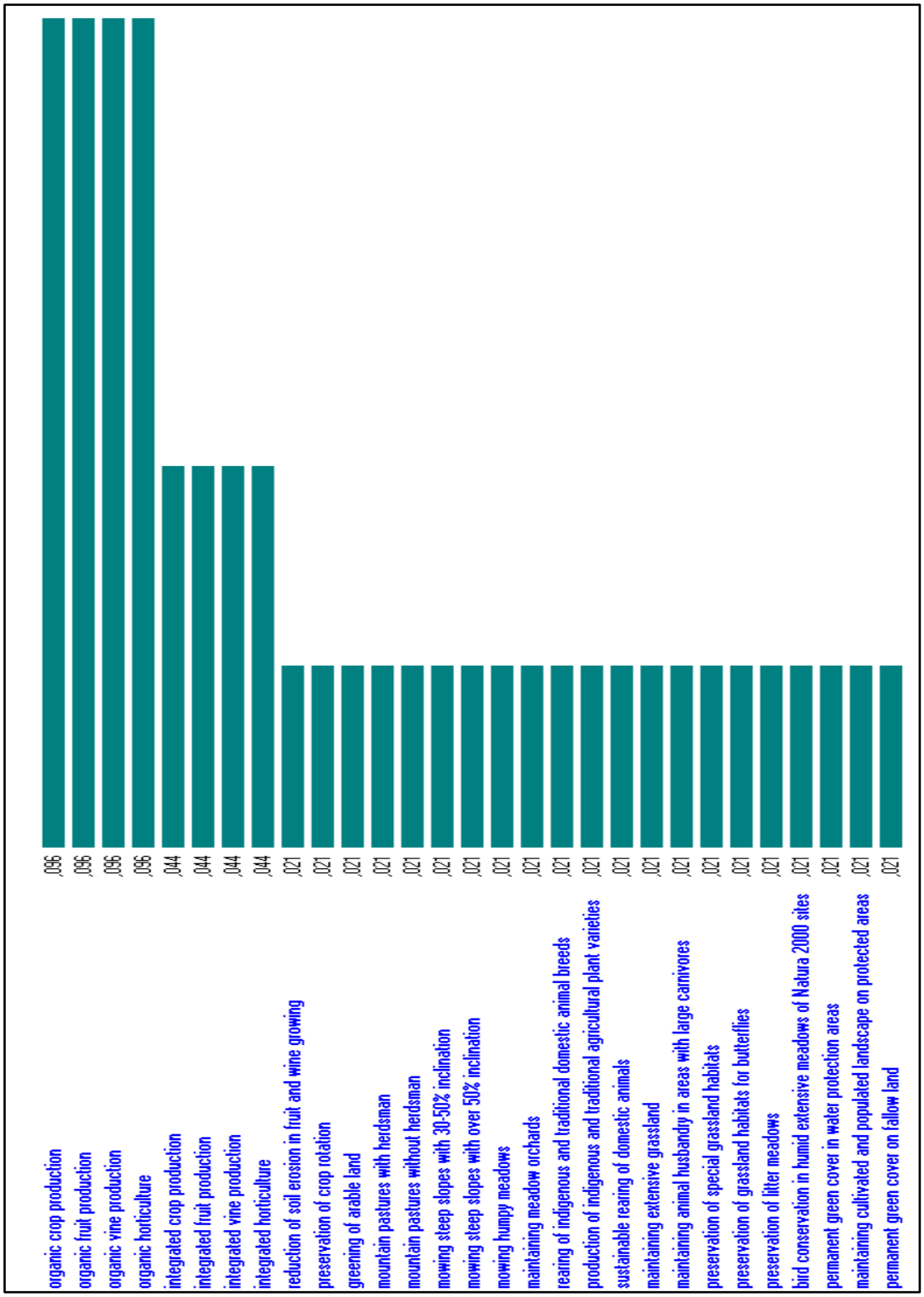


Figure 5: Weights of measures with respect to “create reliable conditions for marketing”

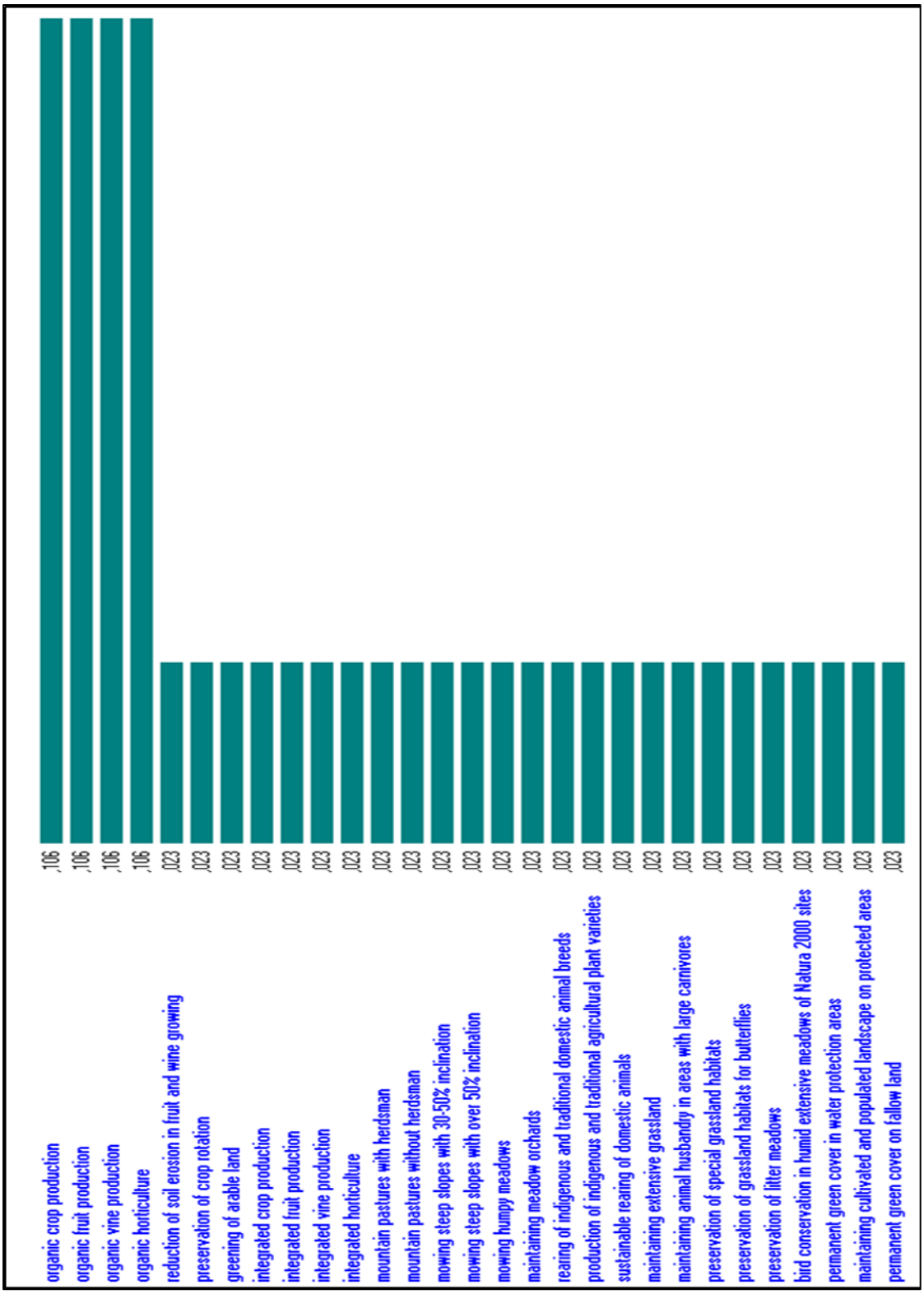


Figure 6: Weights of measures with respect to attribute “yield reduction by changing method of production”

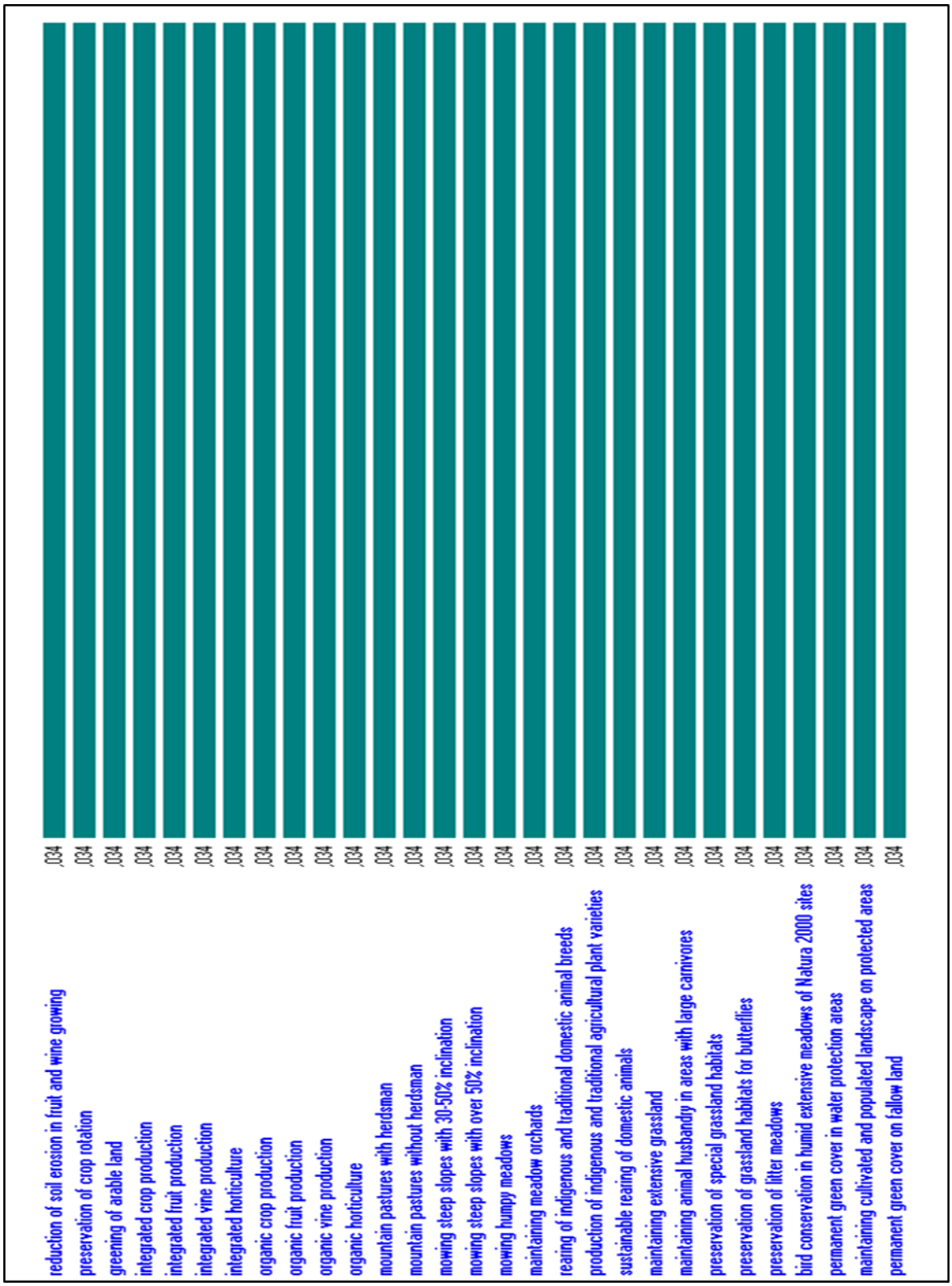


Figure 7: Weights of measures with respect to “stop the decline of biodiversity”

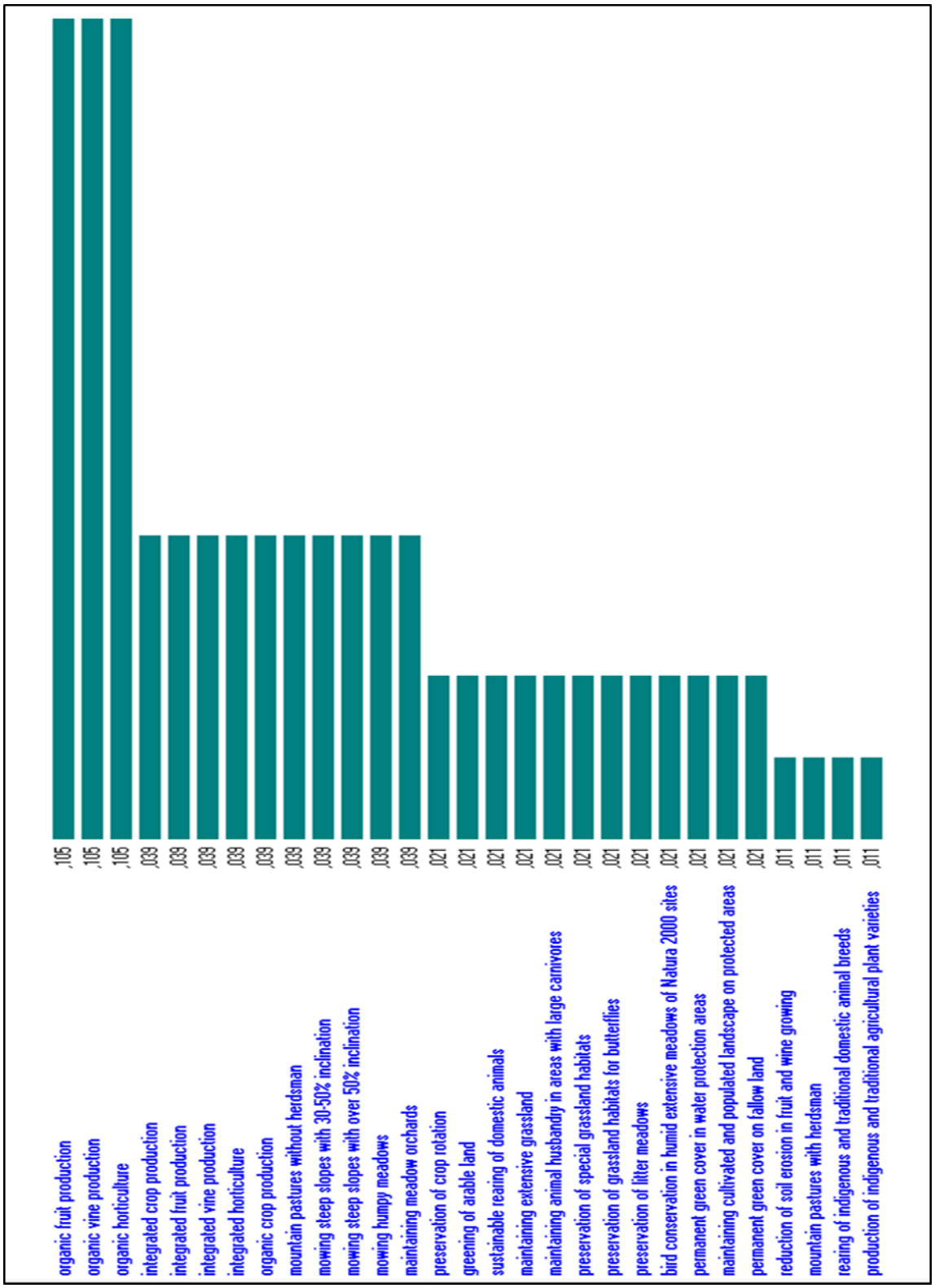


Figure 8: Weights of measures with respect to “reduce discharging chemicals into the environment”

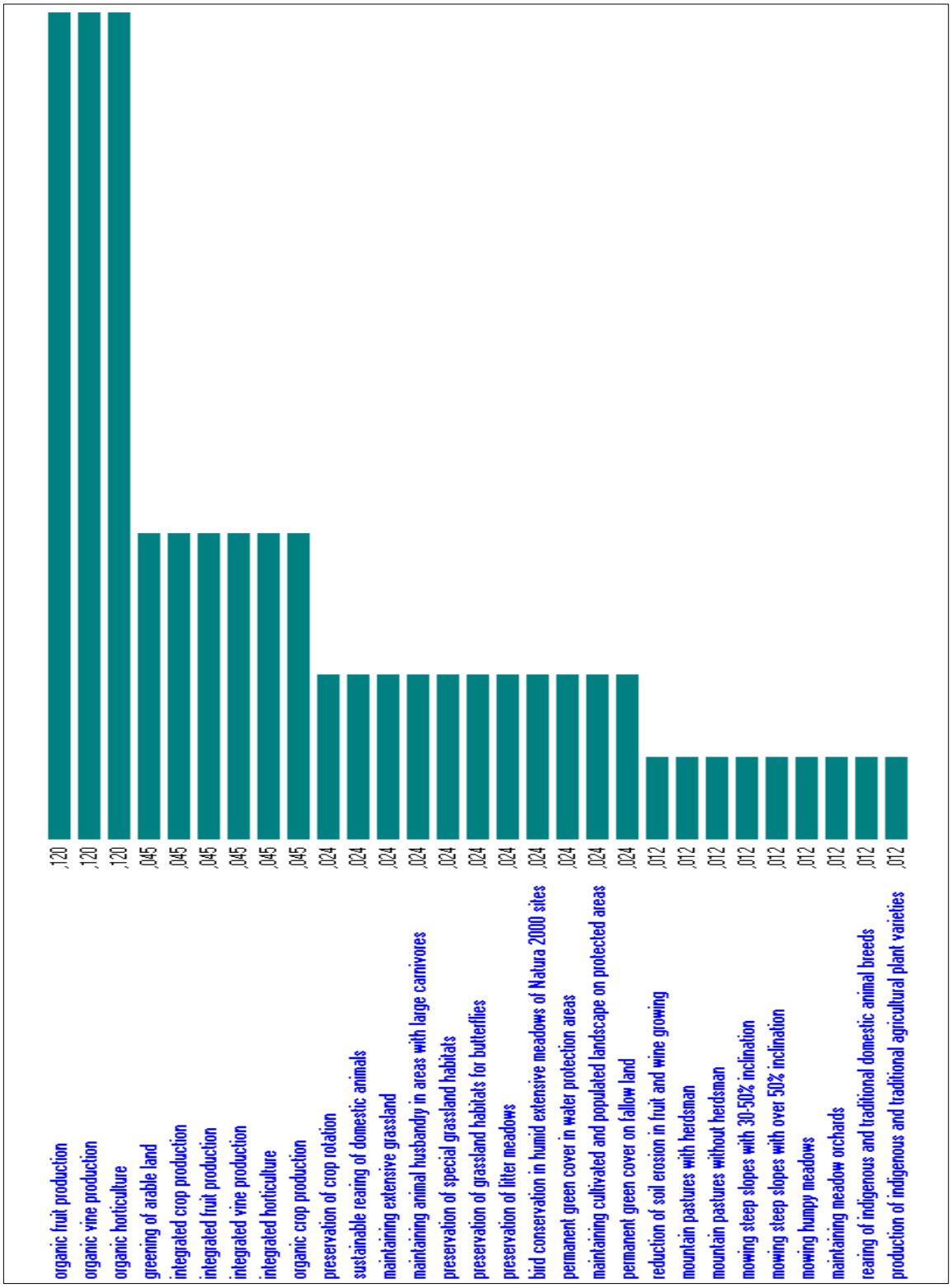


Figure 9: Weights of measures with respect to “prevent pollution of drinking water and its sources”

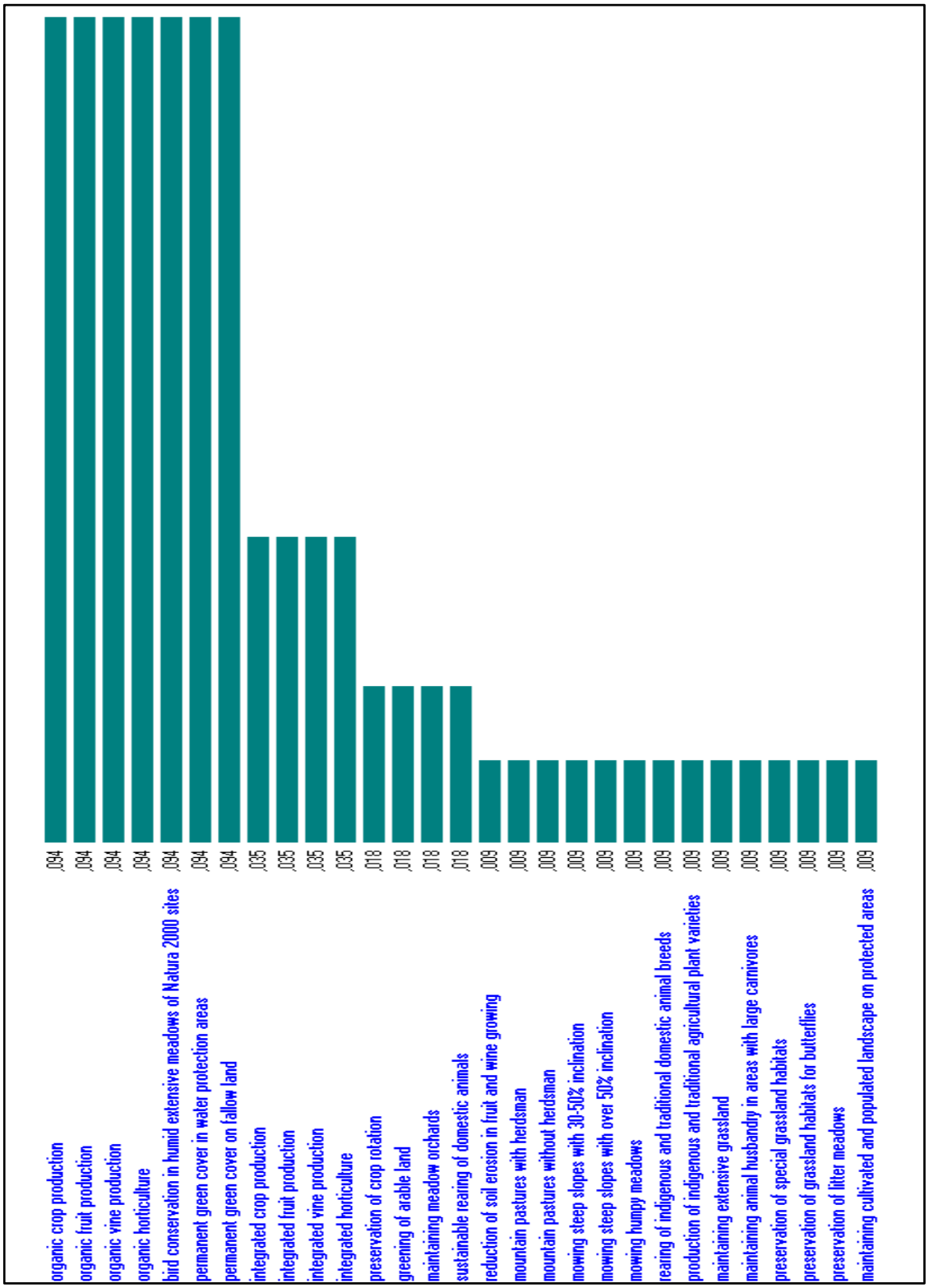


Figure 10: Weights of measures with respect to “improve soil quality and fertility”

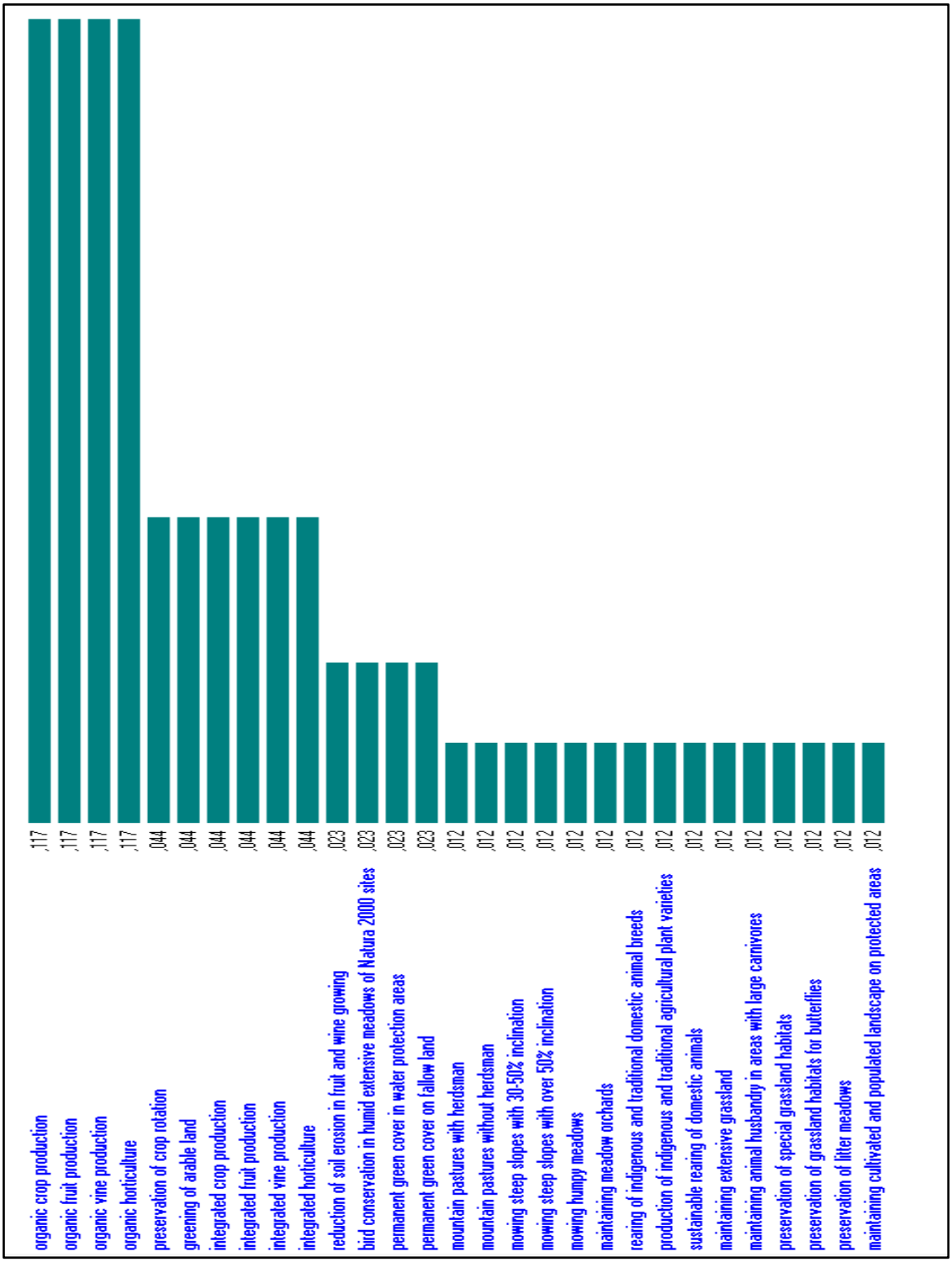


Figure 11: Weights of measures with respect to “Create employment”

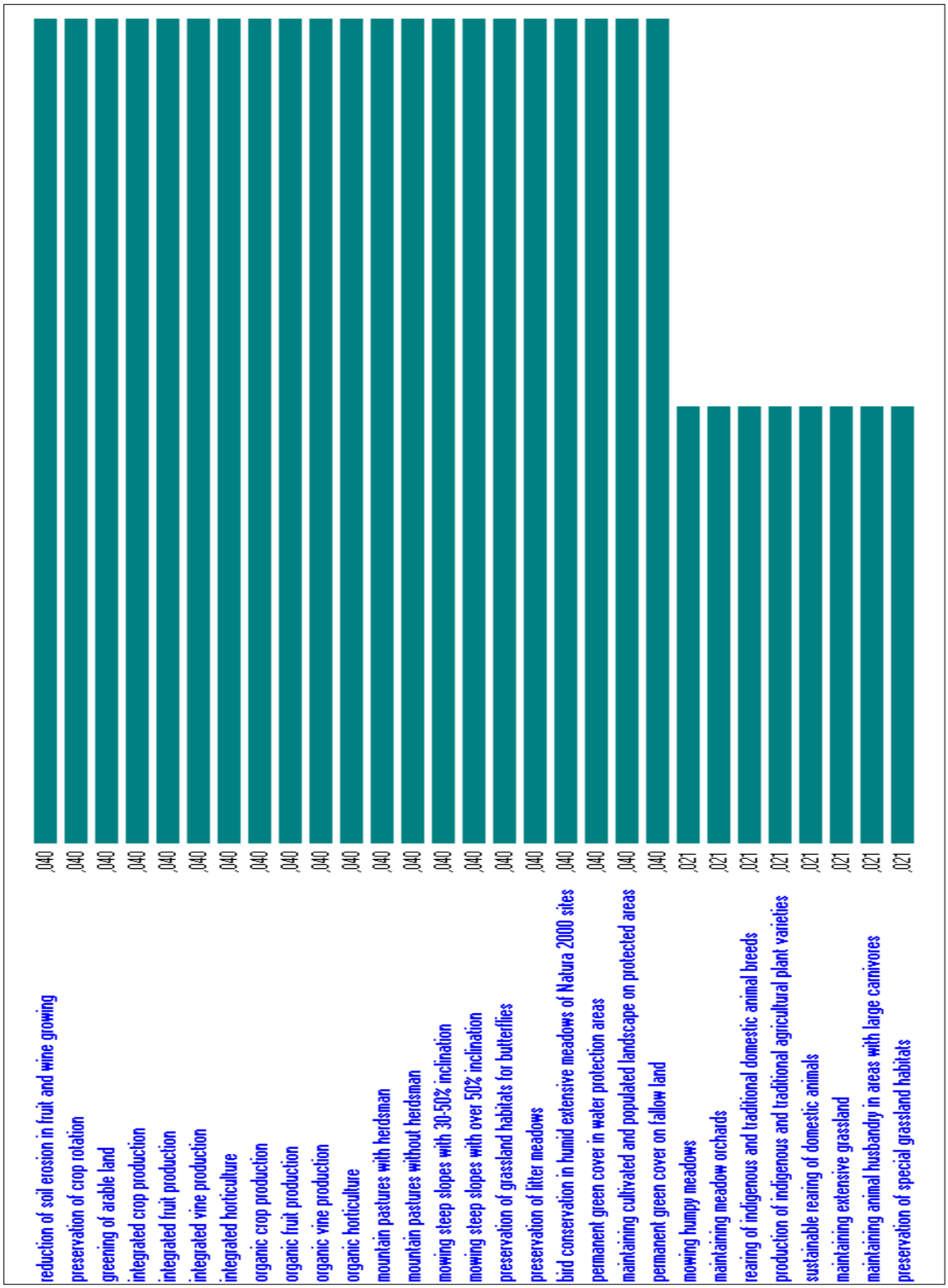


Figure 12: Weights of measures with respect to “conservation of utilized agricultural land”

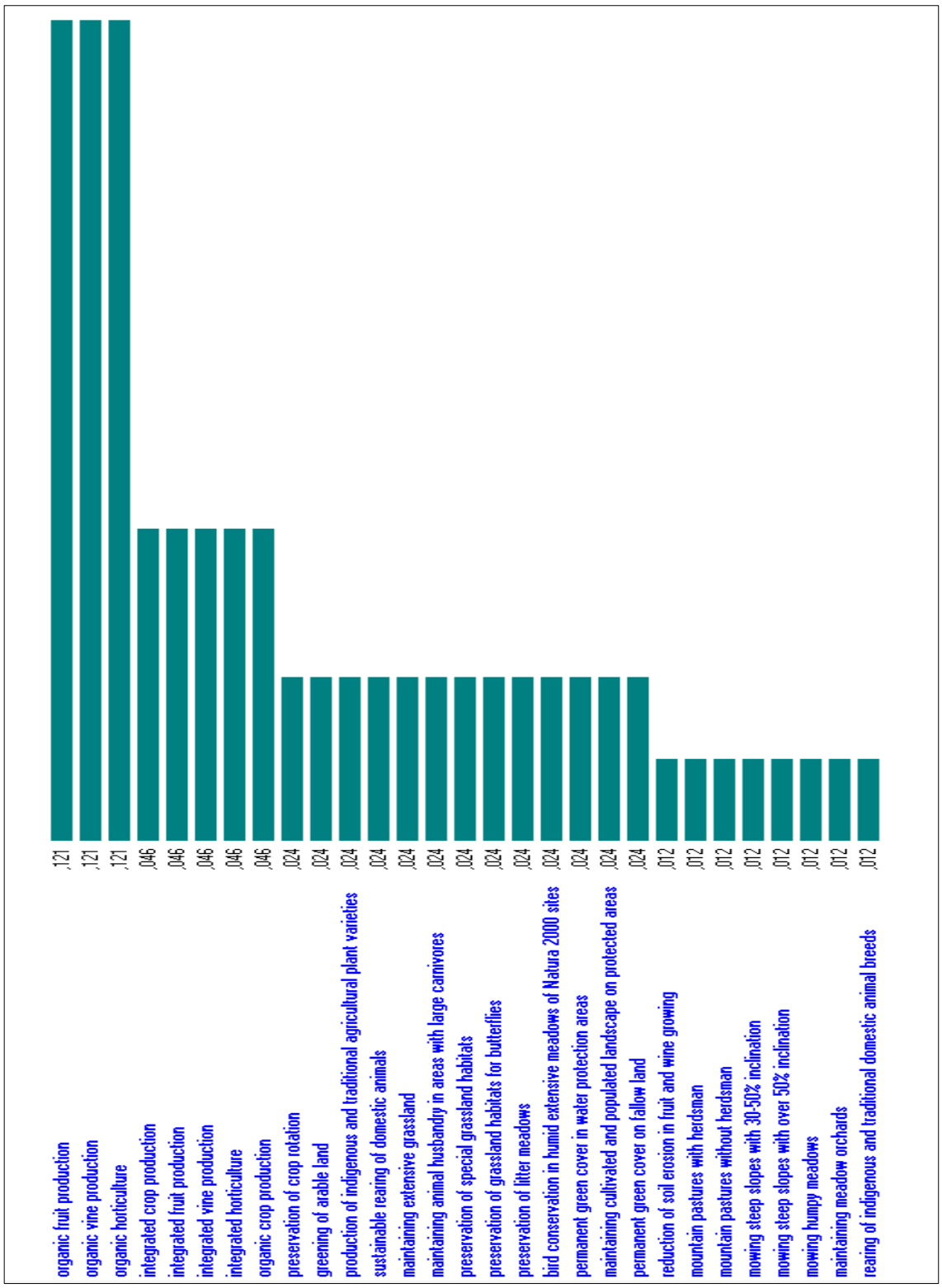


Figure 13: Weights of measures with respect to "Preservation of autochthonous and traditional domestic animal breeds"

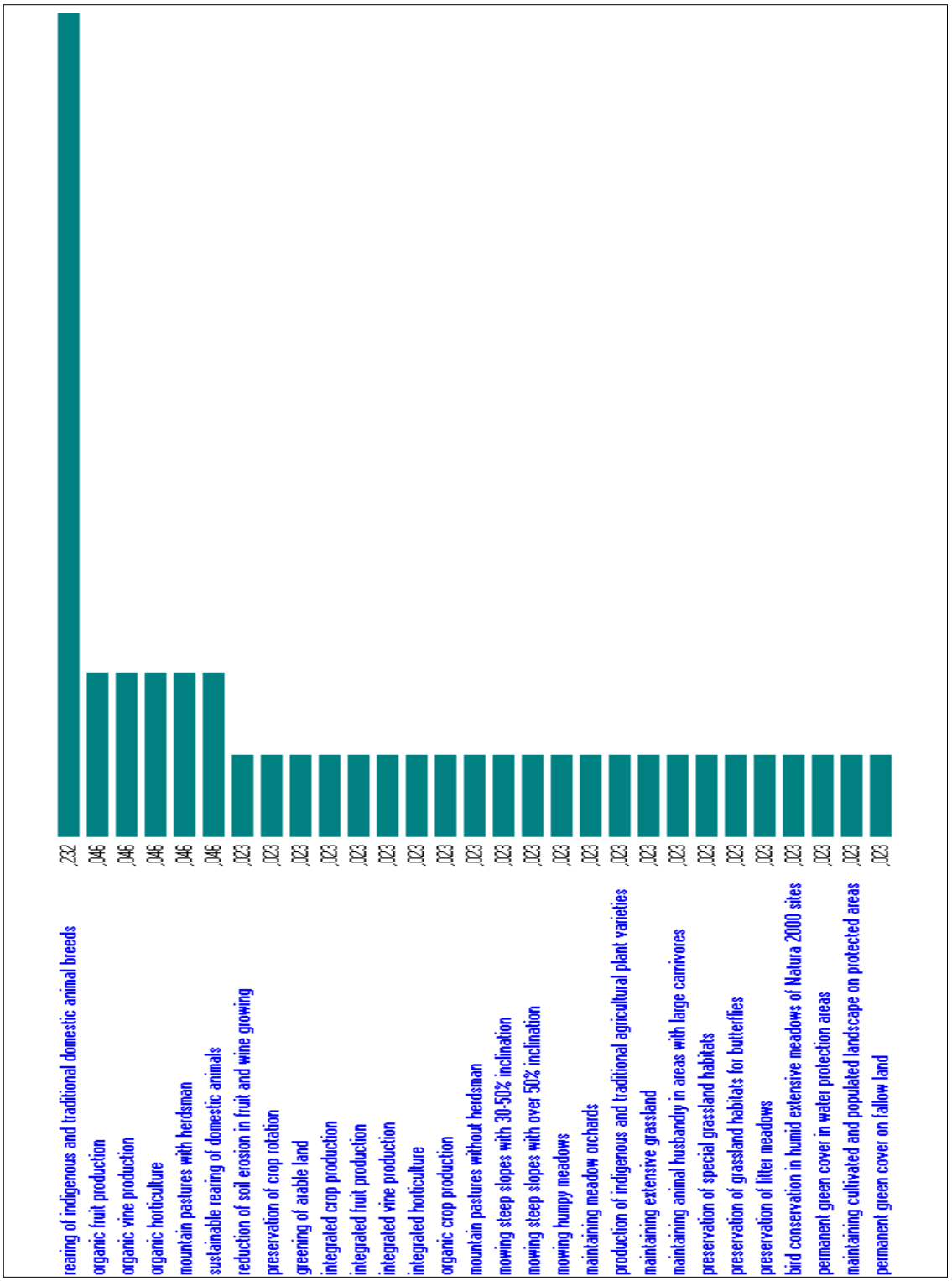


Figure 14: Weights of measures with respect to “Preservation of autochthonous and traditional domestic plant

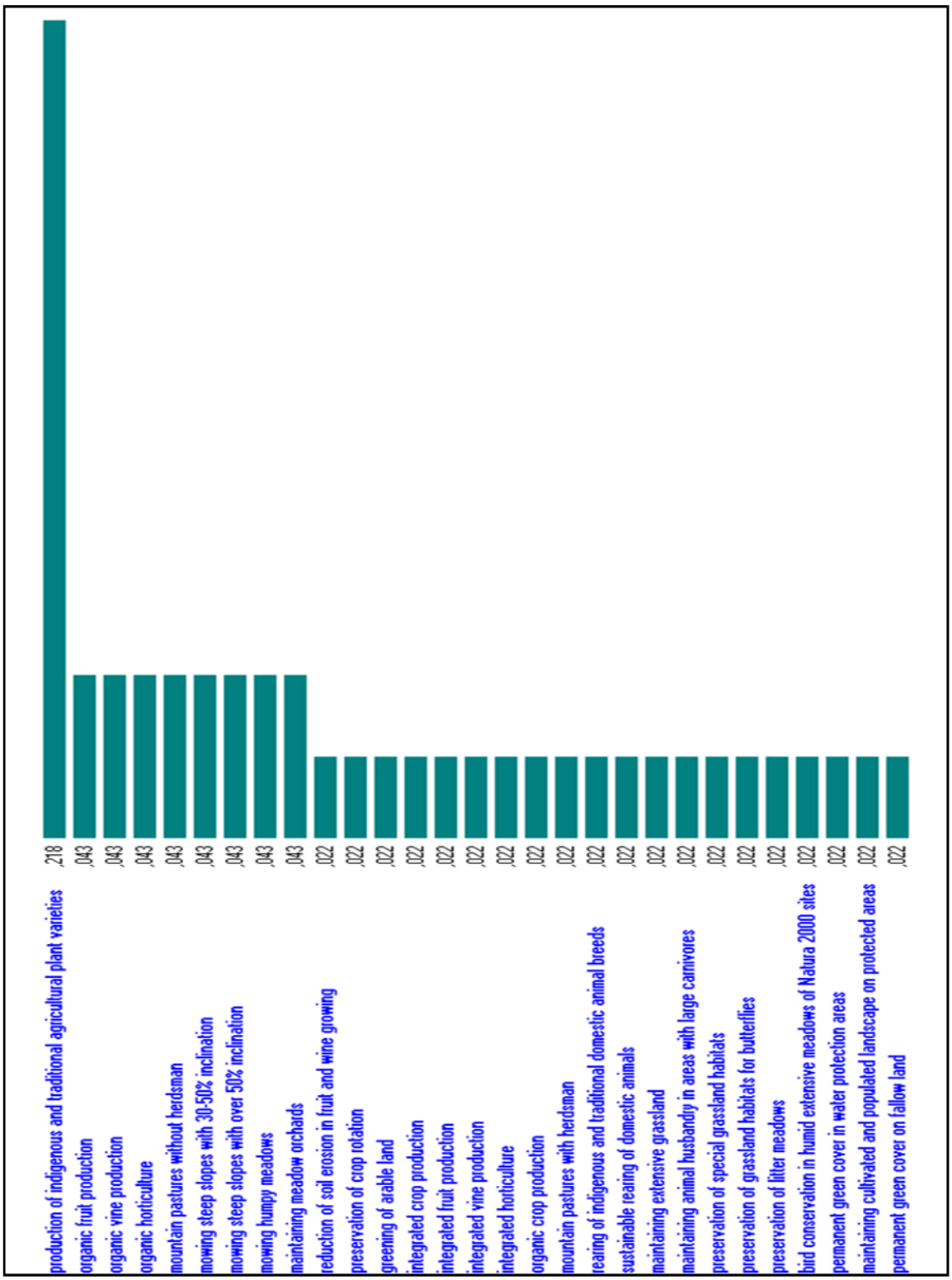


Figure 15: Weights for measures with respect to “Preservation of agriculture in less favoured areas”

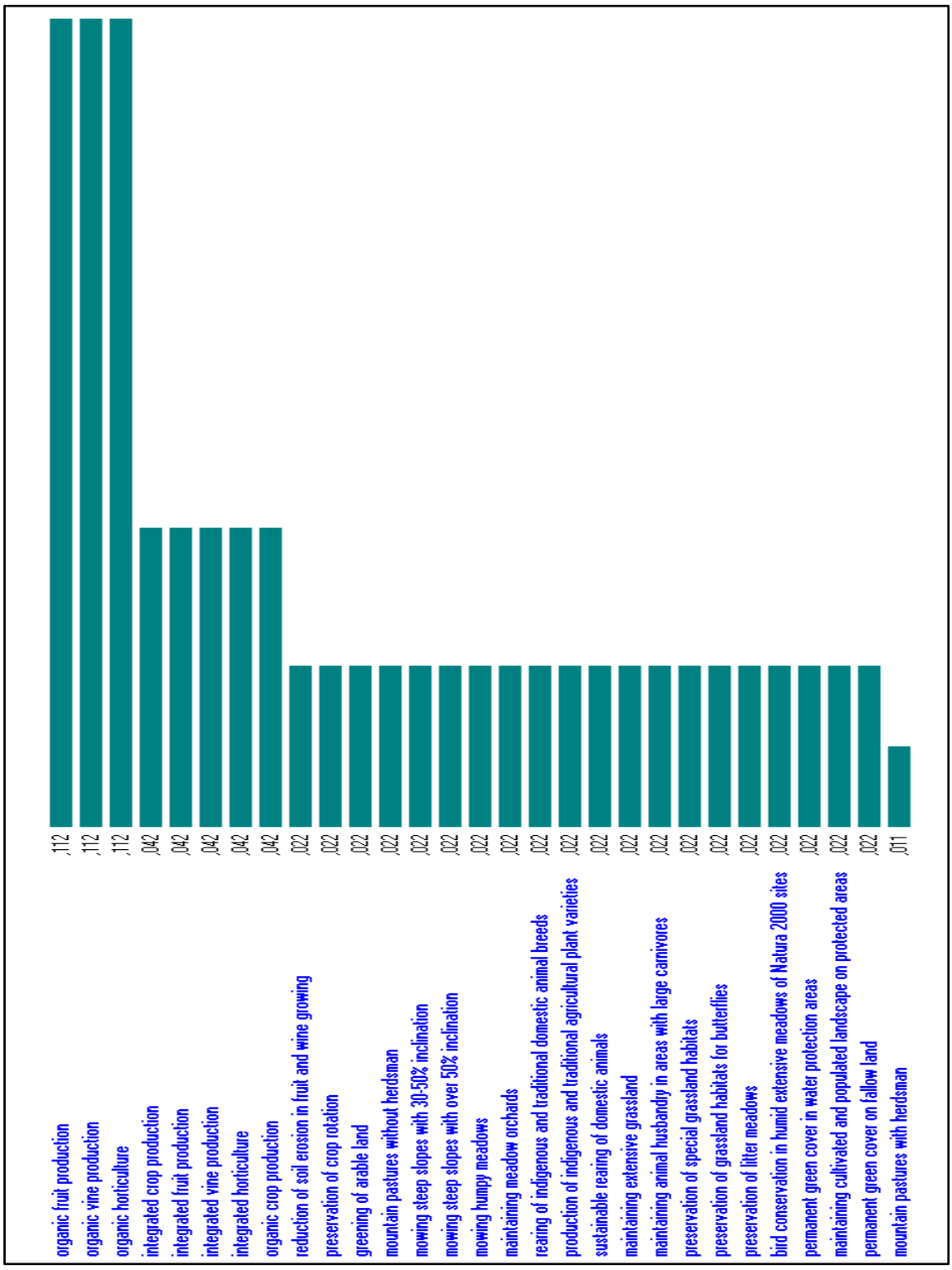


Figure 16: Weights of measures with respect to “conservation of typical cultural landscape, specific features and natural habitats

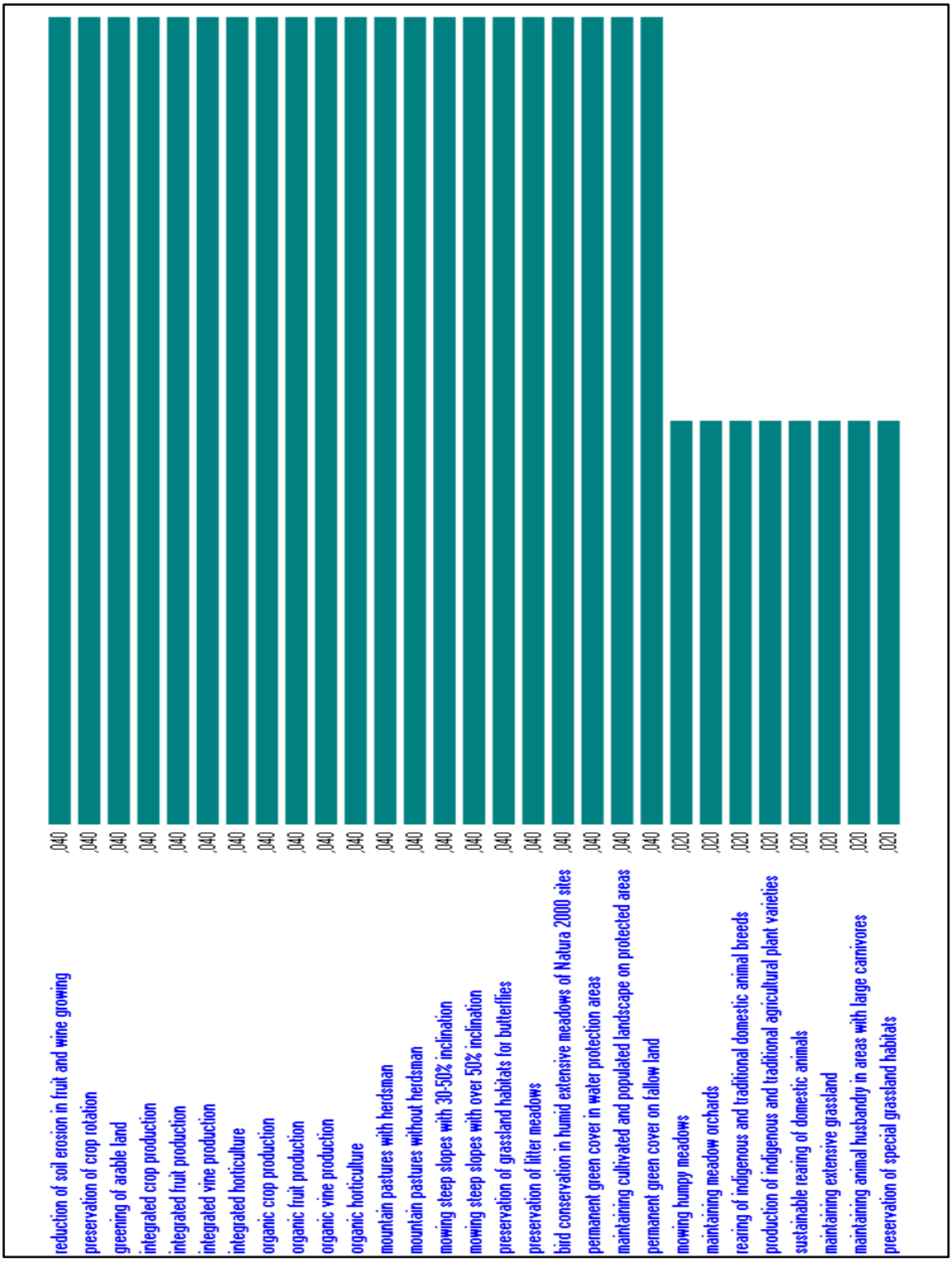
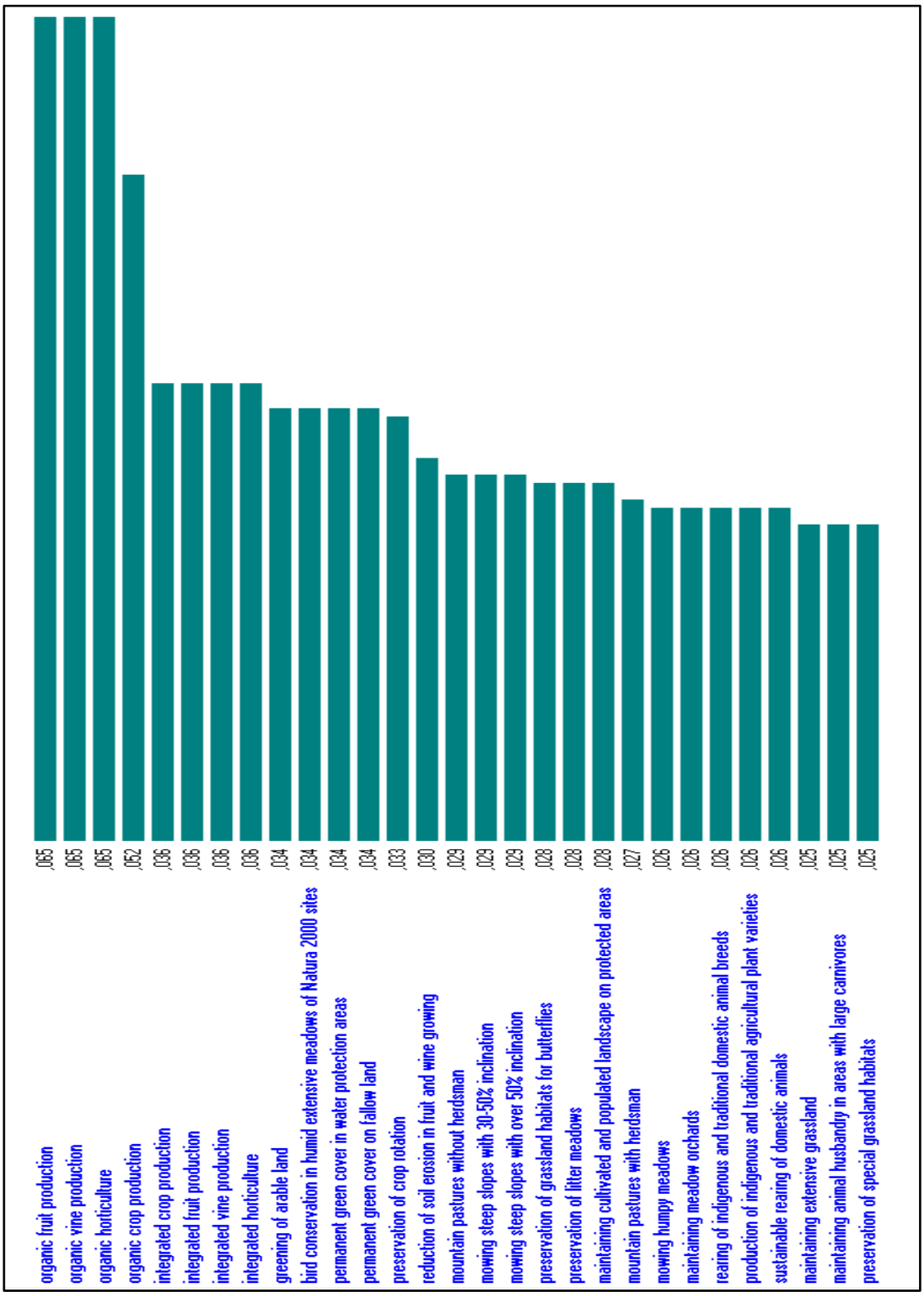


Figure 17: Global priority weights of measures



APPENDIX III: Sensitivity test for criteria

Figure 1: Default sensitivity analysis with respect to "promote environmental friendly agricultural practices"

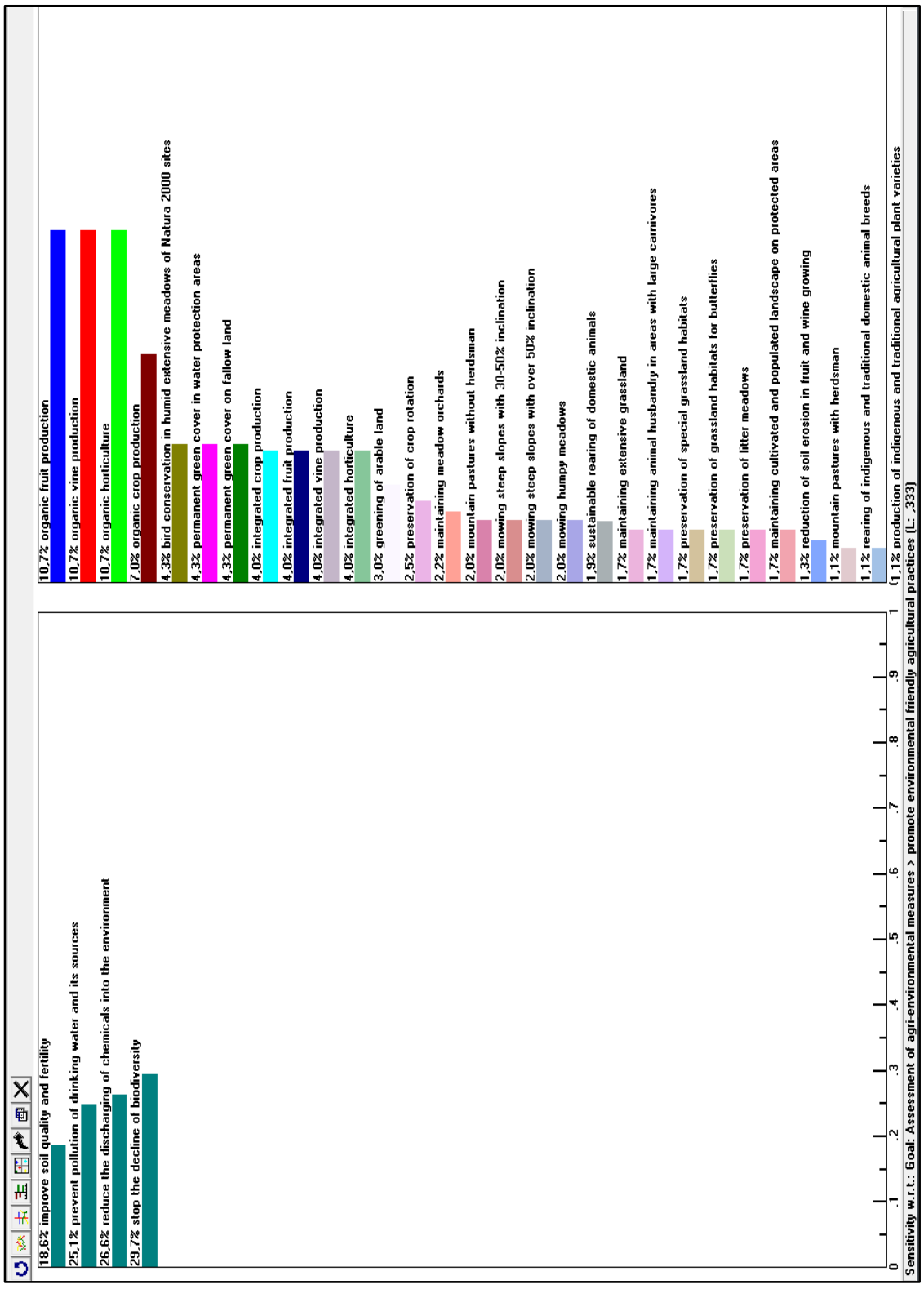


Figure 2: Sensitivity analysis with respect to criteria “promote environmental friendly agricultural practices” after altering attribute “improve soil quality and fertility”

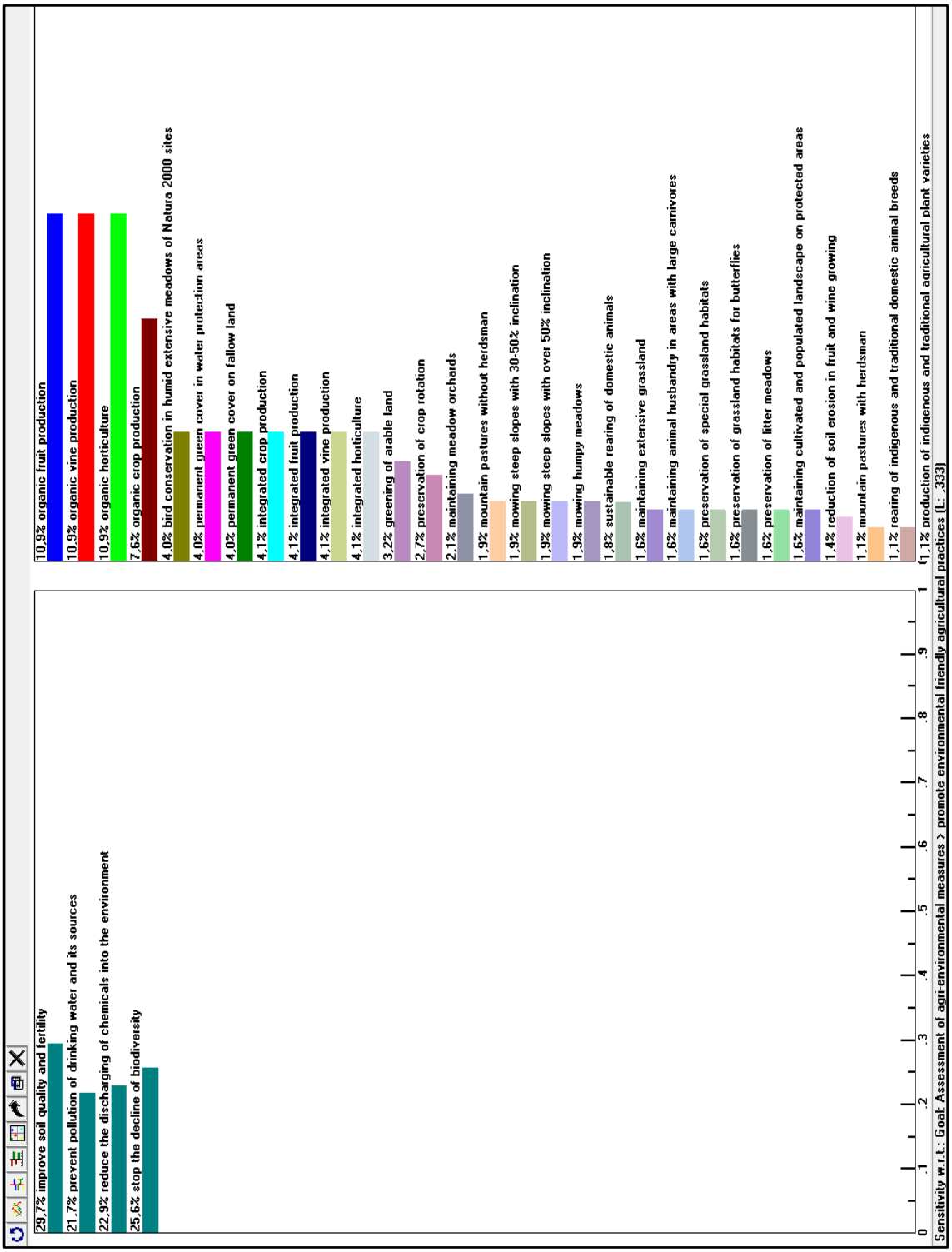


Figure 3: Sensitivity analysis with respect to criteria “promote environmental friendly agricultural practices” after altering attribute “prevent pollution of drinking water and its sources”

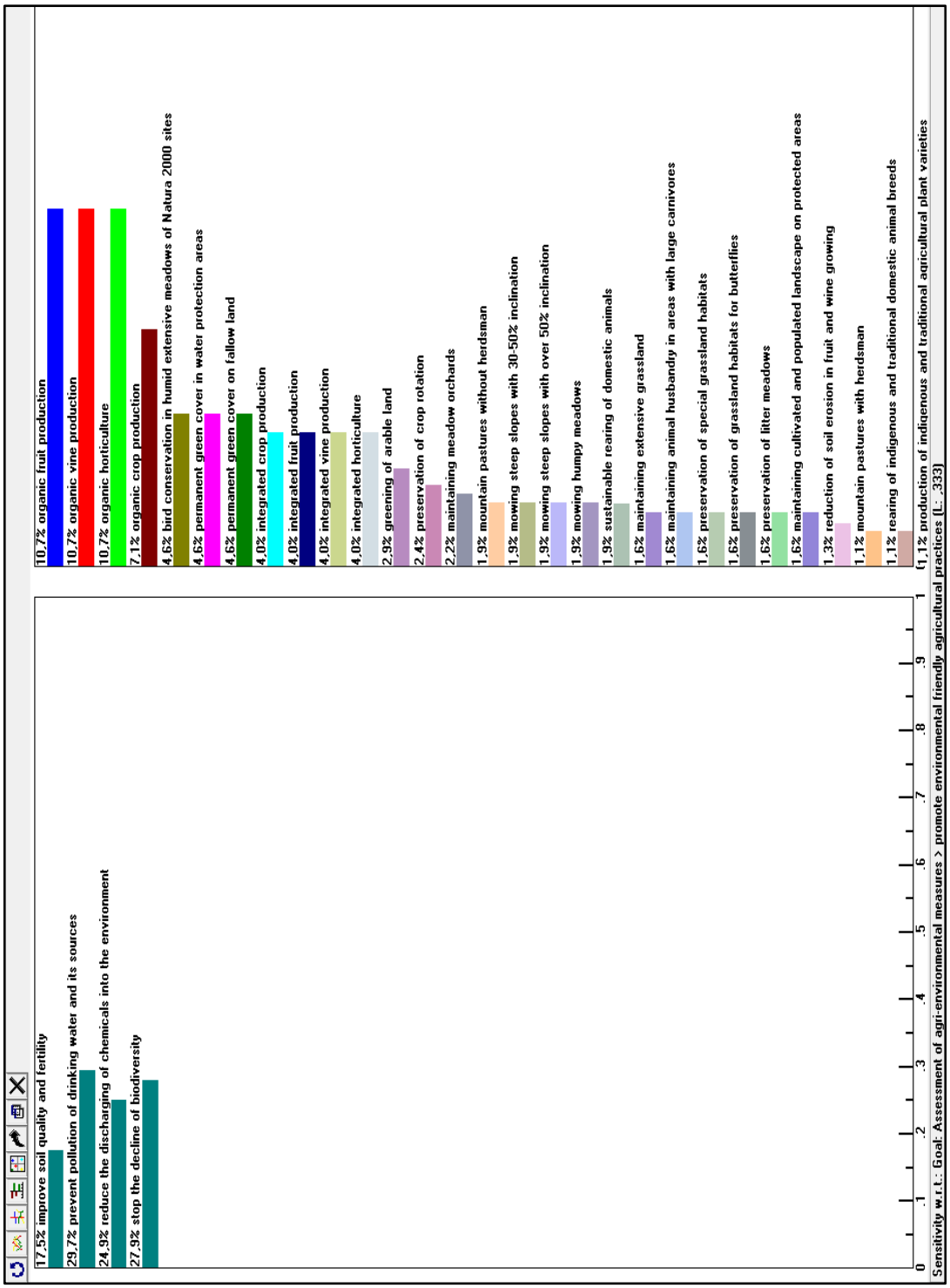


Figure 4: Sensitivity analysis with respect to criteria “promote environmental friendly agricultural practices” after altering attribute “reduce discharging of chemicals into the environment”

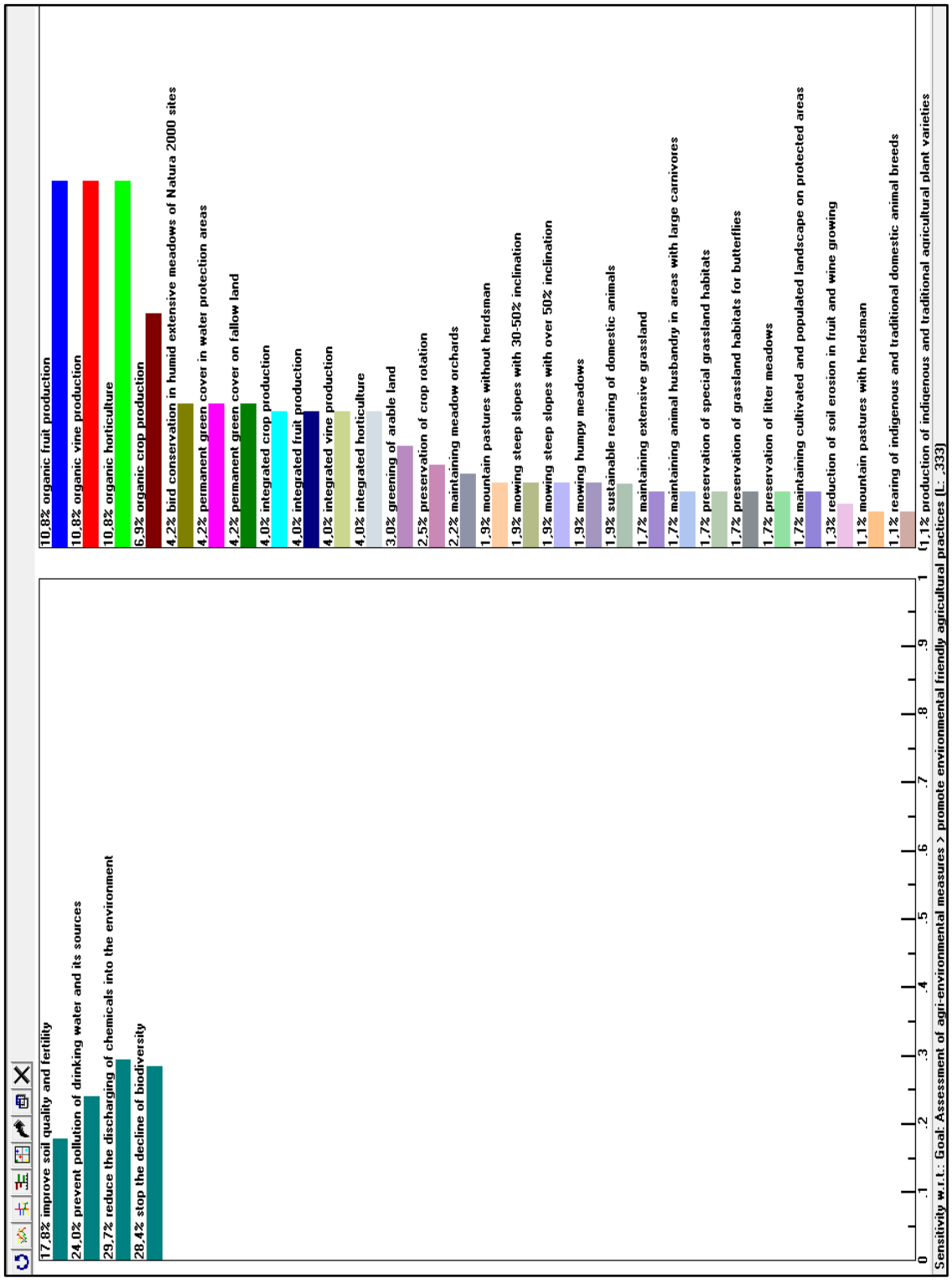


Figure 5: Default sensitivity analysis with respect to criteria "improve rural areas to prevent marginalisation"

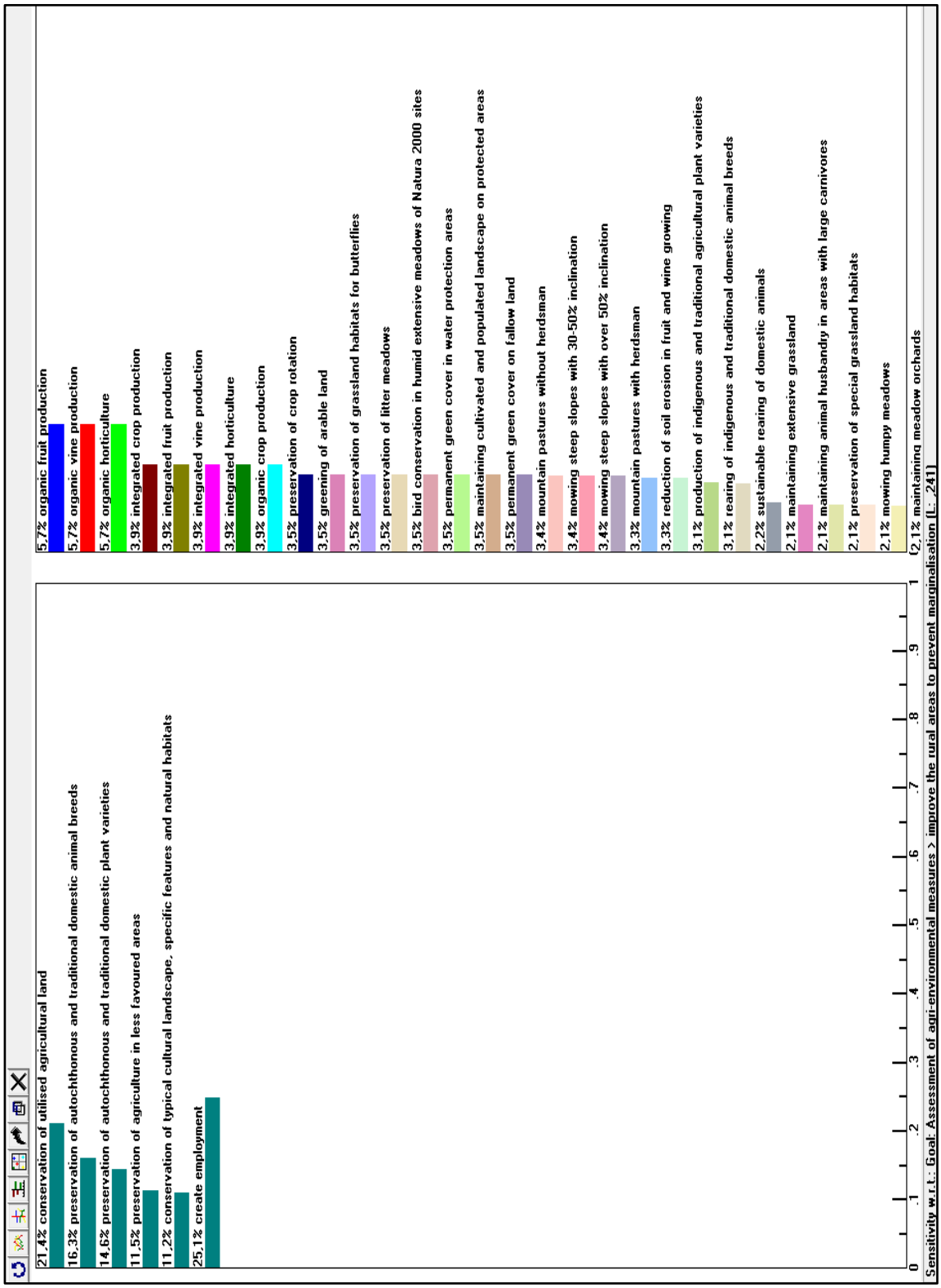


Figure 6: Sensitivity analysis with respect to criteria "improve rural areas to prevent marginalisation" after altering attribute "conservation of utilised agricultural land"

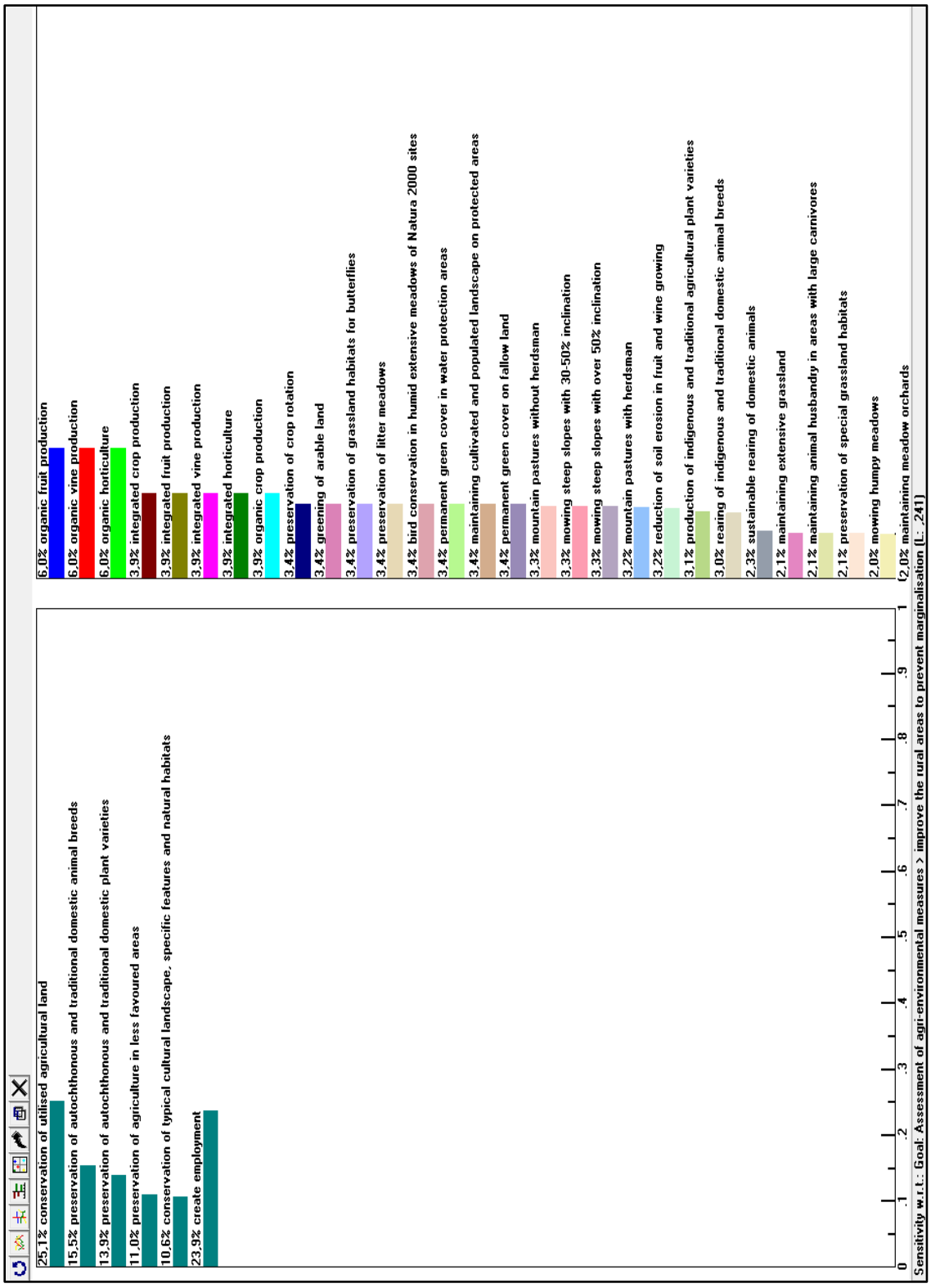


Figure 7: Sensitivity analysis with respect to criteria “improve rural areas to prevent marginalisation” after altering attribute “preservation of autochthonous and traditional domestic animal breeds”

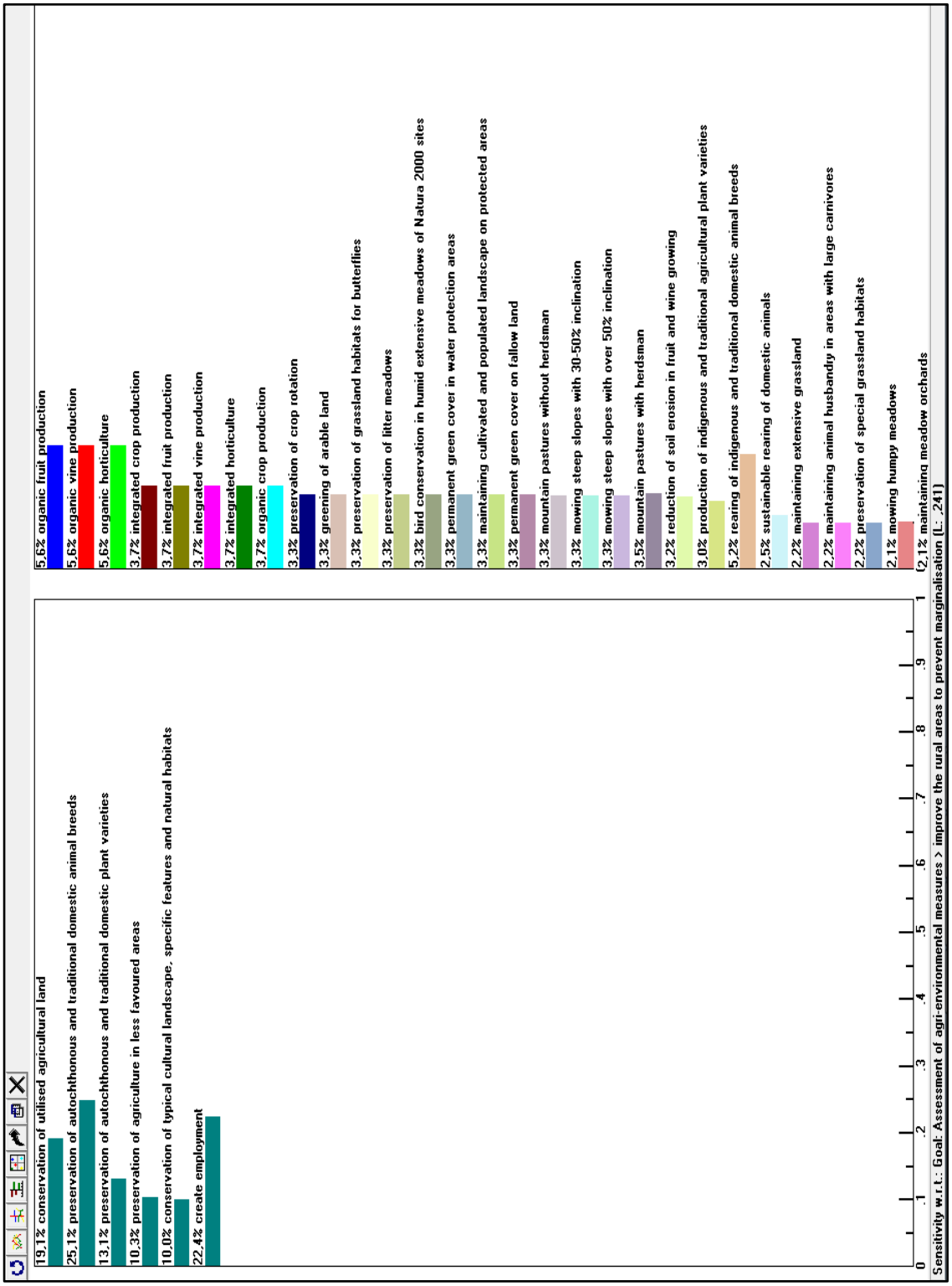


Figure 8: Sensitivity analysis with respect to criteria "improve rural areas to prevent marginalisation" after altering attribute "preservation of autochthonous and traditional domestic plant varieties"

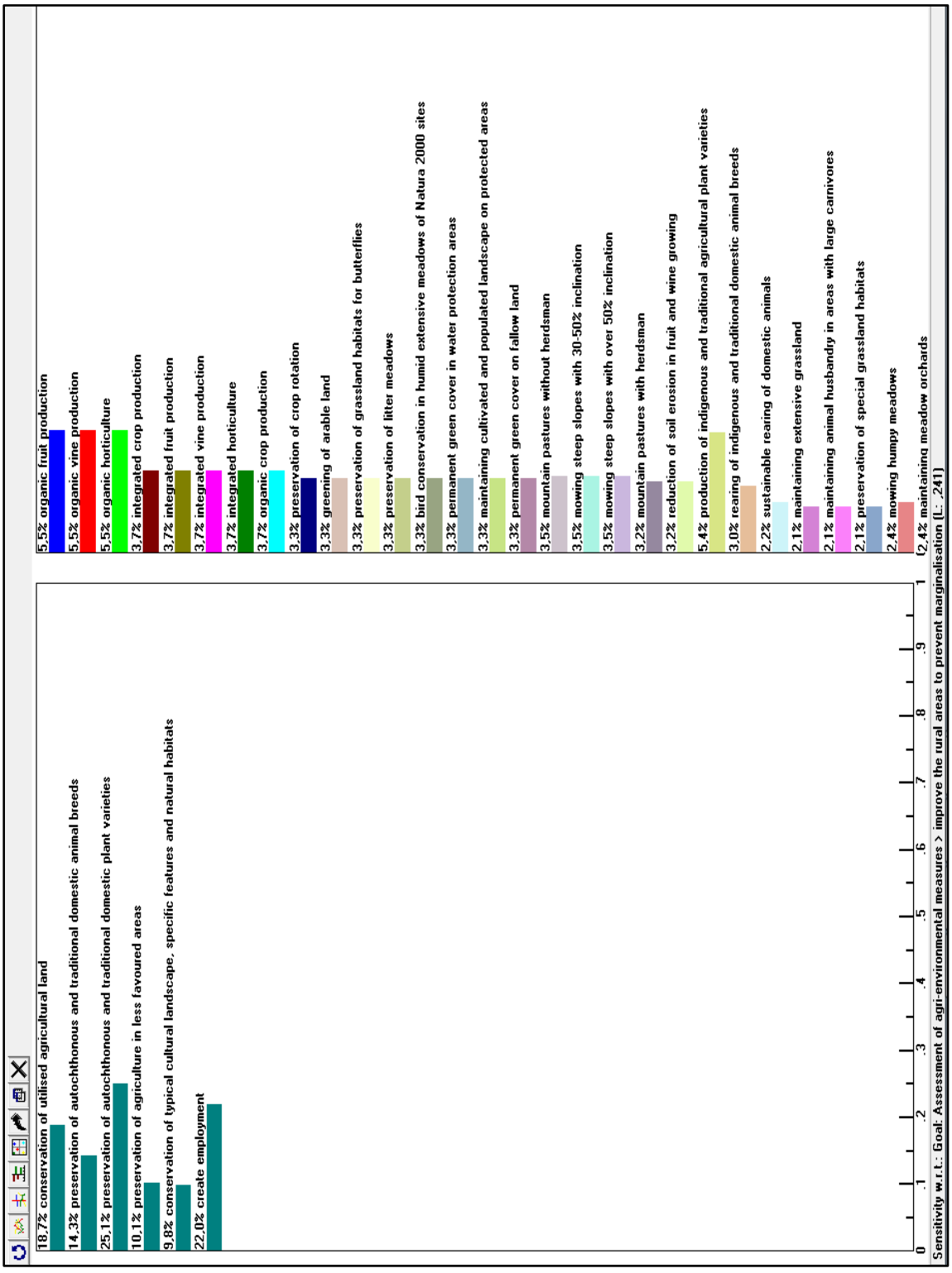


Figure 9: Sensitivity analysis with respect to criteria "improve rural areas to prevent marginalisation" after altering attribute "preservation of agriculture in less favoured areas"

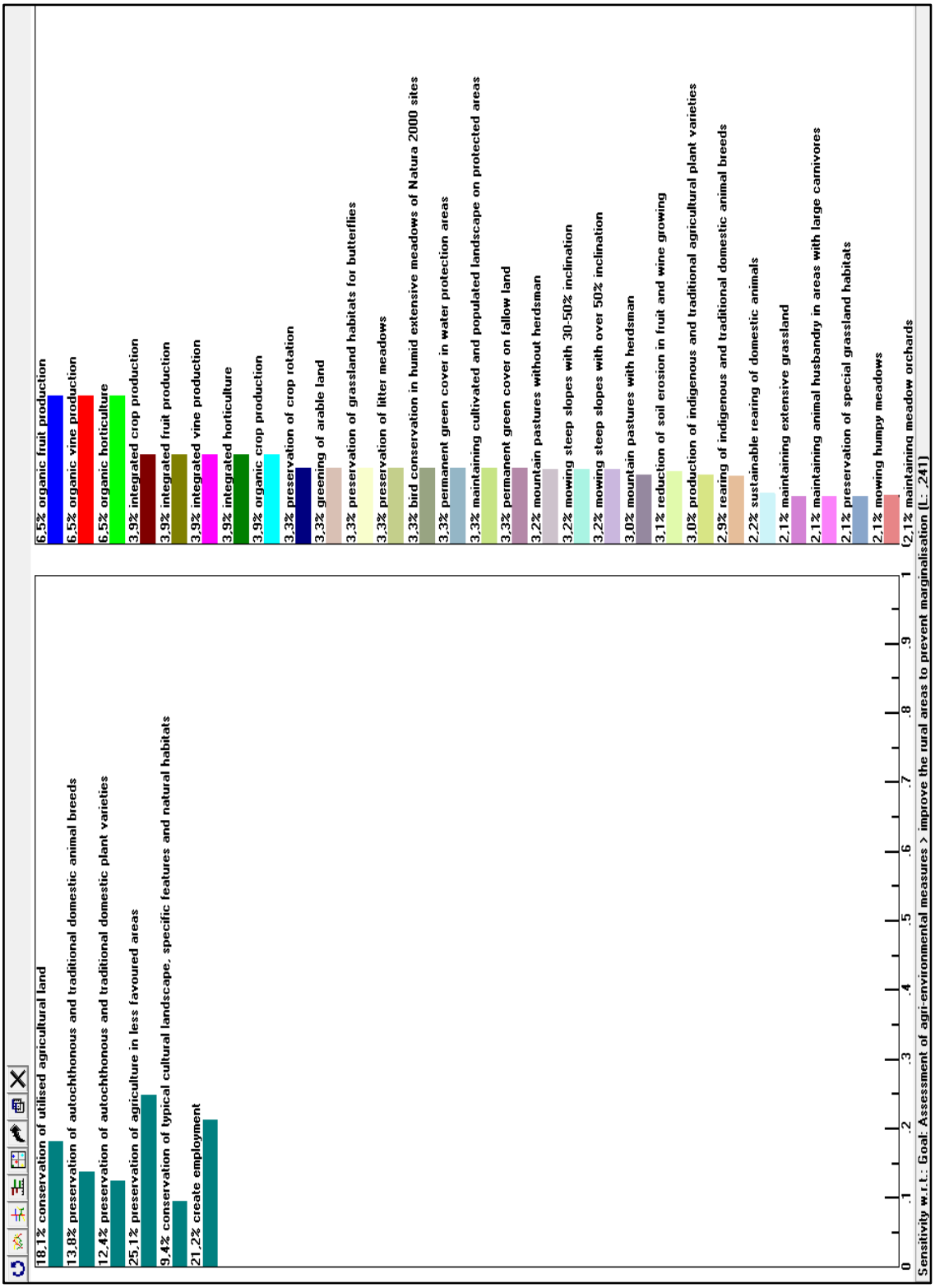


Figure 10: Sensitivity analysis with respect to criteria "improve rural areas to prevent marginalisation" after altering attribute "conservation of typical cultural landscape, specific features and natural habitats"

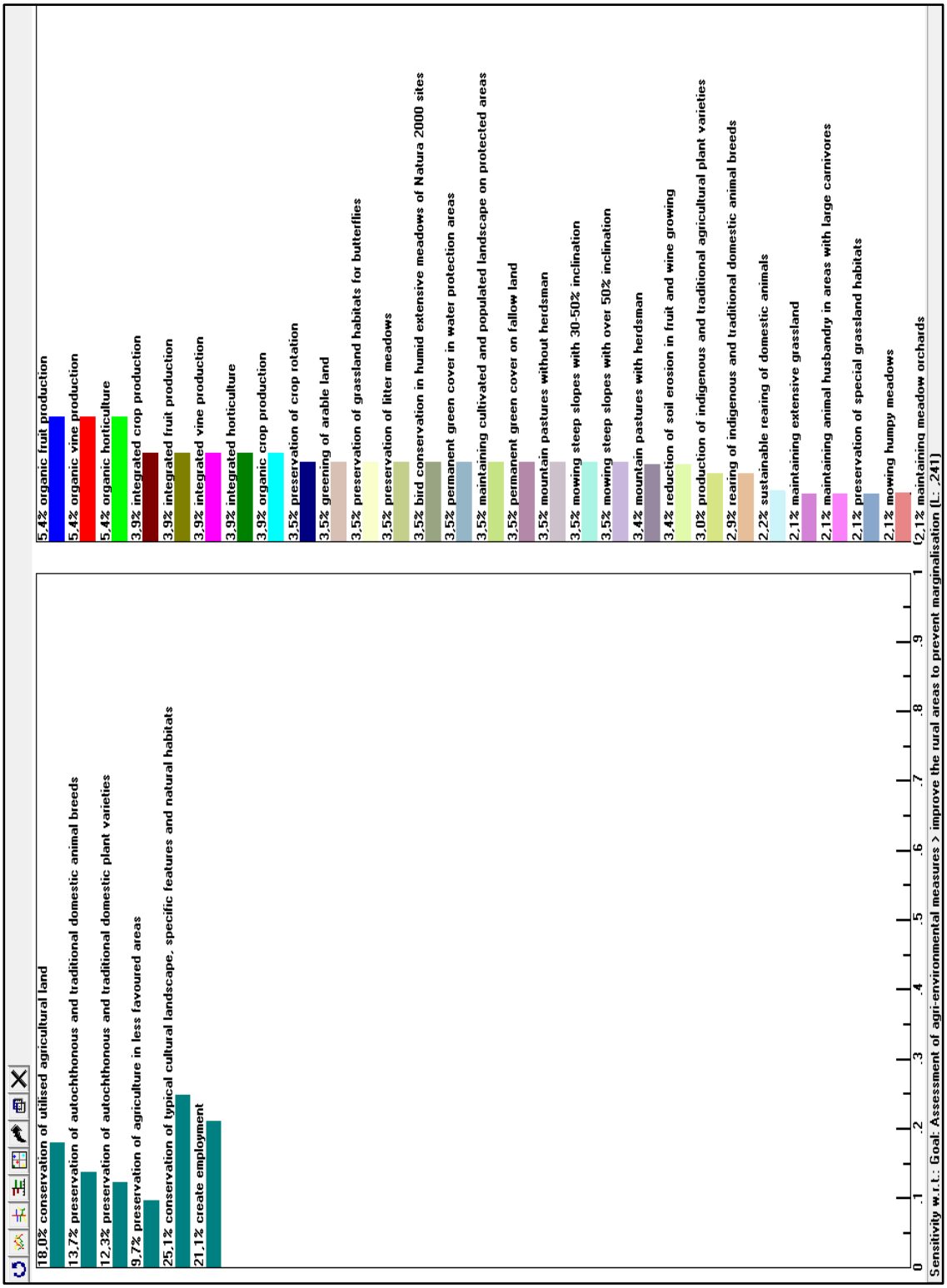


Figure 11: Default Sensitivity analysis with respect to criteria “production and economic consequences”

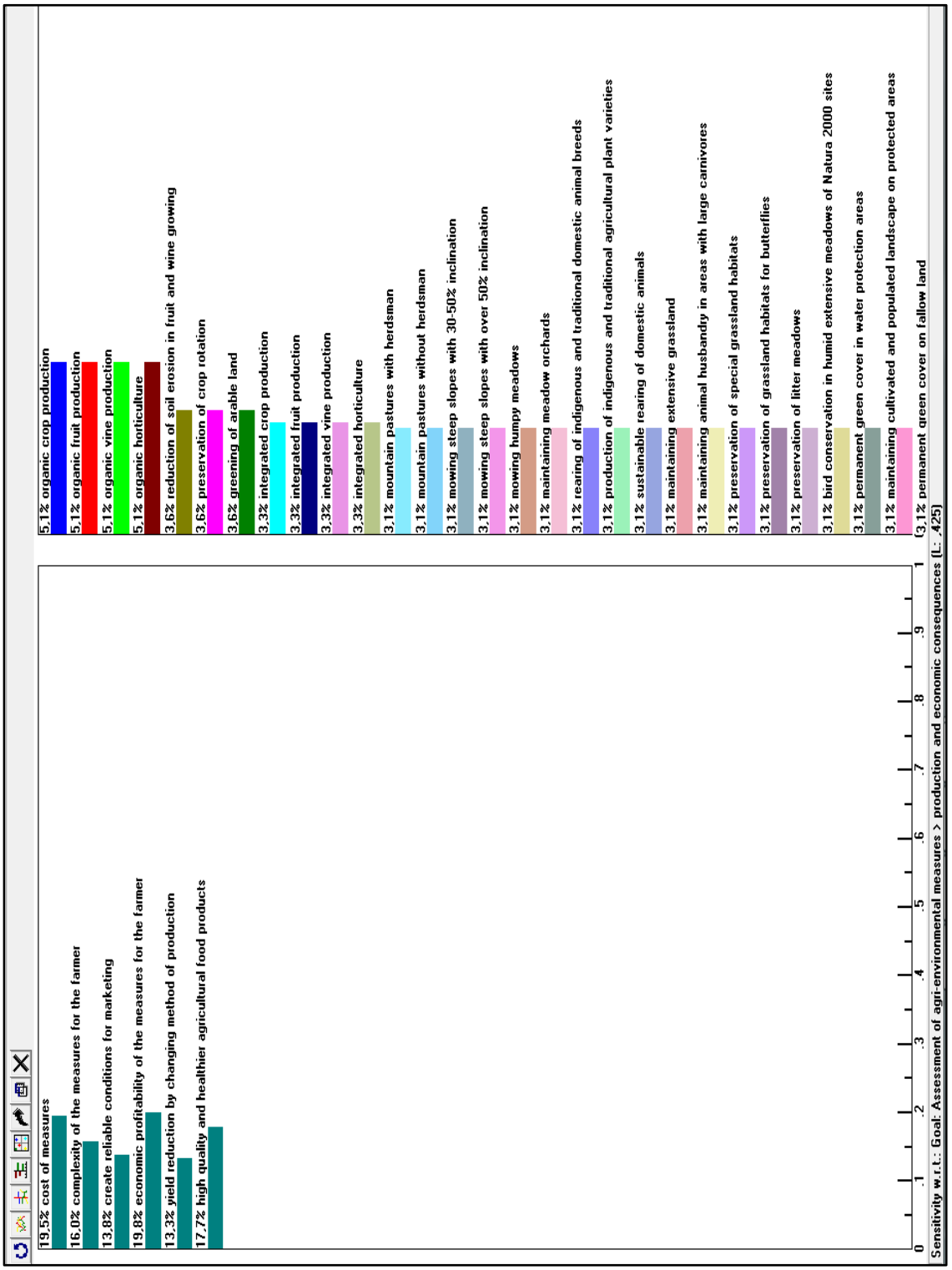


Figure 12: Sensitivity analysis with respect to criteria "production and economic consequences" after altering attribute "cost of measures"

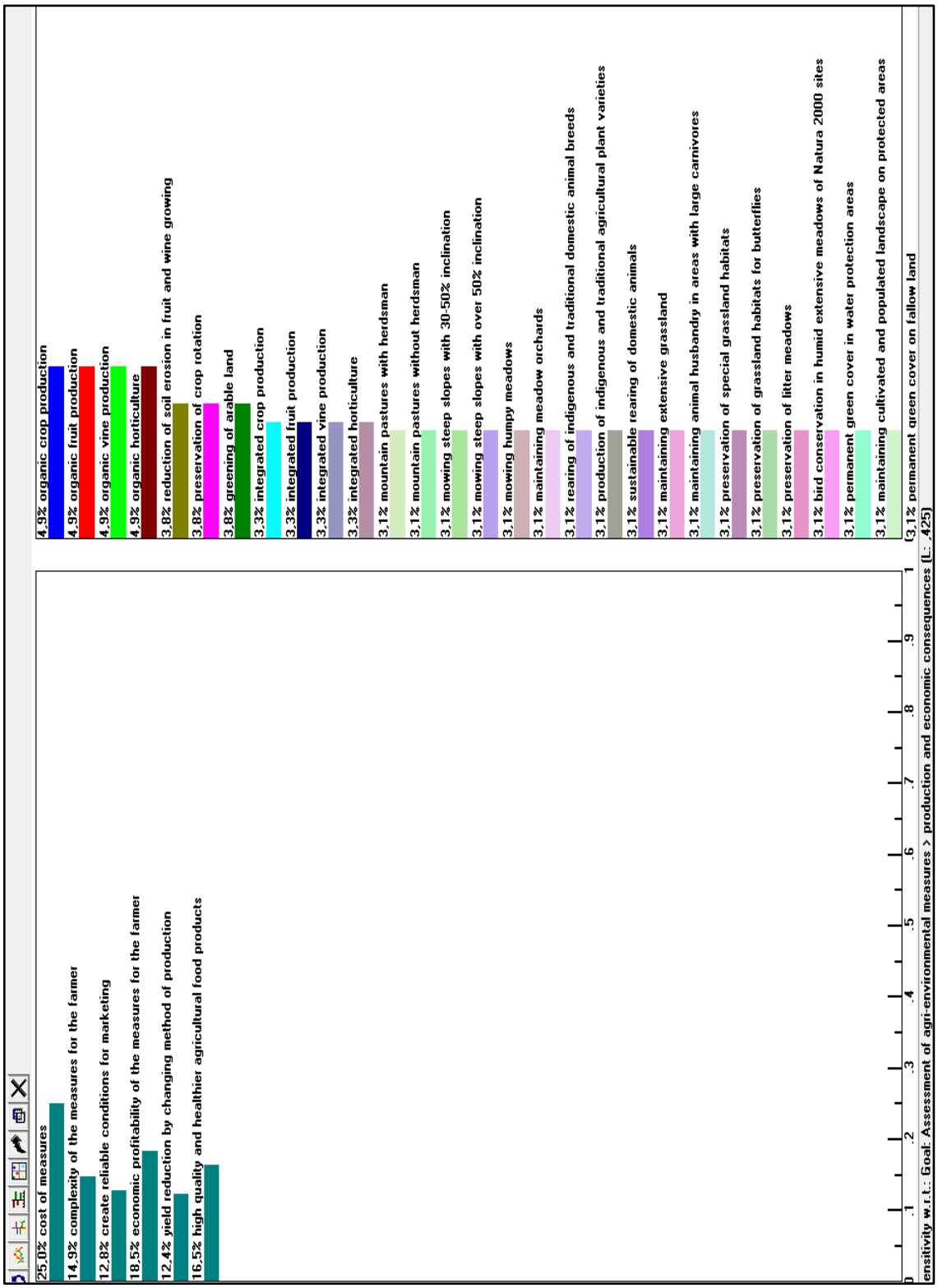


Figure 13: Sensitivity analysis with respect to criteria "production and economic consequences" after altering attribute "complexity of the measures for the farmer"

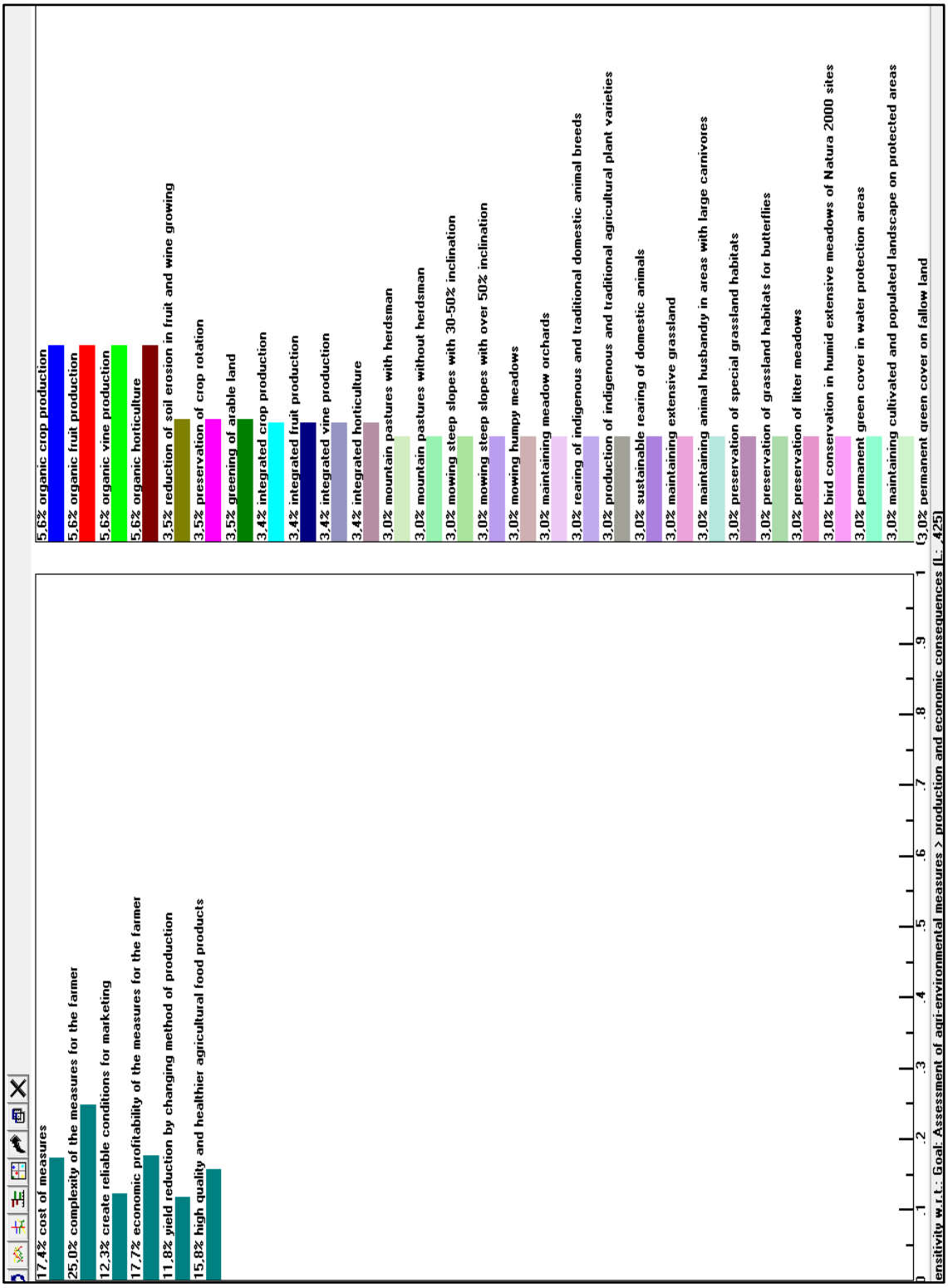


Figure 14: Sensitivity analysis with respect to criteria “production and economic consequences” after altering attribute “create reliable conditions for marketing”

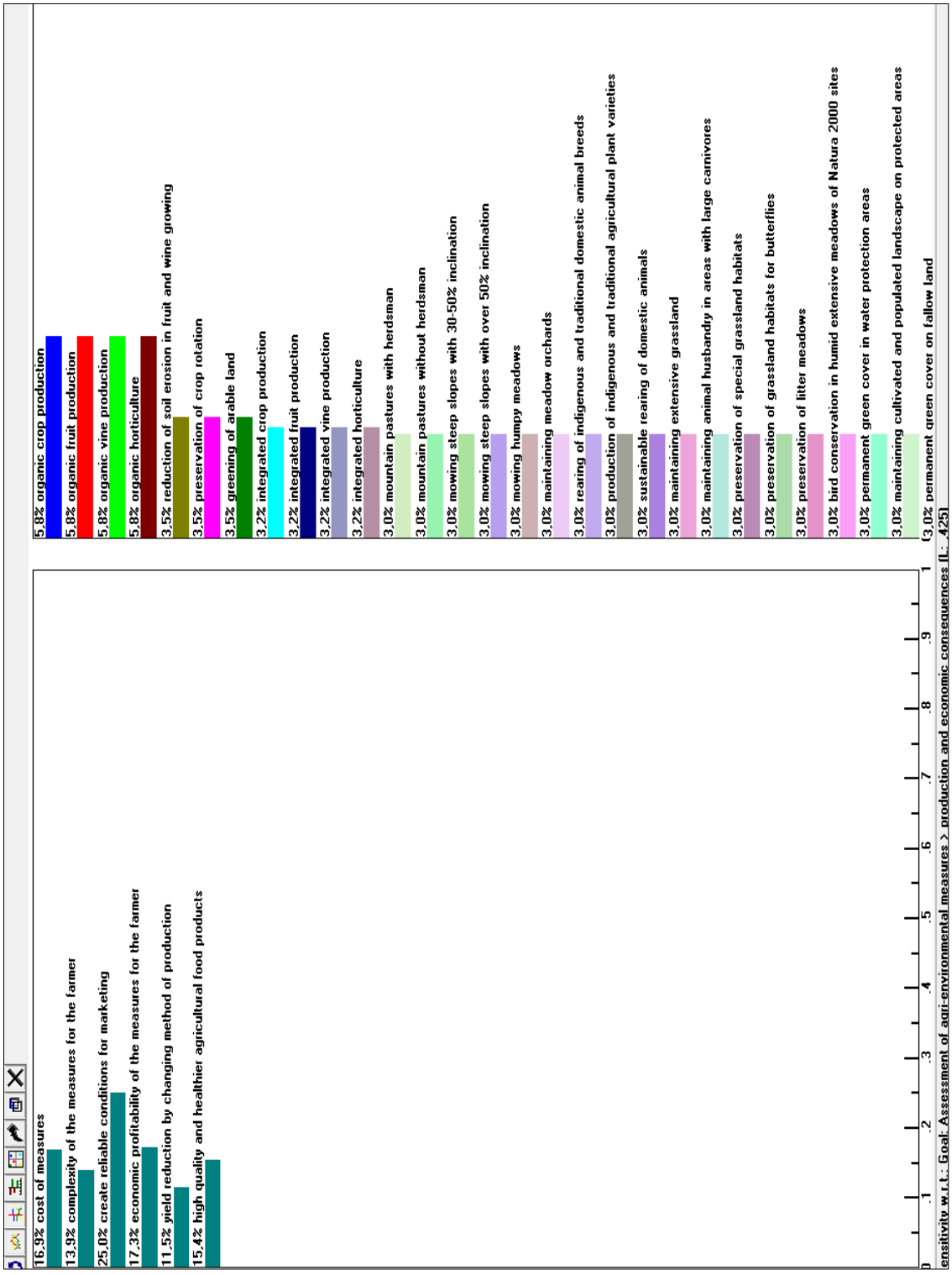


Figure 15: Sensitivity analysis with respect to criteria "production and economic consequences" after altering attribute "economic profitability for the farmer"

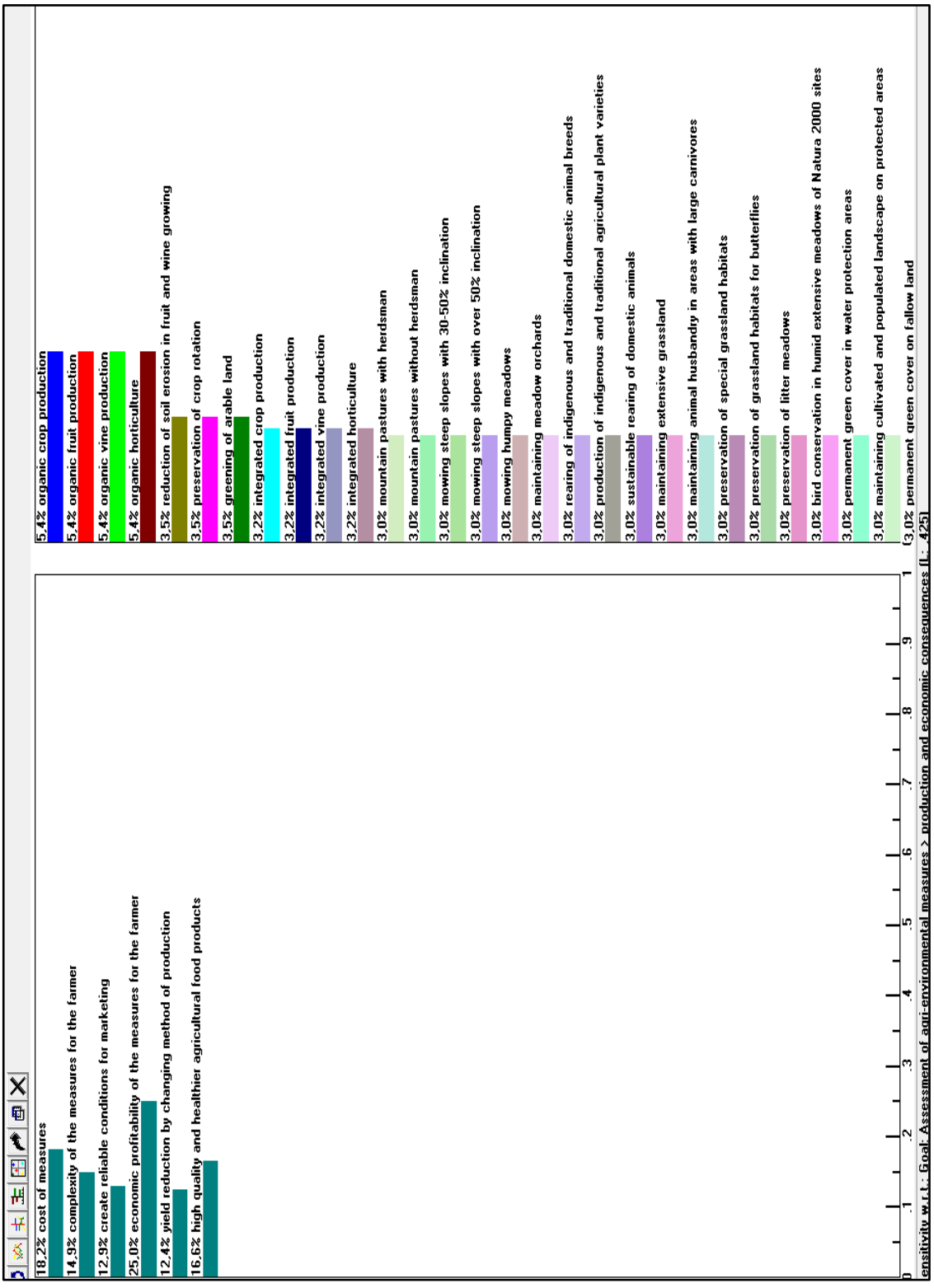


Figure 16: Sensitivity analysis with respect to criteria “production and economic consequences” after altering attribute “Yield reduction due to change of production method”

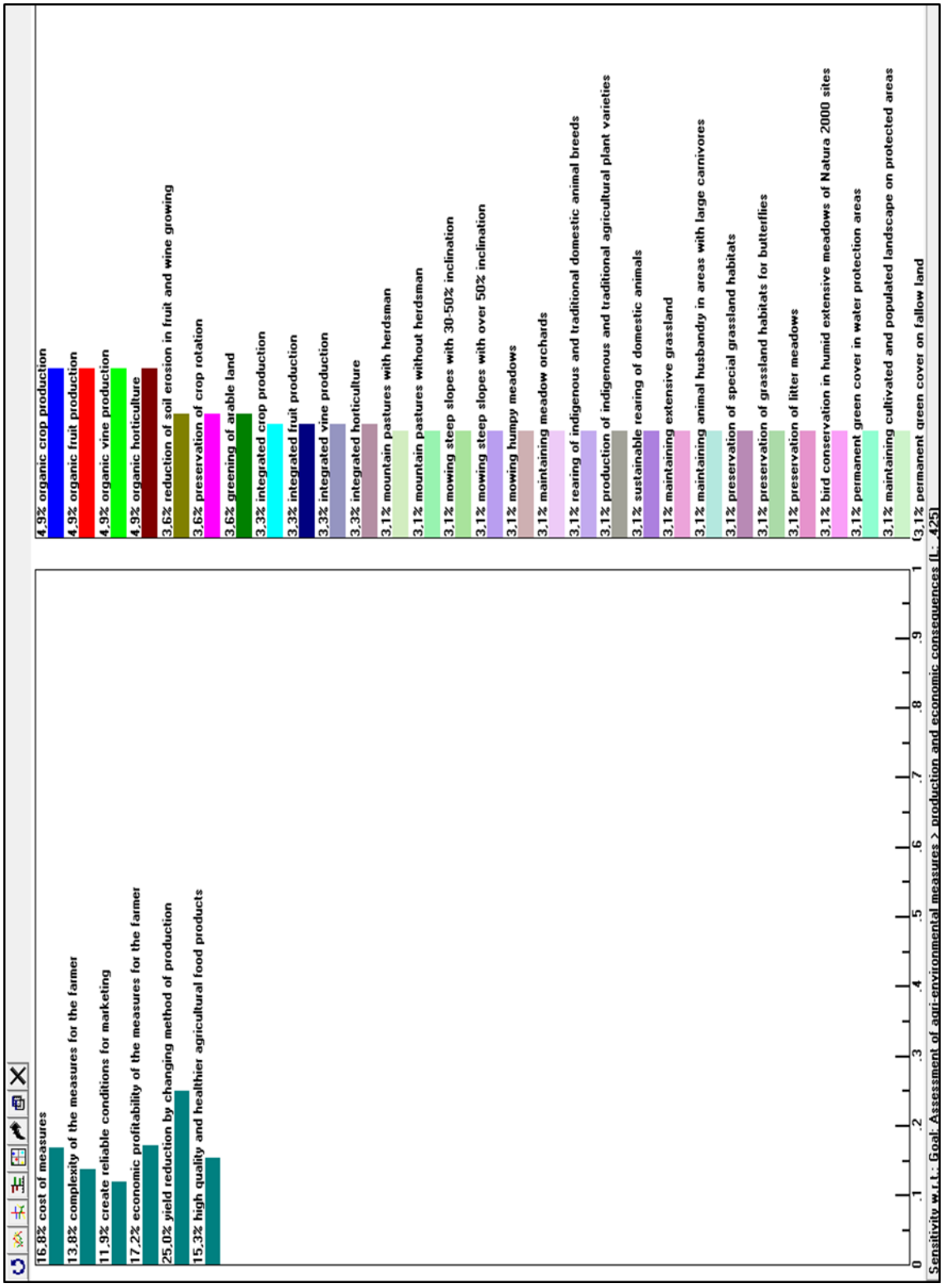
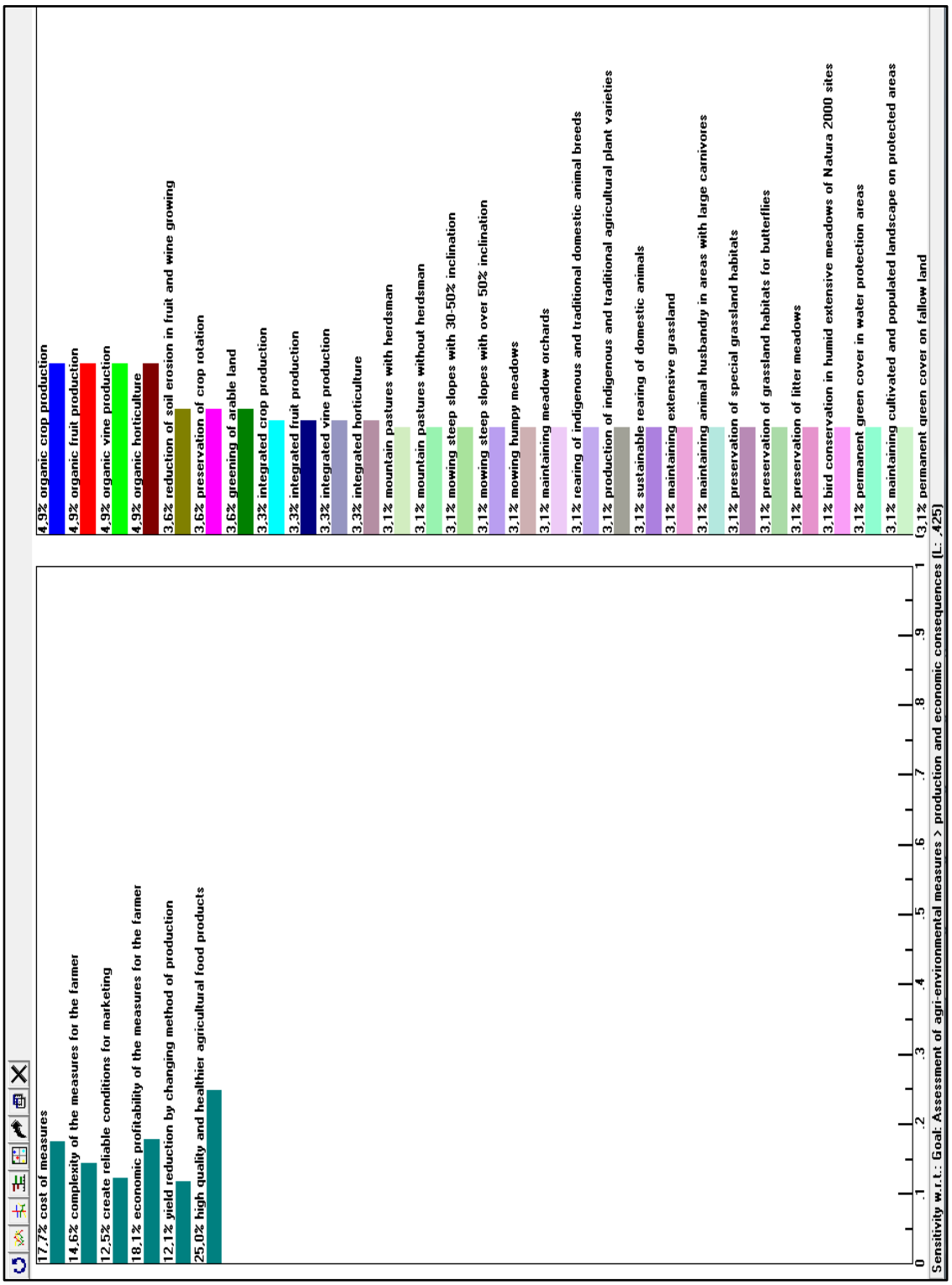


Figure 17: Sensitivity analysis with respect to criteria “production and economic consequences” after altering attribute “High quality and healthier agricultural food products”



APPENDIX IV

Personal bibliography 1988-2015

MONICA HUEHNER

SCIENTIFIC ARTICLES AND OTHER COMPLETED WORK

Original scientific article

1. ROZMAN Črtomir, HÜHNER Monika, KOLENKO Matej, TOJNKO Stanislav, UNUK Tatjana, PAŽEK Karmen. Apple Variety Assessment with Analytical Hierarchy Process. *Erwerbs-Obstbau*, 2015, http://link.springer.com/article/10.1007/s10341-015-0236-8 [SPRINGER.COM-ID: DOI 10.1007/s10341-015-0236-8]

Master´s thesis

2. MUDIMA Monica. Wirkung verschiedener Wachstumsregulatoren auf Entwicklung und Ertragsbildung bei Soja (Effect of various growth regulators on development and yield in soybean). Master´s thesis at the Institute of Tropical Agriculture of the University of Leipzig. 1988. 39p.

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I, the undersigned, Monica Rudawiro Huehner, with the student registration number 51052358, declare that the work entitled **Application of the Analytic Hierarchy Process for the assessment of agri-environmental measures of the Rural Development Programme:**

- is a result of my own research work with the help of my supervisor and consists of correctly specified results,
- has not been submitted as a whole or in part to any other faculty or university for the acquisition of a higher degree and
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Study programme: FALS DR AGRICULTURAL ECONOMICS, Ph.D.

Title of thesis: **Application of the Analytic Hierarchy Process for the assessment of agri-environmental measures of the Rural Development Programme**

Supervisor: Prof. Dr. Črtomir Rozman

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Vpisna številka: 51052358

Študijski program: AGRARNA EKONOMIKA, 3. STOPNJA

Naslov doktorskega dela: UPORABA ANALITIČNEGA HIERARHIČNEGA PROCESA ZA OCENJEVANJE KMETIJSKO-OKOLJSKIH UKREPOV PROGRAMA ZA RAZVOJ PODEŽELJA

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