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Efficiency analysis of alternative production systems in Kosovo - an ecosystem services approach

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SUMMARY

The efficiency estimation and the interpretation of its behavior are of extreme interest for primary producer in agriculture as well as for policy makers. The efficiency analysis became very popular with the extensive increase of the resource depletion. It is a technique that measures output/input ratio of a decision making unit that converts inputs into outputs. In agriculture, efficiency analysis is crucial to improve competitiveness at sector level through the improvements of resource utilization by farms and it also serves for evidence based policy making.

In Kosovo one of the main objectives of Agriculture and Rural Development Plan 2007-2013 and 2014-2020 is to improve competitiveness and the efficiency of primary agricultural producers and to attain sustainable land use. Regardless of this, there was a lack of studies on farm efficiency estimation and the productivity changes of the agriculture sector in Kosovo. Therefore, the conducted study of this thesis focuses on estimation and the analysis of efficiency at farm level. More specifically, the study aimed estimation of technical, economic, and environmental efficiency of the farms oriented on tomato, grape and apple production. In addition, identification of the factors that extensively explain the variation of the efficiency scores among farms was sought.

The study was based entirely on primary data, collected in three different stages. In the first stage, a survey using structured questionnaire was conducted with 120 farms which were distributed equally for each selected production system in the study. This group of data provided information on demographics and composition of the farm household, employment status, sources and composition of the farm income, land use, crop production, yields and inputs used. In the second stage of the study, 304 soil samples were collected at cultivated and uncultivated farm land. The soil chemical analysis were carried out in order to be able to describe internal soil nutrition and soil quality for each farm. In the third stage of the research, data describing the ecological aspect of biodiversity provided by farms was collected.

Descriptive statistics, analysis of variance, statistical tests and correlation coefficients were used to describe and analyze household and farm characteristics of the three production systems. Principle Component Analysis and Normative Method were used to aggregate soil chemical parameters into one index value that described soil quality at farm level. Shannon's Diversity Index based on the number of cultivated varieties within each crop (tomato, apple and grape) was used as an indicator for agro-biodiversity provision by each farm.

Farm efficiency scores were obtained using a Data Envelopment Analysis, which is a linear programming optimization technique that measures relative efficiency of a set of comparable units. Two different objective functions under constant and variable returns to scale were estimated for the technical and economic efficiency. At the input oriented model, the objective function was to minimize the level of all inputs used in the production function while keeping the output level constant. While, at the output oriented model the objective function is other way around. The inputs used in the technical and economic efficiency estimation were saplings, fertilizers, packing, machinery and labor and the sales of tomato, apple and grape yields as an output. In the second stage of the analysis, truncated regression model was performed to see which of the farm characteristics were statistically important for efficiency scores variation among farms. At the environmental efficiency estimation in addition to the aforementioned inputs and outputs, soil quality and agro-biodiversity were introduced as desirable outputs in the production function.

In general, the efficiency scores for three different production systems were high, showing that there was little space for efficiency improvement. On average, tomato farms tend to be more technical efficient, followed by scale, revenue, and cost allocative efficiency. The lowest average for this group of farms was on cost efficiency. The input prices played an important role for farm efficiency, when cost-minimizing objective function was considered.

Farmers oriented in grape production were very scale efficient, followed by technical, revenue and cost allocative efficiency. Similar to the previous group, the average of cost efficiency score was the lowest and this can be explained with the differences of market prices for less attractive vine varieties and more attractive ones. Farmers which were cultivating vine varieties less attractive for vine processors, had significantly lower price per unit of output and less revenue. This on the other side increased the costs per unit of output and also decreased the average cost efficiency score.

Apple farms on average were performing relatively well in terms of technical efficiency which was the highest on average, followed by revenue efficiency and scale efficiency. Same as for grape producers, the average cost efficiency score was the lowest, indicating high variations of the market input and output prices among the farmers.

Factors which were proved to be statistically important in explaining the variation of the efficiency scores among the farms were household size, farm size and number of cultivated crops, number of land plots, farmer's education and experience in farming.
On average, the farm efficiency scores increased when environmental variables were introduced into the model. The distribution of the efficiency scores reallocated farms from lower to the higher efficiency ranges between technical and environmental efficiency.

In terms of the position in ranking between technical and environmental efficiency estimation, three different group of farms were found. A group of farms which showed increase in ranking at environmental efficiency when compared to the technical one. Farms with no difference in ranking, and a group of farms showing a decrease in ranking at environmental efficiency compared to the technical efficiency.

Farms which displayed an increase in ranking were mostly farms that improved or maintained good quality of soil at farm land and good level of agro-biodiversity provision. The second group of farms showed no difference in ranking, as they were fully efficient in technical and environmental efficiency estimation. The third group of farms which showed a decrease in ranking were those farms performing weakly in both technical and environmental efficiency. This group of farms were also having lower soil quality at farm land and lower agro-biodiversity when compared to the averages of total sample.

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ABBREVIATIONS

AE	Allocative Efficiency
ANOVA	Analysis of Variance
ARDP	Agriculture and Rural Development Program
BCC	Banker, Charnes, and Cooper
CAE	Cost Allocative Efficiency
CAP	Common Agricultural Policy
CCR	Charnes, Cooper and Rhodes
CE	Cost Efficiency
CEFTA	Central European Free Trade Agreement
CI	Confidence Interval
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
DRS	Decreasing Returns to Scale
EAP	Environmental Action Plan
ETE	Environmental Efficiency
EU	European Union
EUR	Euro
FADN	Farm Accounting Data Network
FAO	Food and Agriculture Organization
FYROM	Former Yugoslav Republic of Macedonia
GDP	Gross Domestic Product
GVA	Gross Value Added
HACCP	Hazard Analysis and Critical Control Points
HH	Household
HNV	High Nature Value
IPA II	Instrument for Pre-accession Assistance II
IPARD	Instrument for Pre-Accession Assistance for Rural Development
IRS	Increasing Return to Scale

LAG	Local Action Groups
LFA	Less Favored Areas
LP	Linear Programming
LSF	Linear Scoring Function
LS	Linear Score
MAFRD	Ministry of Agriculture Forestry and Rural Development
MA	Managing Authority
MAO	Municipal Agricultural Office
MC	Monitoring Committee
MTE	Mid-Term Evaluation
NA	Normative Approach
NIRS	Non Increasing Return to Scale
NSQI	Normalized Soil Quality Index
NVA	Net Value Added
PCA	Principle Component Analysis
PD	Paying Department
PIMDEA	Performance Improvement Management Software
PTE	Pure Technical Efficiency
PU	Paying Unit
RAE	Revenue Allocative Efficiency
RE	Revenue Efficiency
SBM	Slacks Based Measure
SD	Standard Deviation
SE	Scale Efficiency
SHDI	Shannon's Diversity Index
SPSS	Statistical Package of the Social Sciences
SQII	Soil Quality Index in Cultivated Land
SQIO	Soil Quality Index in Uncultivated Land
SQI	Soil Quality Index
TE	Technical Efficiency
UAA	Utilized Agricultural Area

VA	Value Added
VL	Value Lost
VRS	Variable Returns to Scale
WB	Western Balkans

1. INTRODUCTION

Agriculture plays a multifunctional role by producing food and fiber which already have visible values in the market (market prices). In addition, it also produces other goods and services that do not have market prices and in general are not valued. Therefore, the system of completely free market was not shown to be a perfect way of solving all economic problems and interventions to modify the outcomes to '[correct] for market failure' became a necessity for achieving better results for the welfare of society as a whole (Mankiw, N. G., 2007). The market mechanism does not function for the provision of goods with a high degree of publicness (Cooper T., 2009). It does not take into account externalities as one of the main deficiencies along with others like imperfect knowledge, imperfect competition, friction in the market mechanism and failure to reflect non-economic goals (Just R., 2004). The environmental externalities on which interventions are based on are the outputs from production that can be either negative or positive. Such outputs are usually disregarded by producers in their decision making process, as they consider only private costs and benefits. Many of these non-marketable positive and negative outputs are closely linked to the agriculture and forestry production. Whenever such positive outputs occur, intervention to encourage these kinds of activities and production of more of these products through support given to the farmers can be justified, as their role is not found only in securing food supply but also in improving environmental quality. However, there are also negative outputs ensuing from the agriculture and forestry production which are carrying costs for the society which needs to be identified and corrected by intervention.

The debates and reforms on optimization of policies and instruments of the Common Agricultural Policy (CAP) are reflecting/reflect the change of societal demand and political priorities and have been taking place since the early 1990s. The Single European Act (1986) was the major revision of the Treaty of Rome (1957), considering environmental protection in all new Community legislation. The Treaties of Maastricht (1992) and Amsterdam (1997) made sustainable development a core of European Union (EU) objective and the Agenda 2000 agreement included a revised set of objectives of the CAP that included 'integration of environmental goals into the CAP' and the 'promotion of sustainable agriculture' (Hill B. , 2012).

A considerable share of the CAP's budget in Pillar two (rural development) goes to agri-environment related schemes such as payments to farmers in Less Favored Areas (LFA), conversion to organic production, and a relatively smaller amount to socio-economic purposes. Up until now, a lot of criticism from different researchers was raised and addressed to the CAP regarding inconsistencies between objectives and the policy measures implemented (Arovuori, 2008).

The Food and Agriculture Organization (FAO) concept note on the remuneration of positive externalities in the agriculture and food sector is part of an effort to link CAP agri-environmental policies to other payments for environmental services (FAO, 2010). The nature and reversal of biodiversity decline is one of the four priorities identified in the Environmental Action Plan (EAP) 2002-2012. The emphasis of action plan and policy primarily lays on confining agricultural practices that pose threats to species and their habitats and encourage new practices that bring benefits to them. Farmland biodiversity is considered to be a public good which has an intrinsic value (Cooper T., 2009). The intensity level of agricultural production determines enhancement of species richness and in this regard extensive agricultural practices is often considered to be a good way of creating an optimal level of disturbances for generating multiple ecological niches that support a wider range of species (Kleijn, 2008). Regardless if farmland biodiversity is seen as being comprised of species and habitats or as a range of related services that they provide to society, both definitions share the characteristics of public goods (Fisher B., and Turner R. K., 2008).

It is understood that market prices may serve as a poor proxy for individual or societal values and that ecosystem service assessment need to include spatial and temporal aspects to be truly policy relevant (Fisher B., 2011). Incorporating ecosystem services into land use decisions typically favors conservation activities or sustainable management over the conversion of intact ecosystems (Balmford A., 2002). Farm characteristics such as crop cover, varieties of crop, land use, practices applied in input use, machinery, and size of the fields are considered to be the main determinants of level at which agriculture can contribute to the provision of public goods e.g. land fragmentation, land ownership and crop diversity (Manjunathaa A.V., 2012).

It is well known that most of the crops in horticultural production system are intensively cultivated with significant use of fertilizers, pesticides and herbicides. On the one side, the cultivation of horticultural crops on open fields can provide color and veriety for the landscape, but as an intensive production system the provision of environmental public goods can increase through adoption of organic methods, biological pest control, and good practices of soil management that avoid soil erosion and contamination (Cooper T., 2009). Permanent crops like grape and apple orchards provide an important habitat for many species including mammals, birds, insects and plants. The number of cultivated grape and apple varieties is important compound of biodiversity.

In addition to the private land owner's interest to manage the soil resource in a sustainable way (e.g. through careful application of the fertilizers, pesticides, herbicides and machinery), society also has interest in maintaining good soil functionality at the present time and for the future generations, as it is seen not only as a base for food production but also to underpin the provision of public goods (Cooper T., 2009). The contribution to soil functionality varies among soil management techniques. Land cover with permanent trees and vegetation, not only contributed positively to promoting biodiversity interest and soil function but also to the cultural landscapes (Chen Q., 2014).

Agriculture plays an important role in provisioning of agricultural landscapes, farmland biodiversity, and water and soil quality which are highly valued by society (Cooper T., 2009). The absence of economic values for such environmental goods and services generally leads to degradation of these goods (Kortelainen M., and Kuosmanen T., 2004). Even though there are evidences for soil quality improvements in the EU countries from agricultural activities, the situation is still unsatisfactory and there is still possibility for further progress (Cooper T., 2009). In practice, the provision of biodiversity is not explicitly recognized as a positive output when production efficiency is measured (Sipiläinen T., Marklund P., Huhtala A., 2008). Therefore, efficiency measures based only on traditional marketable inputs and outputs without incorporation of other non-marketable inputs or outputs yields biased efficiency scores.

1.1 Problem statement and justification

Despite of its comparative production advantage, due to the damages caused by the last war (1999), in the last two decades Kosovo became a net importer for most of the agricultural products, including horticultural products (Fischer Ch., 2004). Horticulture production is of high importance for the agriculture sector, accounting for approximately 40% of the agricultural output (Imami D., 2016). In the last decade, the demand for horticultural products increased more than for any other agricultural product (MAFRD, 2014) and it is expected to further rise in the future, driven by the augment in purchasing power (Imami D., 2016). According to the Green Report 2014 published by the MAFRD, the self-sufficiency ratio for most of the horticultural products (with exception of potatoes) is relatively low. The increase of the self-sufficiency ratio for tomatoes was fairly low during the time period 2007-2013 (2007 - 49.9%; 2013 - 55.7%) compared to the one for apples, which was significantly higher (2007 – 38.9%; 56.7%) (MAFRD, 2014).

Since 2007 there has been a significant improvement of financial support from the Government of Kosovo and the international donor community for the agriculture sector. In the last few years the private side has shown a remarkable interest to invest in the agrifood sector. One of the main objectives of the agriculture sector stated in the Kosovo Agriculture and Rural Development Plan (ARDP) 2007-2013 as well as in the ARDP 2014-2020 is to increase *competitiveness* and the *efficiency* of primary agricultural production which will yield higher income for the farmers and improve living standards in rural areas, as well as impact import substitution and take advantage of export markets.

Taking into account the stated objectives in the ARDP 2007-2013 and 2014-2020, we considered that measuring the efficiency of farms is crucial in order to improve understanding of factors that explain differences in the efficiency among farms and also provides possibilities for better utilization of resources (land, labor and capital) by farms. Despite its importance until 2014 there were no studies conducted on measuring neither farm efficiency, productivity growth nor changes in the agriculture sector of Kosovo. A first study entitled '*Migration and agriculture efficiency-evidence from Kosovo*' was published in 2014 by Sauer J. et al.. The study used a parametric stochastic frontier approach to estimate efficiency of the farms in Kosovo. The mean of the technical efficiency for the whole sample was estimated to be 61.1% (SD = 24.3%) (Sauer J., Gorton M., Davidova S., 2014). The data used in this study was coming from Annual Agricultural Household Surveys conducted by Statistical Office of Kosovo 2005-2008. It should be emphasized that agricultural households included in the sample were subsistence household farms that cultivated more than 0.10 hectares (ha) of arable land or less than 0.10 ha of utilized arable land but had at least: 1 cow or 5 sheep/goats or 3 pigs or 50 poultry or 20 beehives. Just recently a new study was published by (Vuçitërna R., 2017) on '*Efficiency and Competitiveness of Kosovo Raspberry Producers*'. The study used an input-oriented DEA method to measure technical efficiency of the raspberry producers in Kosovo. Nevertheless the attention and support given to the agriculture sector by the government and other international donor organizations has increased significantly in recent years and is expected to further increase in the coming years (Imami D., 2016).

Considering all these factors/circumstances, such as the objectives of the agriculture sector in Kosovo, the low self-sufficiency ratio, the negative trade balance, the increased financial support given to the agriculture sector, the importance of efficiency measurements and analysis in regard to the agriculture sector's objectives, the absence of studies on the efficiency, and the need for more efficient use of existing technologies and resources. All these factors justify the need to conduct a study on this topic.

1.2 Objective of the study

The overall objective of the study was to estimate efficiency levels among the private farms in Kosovo which were oriented more on tomato, grape and apple production. The utilized agricutlural area for vegetables and fruits was used as criterion in the selection process of crops to be included in the study. Taking into consideration this criterion tomatoes (within vegetables), apples and grapes (within fruits) were the most cultivated crops.

Within this context the study aimed to achieve the following specific objectives:

- Estimate economic efficiency of the three different production systems considered in the study;
- Estimate environmental efficiency of three different production systems with the inclusion of environmental variables into efficiency measure;
- Identify factors that comprehensively/extensively explain the variation of the efficiency scores among the selected farms for each production system and estimate potential reduction of the input costs or increase of output levels that can improve economic and environmental efficiency of the farms.
- Derive recommendations for more efficient use of existing technology and resources and foster the degree of multifunctionality.

2. OVERVIEW OF THE AGRICULTURE SECTOR IN KOSOVO

2.1 Background information

In 2012, the real Gross Domestic Product (GDP) growth was 2.5% and GDP per capita 2,721.0 EUR. Compared to 2011, an inflation rate in 2012 was lower for 2.5%. Even though unemployment rate shows a decrease in 2013, it still remains a serious problem for the country's economy and at a very high rate in comparison to the other regional countries and with the EU countries. The unemployment rate in 2013 was estimated to be 30.0 %. The share of food, beverages and tobacco in total household's expenditures in 2012 was at 45%.

Table 1: Macroeconomic indicators

Indicator	Unit	2006	2007	2008	2009	2010	2011	2012
Total area	km^2	10,908	10,908	10,908	10,908	10,908	10,908	10,908
Population	000	2,100	2,130	2,153	2,181	2,181	1,740	1,816
GDP (at current prices)	mill. EUR	3,120	3,461	3,940	4,008	4,291	4,770	4,916
Value added (at current prices)	mill. EUR	2,745	3,034	3,487	3,533	3,697	4,043	:
Economic growth (real change in GDP)	%	3.4	8.3	7.2	3.5	3.2	4.4	2.5
GDP per capita	EUR	1,890	2,062	2,310	2,311	2,436	2,668	2,721
Inflation	%	0.6	4.4	9.4	-2.4	3.5	7.3	2.5
Unemployment rate	%	44.9	43.6	47.5	45.4	44.0	44.8	30.9

Source: Kosovo Agency of Statistics, 2006-2012.

2.2 The role of the agriculture sector in the country's economy

Agriculture has historically been an important sector for the economy of Kosovo. The average share of the agriculture, forestry, hunting and fishery sector in Gross Value Added (GVA) for the period of time 2006-2011 was about 15%. The agriculture share in total employment rate in 2012 was estimated to be 4.6% (Table 2). When we consider the contribution of the agriculture sector in GVA and the estimated employment rate into agriculture, it gives an indication of a sector with good efficiency rate. However, this figure (4.6%) covers only formal employment in the agriculture sector. The Agriculture sector in Kosovo aside from the employment and its economic contribution it also provides a social safety net for a large number of the family farms living in rural areas. Agriculture is at a small scale, predominating subsistence farms with small land tenure and enormously fragmented (MAFRD, 2013).

Table 2: Key agricultural statistics

	Unit	2006	2007	2008	2009	2010	2011	2012
GVA of the agriculture, forestry, hunting and fishery sector								
GVA (at current prices)	Mill. EUR	372.4	479.6	526.3	532.7	630.3	705.5	615
Share in GVA of all activities	%	13.6	15.8	15.1	15.1	17.1	17.5	:
Employment in the agriculture, forestry, hunting and fishery sector								
Number	000	:	:	:	:	:	:	13900.0
Share in total employment	%	:	:	:	:	:	:	4.6
Trade in food and agricultural products								
Export of agri-food products	Mill. EUR	9.9	17.0	18.15	17.4	24.7	26.2	20.6
Share in export of all products	%	8.9	10.3	9.1	10.5	8.3	8.2	7.5
Import of agri-food products	Mill. EUR	319.0	384.1	432.3	431.1	482.8	561.4	572.7
Share in import of all products	%	24.4	24.4	22.4	22.3	22.4	22.5	22.8
Trade balance in agri-food products	Mill. EUR	-309.1	-367.1	-414.2	-413.7	-458.1	-535.2	-552.1

Source: Kosovo Agency of Statistics, 2006-2012; Green Report Kosovo 2013.

2.3 Land resource and farm structure

According to the latest statistics, the total agricultural land of Kosovo amounts at 357,748 ha, out of which 253,563 ha is arable land, 7,071 ha land under permanent crops (orchards and vineyards), and 97,114 ha land under permanent grassland (meadows and pastures). The total farm land is used by 185,765 farms, out of which 185,424 (99%) are small farms (MAFRD, 2013). The share of the utilized agricultural area from total area is 25.4% and the utilized agricultural area per 1,000 of population is 125.6 ha.

Kosovo has an unfavorable farm structure (Table 3), with an average Utilized Agricultural Area (UAA) per holding of 1.5 ha, fragmented into 7 plots. For the period of time 2007-2012 the number of farms remained almost constant but the UAA per holding increased by 5.7% and this was notably taking place at large and specialized farms (MAFRD, 2013).

Table 3: Farm structure by size in 2012

Farm size (ha)	Number of farms	Area (ha)	% of farms
0.01 – 0.5	45,818	13,300	24.7
0.51 – 1.0	51,665	39,385	27.8
1.01 - 1.5	35,589	43,772	19.2
1.51 - 2.0	15,719	27,830	8.5
2.01 – 3.0	19,995	49,340	10.8
3.01 – 4.0	5,777	20,009	3.1
4.01 – 5.0	3,748	16,646	2.0
5.01 – 6.0	2,317	12,622	1.2
6.01 – 8.0	2,582	17,847	1.4
8.01 – 10	1,007	8,972	0.5
> 10	1,547	27,641	0.8
Total	185,765	277,364	100.0

Source: Green Report Kosovo 2013, 2013.

2.4 Agricultural production and consumption

The agricultural production is characterized with a small farm size, outdated technology and farming practices, inefficient management practices, inappropriate use of the agricultural inputs, an unfavorable credit market and an insufficient provision of technical expertise. All these highlighted factors bring Kosovo's agricultural production/yields fairly below the EU averages. The majority of the agricultural production is sold at the domestic market for human consumption and limited amount to the processing industry, mainly without a long term contractual bases. Due to the many small farms and the limited amount of the agricultural production, Kosovo's agricultural processors are facing high collection costs and consequently making them less competitive in the market.

The average share of the crops in total agricultural goods output for the period of tie 2010-2012, was considerably higher (54.3%) compared to the livestock output (45.7%). However, the contribution of the livestock branch to the total agricultural goods output was apparently more constant for the given period of time (Figure 1).

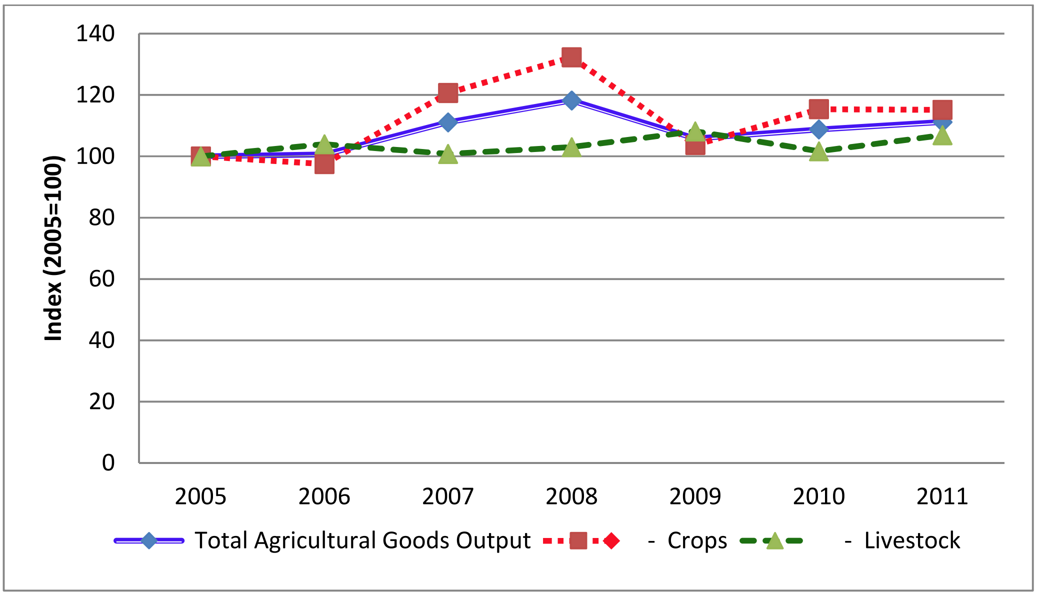


Figure 1: Indices of agricultural goods output 2005-2011

The most important crops for agricultural production are cereals, predominantly wheat and maize. In 2012, the total cultivated area with cereals was 137,214 ha, out of which 31,181 ha was cultivated with maize and 3,115 ha with rye, barley, malting barley and oat (Table 4). A high proportion of the agriculture area is cultivated with forage crops such as hay, grass, alfalfa, trefoil, vetch, wheat fodder, rye fodder, barley fodder, oat fodder, maize fodder and in total these crops sum up to 94,400 ha.

Table 4: Crop production structure 2006-2012, in 000 ha

Crop	2006	2007	2008	2009	2010	2011	2012
Cereals	110.0	102.4	115.0	120.0	119.9	121.1	137.2
Potato	3.1	5.0	3.7	3.4	3.8	3.7	3.2
Grapes	3.0	3.0	3.0	3.1	3.1	3.2	3.2
Fruits	3.2	3.8	4.0	3.0	3.4	3.6	3.9
Vegetable	8.1	8.3	8.6	8.4	9.0	9.2	8.4
Beans	4.8	4.4	4.2	4.1	3.6	3.3	3.0
Forage	96.7	108.4	104.7	91.4	99	98.8	94.4

Source: Green Report Kosovo 2013, 2013.

A considerable area of the agricultural land is occupied with vegetable production (8,405 ha, 2012; Table 5). The most cultivated and consumed vegetables in Kosovo are tomato, pepper, cucumber, water melon, pumpkin, cabbage, and onion. In 2012, among the all cultivated vegetables the highest increase of the cultivated area was recorded for tomato (31%) and the production rose by 22%.

Table 5: Area and production of the main cultivated vegetables, 2006-2012

Cultivated area	Unit	2006	2007	2008	2009	2010	2011	2012
Area used for vegetable	ha	8111	8312	8592	8351	8987	9190	8405
Area used for tomato	ha	787	923	903	821	935	967	1271
Tomato production	t	15195	14697	20587	15107	60318	62358	13693
Share of tomato	%	9.70	11.10	10.50	9.83	10.40	10.52	15.12
Yield	t/ha	19.30	15.92	22.79	18.40	64.51	64.48	10.77
Area used for pepper	ha	2733	2231	2523	2955	2914	2993	3153
Share of pepper	%	33.69	26.84	29.36	35.38	32.42	32.56	37.51
Pepper production	t	62925	35959	51274	46669	93924	96322	50744
Yield	t/ha	23.02	16.11	20.32	15.79	32.23	32.18	16.09
Area used for cucumber	ha	277	344	278	316	343	359	255
Share of cucumber	%	3.41	4.13	3.23	3.78	3.81	3.90	3.03
Production of cucumber	t	7528	7088	9032	7199	12902	13502	5239
Yield	t/ha	27.17	20.60	32.48	22.78	37.61	37.61	20.54
Area used for water melon	ha	700	901	1029	954	1141	1240	847
Share of water melon	%	8.63	10.83	11.97	11.42	12.69	13.49	10.07
Production of water melon	t	18821	15048	24736	18896	25743	27975	17080
Yield	t/ha	26.88	16.70	24.03	19.80	22.56	22.56	20.16
Area used for cabbage	ha	921	620	703	962	836	842	568
Share of cabbage	%	11.35	7.45	8.18	11.51	9.30	9.16	6.75
Production of cabbage	t	25012	15425	19041	27895	22988	23154	13975
Yield	t/ha	27.15	24.87	27.08	28.99	27.49	27.49	24.60
Area used for onion	ha	810	1059	1205	798	1043	1074	881
Share of onion	%	9.98	12.74	14.02	9.55	11.60	11.68	10.48
Production of onion	t	11376	10934	15987	8697	13257	13655	8601
Yield	t/ha	14.04	10.32	13.26	10.89	12.71	12.71	9.76
Other	%	23.21	26.87	22.70	18.50	19.75	18.66	17.01
Total cultivated area	%	100	100	100	100	100	100	100

Source: Kosovo Agency of Statistics: Agricultural Households Survey, 2006-2012.

Increasing productivity and competitiveness of the agricultural production is a long term policy objective in Kosovo. However, the average yields for crops (t/ha) still remain below the European average. The average yield in wheat production for the period of time 2010-2012 was 73.3% of the EU-27 average. In 2012, the average maize yield was recorded at 2.8 t/ha which is still fairly low compared to the EU-27. In 2012, the average yield for potatoes was 55% lower compared to the years 2011 and 2010 (Figure 2). The average yield for potatoes from 2010-2012 was recorded at 19 t/ha, which is 69% of the average yields realized by EU farmers.

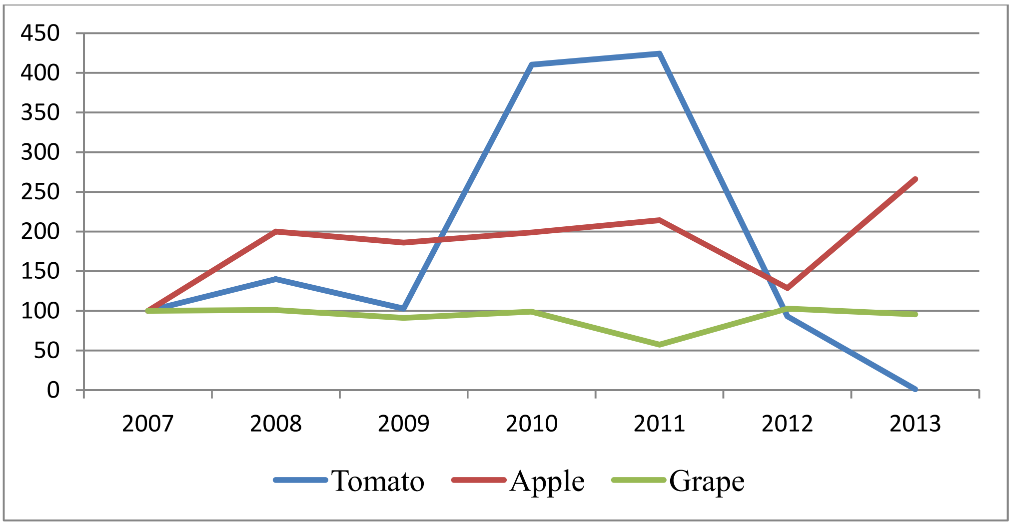


Figure 2: Yield indices of the selected crops in the study, 2007-2013

Source: Green Report 2014, MAFRD.

In 2012, the total area with the fruit production was 7,071 ha and the most cultivated fruits were apple, pear, plum, sour cherry, and grape which all together take up to 95% of the cultivated area with fruits. About 25% of the total cultivated area with fruits is planted with apple and compared with the previous year this area in 2012 decreased by 4%. The range of the planted apple cultivars is wide up to 20 but those most frequently grown are Idared, Golden Delicious, Jonagold, Granny Smith and the rootstocks used are mainly M9, MM106, and M26 (Spornberger, et al., 2014). The total domestic production of the apple fruit fulfilled only 53% of the domestic needs (Table 6) and out of the total domestic production around 60% is used for the household needs (MAFRD, 2013).

Table 6: Supply balance for apple, 2006-2012

	Unit	2006	2007	2008	2009	2010	2011	2012
Area used for fruits	ha	6,157	6,812	6,999	6,027	6,578	6,733	7,071
Area used for apple	ha	1,096	1,068	1,686	1,355	1,661	1,790	1,725
Share of apple	%	17.8	15.7	24.1	22.5	25.3	26.6	24.4
Yield	t/ha	8.55	5.91	7.48	8.67	7.55	7.55	4.71
Production	t	9,372	6,307	12,612	11,742	12,545	13,523	8,120
Import of apple	t	10,759	9,929	9,684	11,161	12,221	11,084	7,134
Supply	t	20,131	16,236	22,296	22,903	24,766	24,607	15,254
Export of apple	t	19	3	63	5	7	3	11
Domestic uses	t	20,112	16,233	22,234	22,898	24,758	24,604	15,243
Self-sufficiency ratio	%	46.6	38.9	56.7	51.3	50.7	55.0	53.3
Waste	t	937	631	1,261	1,174	1,255	1,352	812
Own final consumption	t	5,061	3,406	6,810	6,341	6,774	7,302	4,385
Human consumption total	t	19,175	15,602	20,972	21,724	23,504	23,252	14,431
Domestic uses total	t	20,112	16,233	22,234	22,898	24,758	24,604	15,243
Producer price (farm gate)	€/kg	0.51	0.56	0.60	0.51	0.49	0.49	0.54
Value of production	Mill. EUR	4.3	3.2	6.8	5.4	5.5	6.0	3.9
Trade balance for apple	Mill.EUR	-2.3	-2.4	-2.7	-3.0	-3.4	-3.3	-4.2

Source: MAFRD, 2013.

Grape and wine production in Kosovo has a history of thousands of years. Different topographies and archeological discoveries give an evidence of ancient Ilirian-Albanian tradition of the grape and wine production. In the cadastral documents of XI-XV centuries, many villages of the municipality of Vushtrri and the territory of Kosovo as whole, was recognized as grape cultivator area (Gjonbalaj, et al., 2009).

Yet, the wine sector remains an important and most promising branch of the agriculture sector. In 2012, the total cultivated area with grape reached at 3,220 ha out of which 22% belong to the table grape varieties. Grape is the only fruit where Kosovo farmers attained higher average yields in 2010-2012 (21.5%) compared to the EU farmers (Figure 3). In the last three years, the average yield for grape was 7.9 t/ha which is 10% higher than in other Western Balkan countries. Kosovo farmers reached comparable grape yields with Italian and Greek farmers.

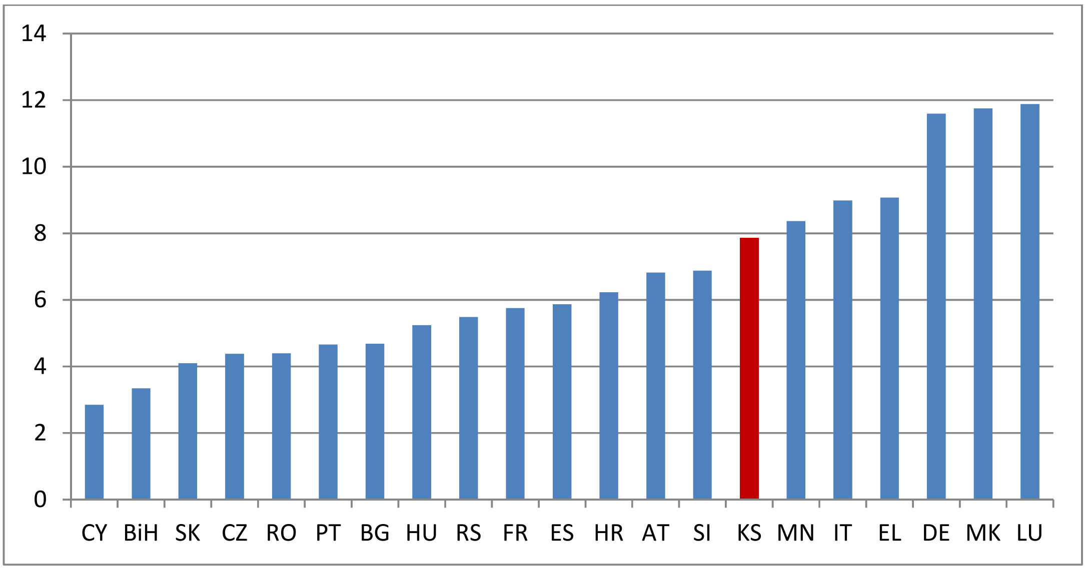


Figure 3: Grape yields comparisons in t/ha with the EU and WBs, 2010-2012

Source: FAO/SWG Project.

In comparison to the previous year the total production of the table grape in 2012 increased by 55%. However, the trade balance remains negative with 528 Mill. EUR and the total production of 7,026 tons cover 87% of the domestic needs (MAFRD, 2013).

Table 7: Supply balance for table grape, 2006-2012

	Unit	2006	2007	2008	2009	2010	2011	2012
Area used for vineyard	ha	2,972	3,007	3,042	3,057	3,140	3,158	3,220
Area used for table grape	ha	620	630	625	637	636	648	703
Yield for table grape	t/ha	10	10	10	9	10	7	10
Production of table grape	t	6,200	6,300	6,250	3,303	6,042	4,536	7,026
Import of table grape	t	2,141	2,264	1,472	2,194	2,251	2,011	1,037
Supply of table grape	t	8,341	8,564	7,722	5,497	8,293	6,547	8,063
Export of table grape	t	131	246	468	90	212	8	18
Domestic use of table grape	t	8,210	8,318	7,254	5,408	8,081	6,539	8,044
Self-sufficiency ratio	%	76	76	86	61	75	69	87
Uses of table grape	t	8,210	8,318	7,254	5,408	8,081	6,539	8,044
Producer price (farm gate)	€/kg	0.75	0.88	0.85	0.83	0.80	0.93	0.93
Value of production (000)	€	4,650	5,544	5,313	2,741	4,834	4,218	6,534
Trade balance	Mill. €	-700.8	-823.0	-980.9	-1,169.4	-1,243.4	-1,469.3	-527.8

Source: DEAAS-MAFRD, 2013.

The range of the wine grape varieties cultivated in Kosovo is more than 40 but around 60% of the total cultivated area is pertained by four varieties such as Vranac, Smederevë, Prokupë, and Game e thjeshtë and Vranac variety is mainly cultivated in the vineyard area of Rahovec. The other three varieties recently has shown a tendency of reduced area, particularly the Prokupë which is considered the oldest variety, with 70% of the grape trees older than 30 years. The range for table grape varieties is shorter and more than 80% of the area is cultivated with Muskat Hamburg, Muskat Italian, and Afuzali.

Table 8: Total area distribution among cultivated wine and table grape varieties

Wine grape varieties	Area (ha)	Table grape varieties	Area (ha)
Vranac	396.37	Muskat Hamburg	258.5
Smederevë	391.98	Muskat Italian	158.79
Prokupë	380.59	Afuzali	154
Game e thjeshtë	317.47	Kardinal	47.72
Rizling Italian	247.97	Moldavkë	14.28
Shardone	118.59	Demirkapi	10
Burgundez i Zi	157	Victoria	8.54
Zhametë	109.56	Rrush Tryeze Eksperimental	7.93
Kaberne Sovinjon	86.78	Antigona	7
Rizling Rajne	69.05	Hershmja e Opuzenit	6.11
Other	242.01	Other	29.8
Total	2,517.37	Total	702.67

Source: Institute of wines and vineyards, 2013.

According to MAFRD register there are 15 licensed companies dealing with grape processing to wine and other grape products and 33 other companies operating as importer of the wine and other grape products. Among the licensed companies the largest one is "Stone Castle Vineyards & Winery" which dominates the market and produces almost 80% of the total domestic wine. In 2012, the main types of the produced red wine were Pinot Noir, Vranac & Game, Merlot, and Cabernet Sauvignon. From the white wine sort were mostly produced Rizling Italian, Chardone and Rizling Rajne (MAFRD, 2013).

Table 9: Wine production, 2008-2012

Production	Unit	2008	2009	2010	2011	2012	Changes 2012/(2009-11) in %	2012/2011 in %
Wine	1000 l	9,372	6,399	3,056	1,521	5,287	44	247
Red wine	1000 l	4,995	4,078	2,082	1,118	2,518	4	125
White wine	1000 l	4,377	2,321	974	403	2,769	125	587

Source: Green Report Kosovo 2013, 2013.

The producer price for wine varies between 1.30 up to 2.50 €/liter and in average it takes 1.55 kg of the grape to produce a liter of wine. The annual average of the wine consumption in Kosovo does not exceed two liters per capita and is significantly determined by household income and employment status of the family members (Gjonbalaj, et al., 2009). Due to the low level of income, the consumers as individuals or a families make effort to select those products that fulfill their primary needs (Bytyqi, et al., 2008). Therefore, wine consumption is usually perceived as a product that fulfills the necessity in a higher hierarchy of the human needs.

The agricultural sector as a whole and particularly the livestock sector was significantly harmed by the conflict in 1999 where approximately 50% of the livestock was killed and around 40% of the livestock infrastructure (stalls) was destroyed (MAFRD, 2003). Since then many efforts were made by donors and also through the import in restocking and increasing the cattle herd size in Kosovo (Table 10). Its contribution to the total agricultural goods output in 2011 amounted to 275.4 million EUR, which is about 14% lower than the contribution of the crop output.

Table 10: Stock of the selected animals in Kosovo in 000 of units, 2006-2012

Animal	2006	2007	2008	2009	2010	2011	2012
Cattle	381.9	321.6	341.6	344	356.7	361.8	329.21
of which milk cows	205.38	189.70	191.5	190.2	194.9	196.1	183.34
Pigs	68.223	39.591	26.7	50.58	50.58	50.58	55.7
of which breeding sows	18	10.4	7.3	12.2	12.2	12.2	:
Sheep/Goats	112.94	151.81	180.12	217.16	229.157	231.209	247.90
of which breeding ewes/goats	74.87	108.18	124.12	158.12	163.49	163.49	175.29
Horses	6663	6147	4973	4213	4213	4213	2139
Poultry	2,525	2,278	2,213	2,390	2,347	2,347	2,318
Beehives	72.16	60.95	43.29	43.15	46.95	44.63	46.48

Source: Green Report Kosovo 2013, 2013.

Out of the total number of cattle in 2012, dairy caws represent 55.6% and comparing with the year 2011 the number of dairy caws in stock decreased by 6.5%.The number of total pigs and breeding sows was increased by 10.1% in 2012 compared to the previous year. Compared to the other selected animals, the total number of sheep and goats stock showed a significant increase between 2006 and 2012. In 2006, Kosovo counted 112,943 sheep and goats and compared to the stock counted in 2012 this number is doubled. In 2012, the number of sheep and goats increased by 7.3% as compared to the previous year. Negative trend was shown in terms of the total number of horses in stock for the period of time 2006-2012. In comparison with the last three previous years, in 2012 the total number of horses in stock decreased by 51%.

The poultry production in Kosovo is characterized by small and medium–scale production units, mainly oriented on eggs production for consumption, whereas, the production of chicken for meat is in the consolidation stage. It has been estimated that the production of eggs fulfills the needs of local costumers by 70% (MAFRD, 2013). Considering suitable environmental conditions, honey and other beekeeping products were considered products with good potential for export. In 2012 the number of beehives increased by 4% as compared with the year 2011. Concerning the amount of honey consumption, it has been estimated that Kosovo has the lowest consumption in Europe, with only 0.400 kg per capita a year (MAFRD, 2013).

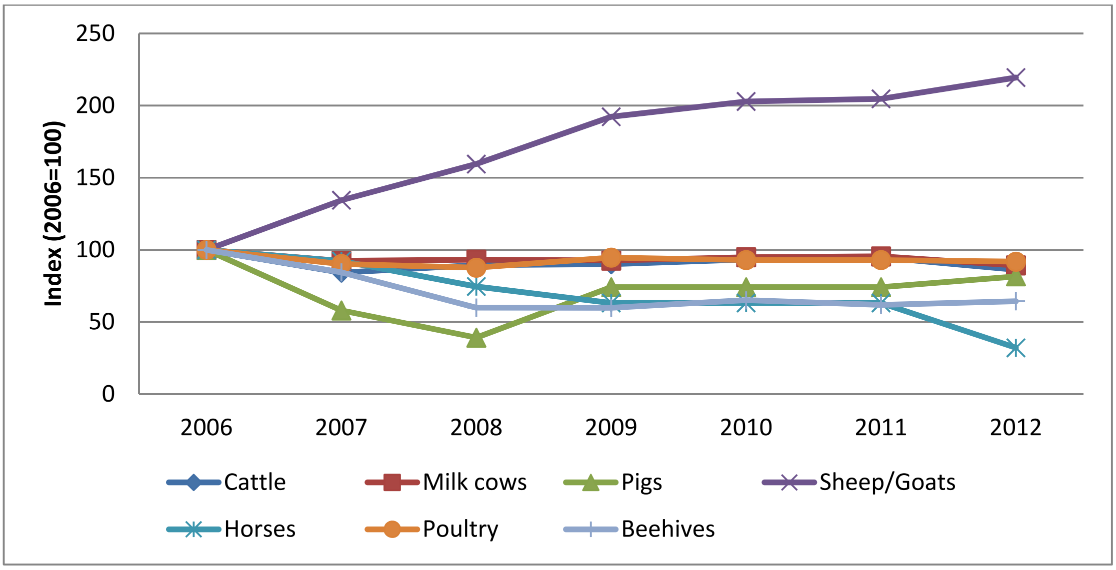


Figure 4: Stock indices of the selected animals in Kosovo, 2006-2012

Source: Own calculation based on Kosovo Agriculture Household Surveys; Green Report Kosovo 2013.

2.5 Agricultural prices

In general the agricultural output prices showed a significant increase during the period of time 2005-2012. The greatest growth of prices for cereals (including rice) was recorded in 2008 and comparing with the year 2005 it was for 88.4% higher (KAS, 2013). In 2012 comparing with 2011, the prices for common wheat, maize, rye and oats increased by 3-4%, except barley which exhibited the highest increase price of 13% (KAS, 2013). Significant price increase was shown for nuts (in a shell). Similar trend was exhibited for table grape, and compared to 2005 the price for it was by 22.4% higher in 2012 (KAS, 2013). In general the prices for vegetables were mostly increasing from 2005 to 2012. On average the agricultural crop output prices are higher in Kosovo compared to the prices of EU. This is an indicator that Kosovo is still confronting weak price competitiveness.

Compared to the crop products, the prices for livestock products were significantly increasing faster for the given time 2005-2012 (Figure 5). If we compare the price of young cattle in 2005 with the price in 2012, it has increased by 31.8%. Between 2005 and 2012, approximately similar price increases have occurred to the other livestock products such as pigs (36.1%), lams (28.6%) and chicken (33.3%). Compared to these livestock products, the prices for eggs and milk showed smaller increase between 2005 and 2012, 24.9% for eggs and 14.3% for cow's milk.

The data on total agricultural input prices indicates a continuously increase of prices during the period of time 2005-2012 (Figure 6). Compared to 2005, the price for seeds and other reproductive material increased by 39% in 2012 and the highest price increase occurred in 2011 (42%) (KAS, 2013). The prices for energy, lubricants and fuels were at 41.6% higher in 2012 compared to 2005, which is the highest price increase from 2005 to 2012. Contrasting, the prices for plant protection products increased only by 2.4% in 2012, taking 2005 as nominal year and were even lower in 2008 and 2009 (KAS, 2013). Positive trend in terms of the price increase was also shown for veterinary services, 29.9% higher in 2012 than 2005. Considering the prices of most observed agricultural inputs, the highest price increase was recorded for fertilizer and other soil improvers as well as for animal feed (KAS, 2013). If we compare the prices of these products between 2005 and 2012, the price for fertilizer and other soil improvers increased by 87.7% and for the animal feed by 69%.

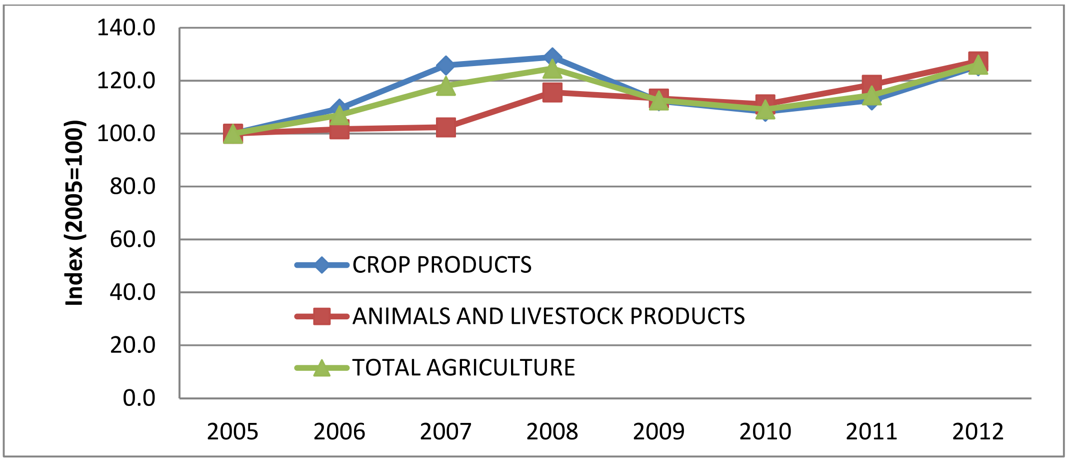


Figure 5: Agricultural output price indices in Kosovo, 2005-2012

Source: Kosovo Agency of Statistics, Output Price Indices 2005-2012.

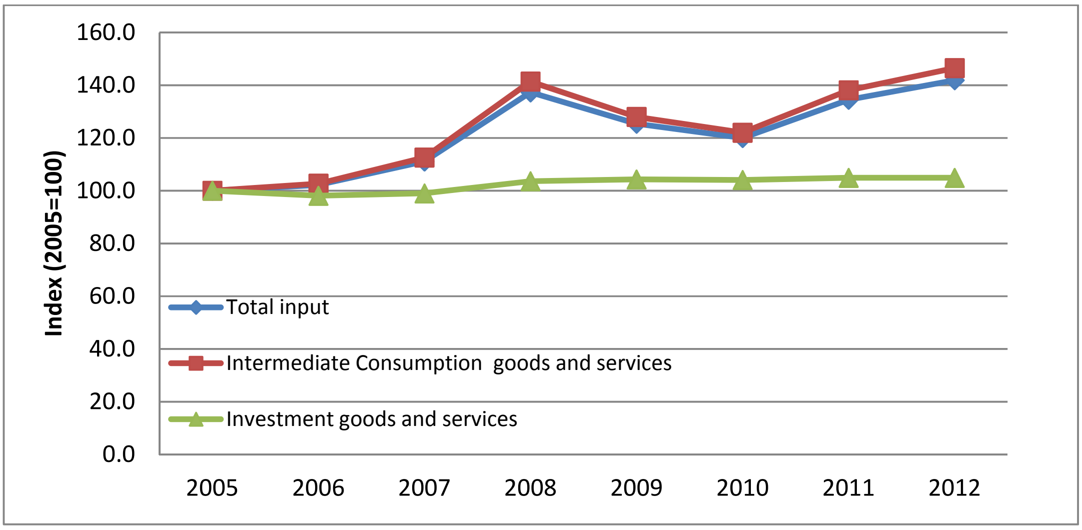


Figure 6: Agricultural input price indices in Kosovo, 2005-2012

Source: Kosovo Agency of Statistics, Input Price Indices 2005-2012.

2.6 Trade in agriculture

Agricultural trade is of great importance for many countries. In July 2007, Kosovo became a member of the Central European Free Trade Agreement (CEFTA), which is based on the concept of free market economy for the countries aiming to become an EU member state. For several years Kosovo is facing negative trade balance, which is dominated by import and significantly lower level of export, resulting in a high country's commercial deficit (Figure 7). The share of agri-food exports in total exports of goods has continuously decreased from 2005 to 2012 and it reached at 7.5% in 2012 (KAS, 2013). The share of agri-food imports in total imports of goods in 2012 amounted at 22.8%, which is considerable higher than the exports for agri-food products (KAS, 2013). Free trade has been shown to heighten the negative trade balance for total export-import of goods as well as for trade balance of agri-food products.

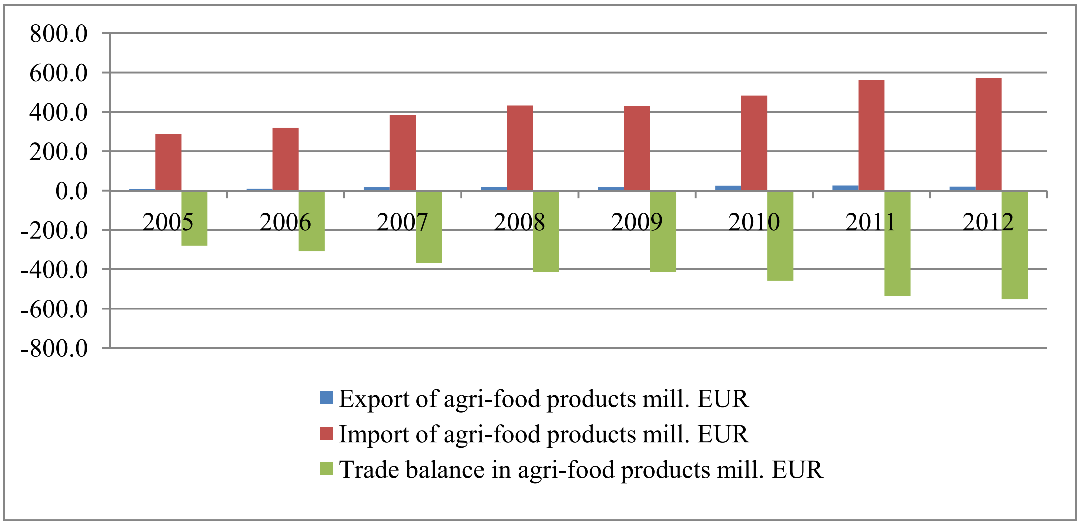


Figure 7: Annual trade balance in food and agricultural products in Kosovo, 2005-2012, Mill. EUR

Source: Kosovo Agency of Statistics-External Trade Statistics 2005-2012.

The import value of the agri-food products in 2012 amounted at 572.7 million EUR, which is 18.6% higher than the import value recorded in 2010. Contrary to this, the export value of the agri-food products in 2012 decreased by 21% compared to the previous year which amounted at 26.2 million EUR (KAS, 2013). More than 70% of the import value for agri-food products is coming from dairy products, cereals, flour, meat and edible meat, tobacco. The most important agri-food export commodities are edible fruits and nuts, processed vegetables, edible vegetables, and products of the milling industry, beverages, spirits and vinegar (Table 11).

Table 11: Main agri-food import/export commodity by group in 2012

Exports				Imports		
No.	Commodities	Value in million EUR	Share in total agri-food exports	Commodities	Value in million EUR	Share in total agri-food imports
1	Preparations of vegetables, fruit or nuts	1.7	8.5	Preparations of cereals	44.9	7.8
2	Edible vegetables, plants, roots, tubers	1.8	8.8	Meat and edible meat	52.2	9.1
3	Products of the milling industry, malt, starches	5.4	26.3	Beverages, spirits and vinegar	57.5	10.0
4	Beverages, spirits and vinegar	7.1	34.4	Tobacco	59.5	10.3

Source: Kosovo Agency of Statistics, External Trade Statistics 2005-2012.

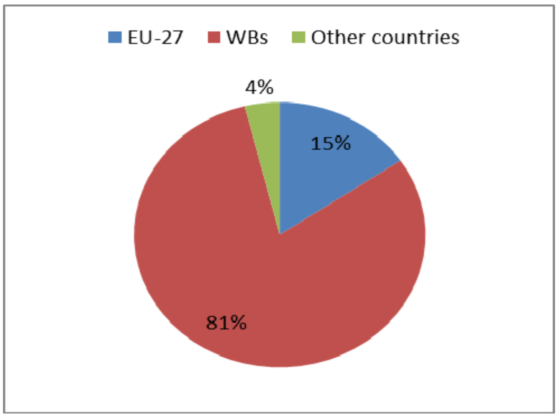


Figure 8: Agro-food exports to EU, WBs and other countries in %, 2012

Source: Kosovo Agency of Statistics, External Trade Statistics 2012.

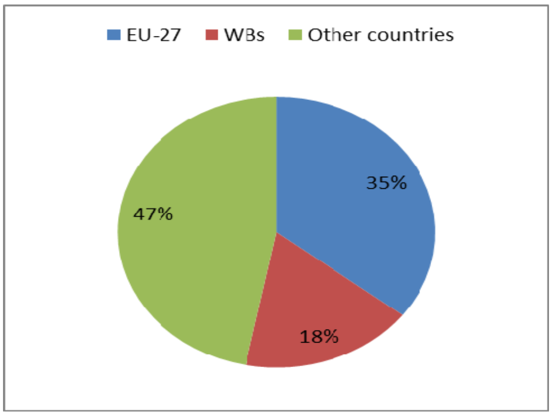


Figure 9: Agro-food imports to EU, WBs and other countries in %, 2012

Source: Kosovo Agency of Statistics, External Trade Statistics 2012.

The main export partners for Kosovo within the EU countries were Germany, Italy and Slovenia amounting at 1.9 million EUR in 2012. Within Western Balkans (WB) countries Kosovo mainly exports agro-food products to Albania and former Yugoslav Republic of Macedonia (FYROM) and smaller amount to Serbia and Croatia. With regard to imports for agro-food products from EU, again Germany, Slovenia, Italy and Bulgaria are the main partners covering more than 60% of the total agro-food imports. Within the WB countries, Kosovo imports agro-food products mainly from FYROM, Croatia and Bosnia and Herzegovina.

2.7 Country agricultural strategy and policy concept

The Ministry of Agriculture Forestry and Rural Development (MAFRD) is the responsible authority in developing and implementing agricultural policy and legislation at the national level. The first compiled strategic document for agriculture in Kosovo was the Green Book entitled "Sustainable Agriculture and Rural Development in Kosovo", which was published in 2003 and consisted of a medium-term strategy for sector development and agricultural policy. In order to establish a legal framework for agriculture and rural development, the Assembly of the Republic of Kosovo adopted the "LAW ON AGRICULTURE AND RURAL DEVELOPMENT No.03/L-098" in 2009. The purpose of this law is the determination of the policies for agriculture and rural development. Within this law are determined objectives, measures and programs for the agricultural policy and rural development. This law determines the rules for providing agriculture public services, research and professional training, data base and information in the field of agricultural policies and rural development.

The Agriculture and Rural Development Program (ARDP) 2007-2013, was established and approved by the Assembly of the Republic of Kosovo on 4th of April 2007. Its initial edition was updated by MAFRD with the support of the Institutional Support for MARFD (ISMAFRD) for the period of time 2009-2013. Later on, considering an extended scope of the ARDP in terms of the inclusion of the direct payments and the provision of a comprehensive picture to pursue the complex targets in the agriculture sector and sustainable rural development, the MAFRD staff supported by Twining project KS2008/1b/AG/01 conducted the second update of the ARDP 2010-2013. Many key actors (competent national authority of the MAFRD, local economic/social partners, municipalities, businesses, civil society, European Commission, donors) were involved in the preparation of this policy document. The vision statement for agriculture and rural development in Kosovo is to "make a balanced contribution to the economic, environmental, social and cultural well-being of rural areas, and Kosovo as a whole, through effective and profitable partnerships between the private sector, central/local government and local communities within the European context" (ARDP 2007-2013, 2010). The stated vision of the ARDP 2007-2013 was interpreted into the following main objectives:

- "additional income for farmers and rural dwellers, leading to improved living standards and working conditions in rural areas;
- improved competitiveness and efficiency of primary agricultural production, in order to achieve import substitution and take advantage of export markets;
- improved processing and marketing of agricultural and forestry products, through increased efficiency and competitiveness;
- improved on-farm/in-factory quality and hygiene standards;
- sustainable rural development and improved quality of life (including infrastructure) through promotion of farming and other economic activities that are in harmony with the environment;
- creation of employment opportunities in rural areas, particularly through rural diversification; and
- alignment of Kosovo's agriculture with that of the EU" (MAFRD, 2010).

In order to make these objectives achievable, specific measures were identified on which policy, financial, legal, administrative and human resources were concentrated. The identified policy measures targeting ARDP objectives constitute of direct support measures and rural development support measures. The first pillar covers direct payments for the sheep and goat sector, the dairy sector, the crop sector, payments for beehives and support of fuel for harvesting. Whereas, the second pillar consists of rural development measures with a composition of four axes and eight measures presented as below:

Axis I → Competitiveness

Measure 1: Development of vocational training to meet rural needs;

Measure 2: Restructuring physical potential in the agri-rural sector;

Measure 3: Managing water resources for agriculture;

Measure 4: Improving the processing and marketing of agricultural products;

Axis II → Environmental and improved land use

Measure 5: Improving natural resource management;

Axis III → Rural diversification and quality of rural life

Measure 6: Farm diversification and alternative activities in rural areas;

Measure 7: Improvement of rural infrastructure and maintenance of rural heritage;

Axis IV → Community-based local development strategies

Measure 8: Support for local community development strategies.

The MAFRD has established relevant operational structures such as the Monitoring Committee (MC) M. d 01/99/09, the Managing Authority (MA) M. d 01/84/89 and the Paying Unit (PU) A.i No 01/2010 responsible for ARDP 2007-2013 implementation.

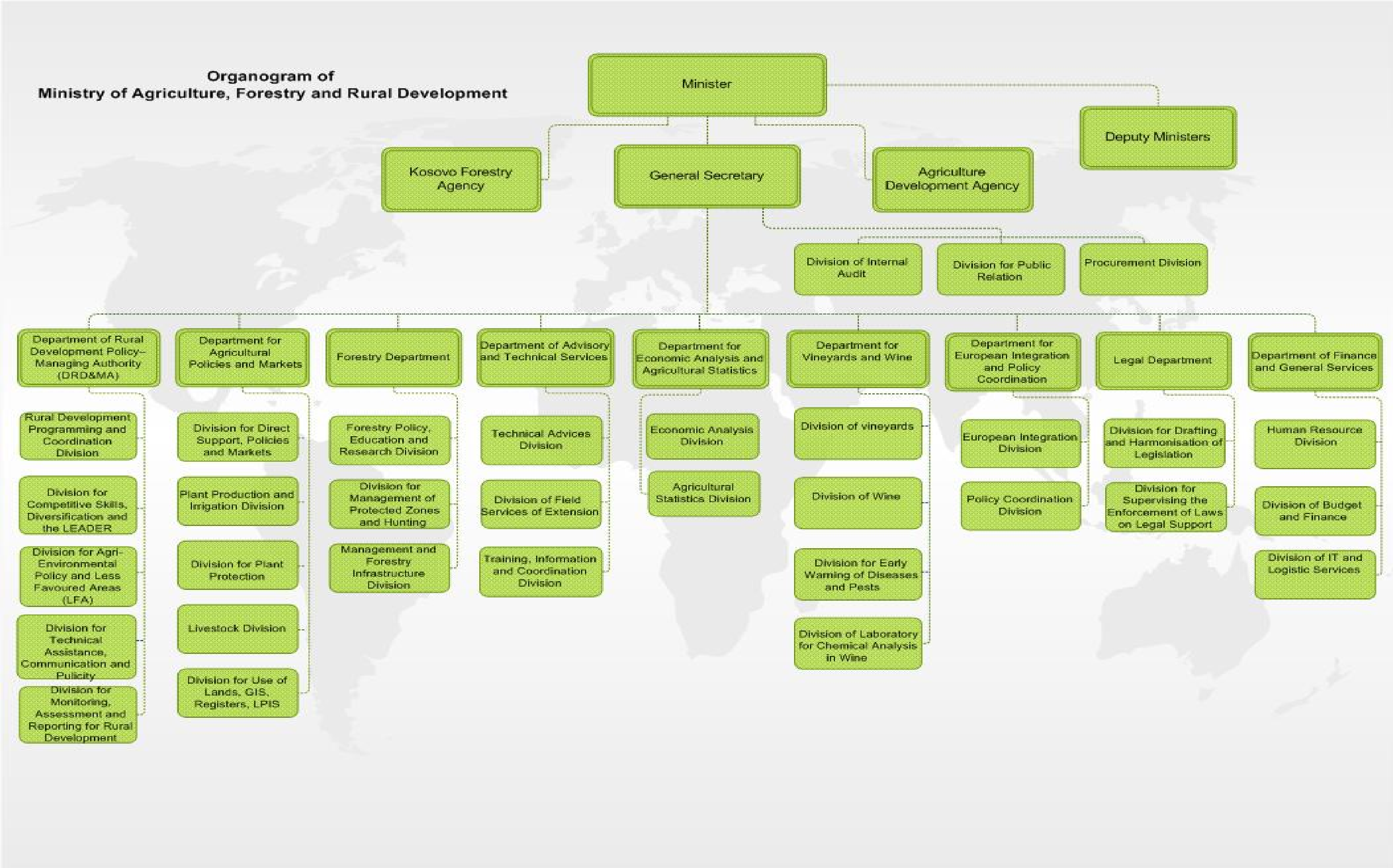


Figure 10: Operational structure of the MAFRD

Source: MAFRD.

Supported by the twinning project, the MAFRD prepared manuals on rules and procedures on the functional structure of the MC, MA, manuals on programing, monitoring and evaluation, and an organization chart and strategy for the further development of the PU. The MC, MA and PU were established in accordance with the Law on Agriculture and Rural Development No.03/L-098. In 2012, the PU was upgraded into the Paying Department (PD) which is now transformed into the Paying Agency which is in full compliance with the Instrument for Pre-Accession Assistance for Rural Development (IPARD) rules and procedures. The main duty of the PD is an execution of the supported schemes drafted by the MA and funded by Kosovo's Government, bilateral and multilateral funds by the EU and other donor organizations. The Annual National Program for Agriculture and Rural Development was the key implementation document of the stated measures in ARDP 2007-2013. An implementation of the identified measures was also supported with an extensive information campaign, aiming at the increase of farmers' awareness and promoting measures under the implementation.

An annual report of the Farm Accounting Data Network (FADN), annual monitoring and implementation reports prepared by the MAFRD, respectively by the Division for Monitoring and Evaluation and Paying Agency, are the key implementation and monitoring documents of the ARDP. In September 2012, the MAFRD in cooperation with the Kastner International and the Austrian Federal Institute of Agricultural Economics on behalf of the EU Twinning Project, elaborated a Mid-Term-Evaluation (MTE) in implementing the ARDP. The MTE assesses all implemented measures of the ARDP during the period of time 2007-2011. Based on the results and recommendations drawn by the MTE as well as through an intensive discourse with socio-economic partners, local action groups, agricultural producers and other organizations, the MAFRD supported by the EU Twinning Project prepared the first draft strategy for the ARDP 2014-2020. On May 23rd, 2013 the draft strategy was firstly presented to the Steering Committee and later on (3rd June, 2013) in conferences to all partners at interest. The conferences offered valuable opportunities to engage the vast array of stakeholders and interest groups in discussions and contributions to the agricultural policy debate and planning of the strategy for ARDP 2014-2020. The Rural Development Policy of Kosovo 2014-2020 will be oriented according to the new strategic directions of the EU Rural Development policy, by taking into consideration the earned experiences during the ARDP 2007-2013 implementation as well as the Country Strategic

Paper Kosovo (09.2013). The stated objectives of the ARDP 2014-2020 are closely based on the Instrument for Pre-accession Assistance II (IPA II) strategic policy objectives but also focus and reflect country strategic objectives for development and specific needs of the Kosovo's agri-food sector, forestry and rural areas.

"Kosovo's Rural Development Program 2014-2020 takes into account EU's strategic objectives for rural development and focuses on the following six priorities:

1) Fostering knowledge transfer for innovation in agriculture, forestry and rural areas;
2) Enhancing competitiveness in all types of agriculture and enhancing farm viability;
3) Promoting food chain organization and risk management in agriculture;
4) Restoring, preserving and enhancing ecosystems dependant on agriculture and forestry;
5) Promoting resource efficiency and supporting the shift towards a low carbon and climate resilient economy in the agriculture, food and forestry sectors;
6) Promoting social inclusion, poverty reduction and economic development in rural areas". (MAFRD, 2013).

The overall objectives of the ARDP 2014-2020 were defined as follows: "(i) to develop competitive and innovation-based agrifood sector with an increased production and productivity capable of producing high quality products and meeting the EU market standards, contributing to the security and safety of the food supply, pursuing economic, social and environmental goals by fostering employment and developing human and physical capital; (ii) to protect natural resources and environment in rural areas, addressing the challenges of climate changes by achieving sustainable and efficient land use and forestry management and by introducing agricultural production methods which preserve the environment; (iii) to improve the quality of life and diversify job opportunities in rural areas by fostering employment, social inclusion and balanced territorial development of those areas". (MAFRD, 2013).

The strategic objectives of the ARDP 2014-2020 will be achieved through an implementation of the rural development priorities and measures under the EU IPA II and the National support measures addressing income, land use and irrigation infrastructure financed by national budget and donors initiatives. Table 12 presents the selected measures which will be implemented in Kosovo, categorized under the four priorities of the EU IPA II for rural development.

Table 12: Selected measures to be implemented in Kosovo for the period of time 2014-2020

Priorities	Measures
Enhancing farm viability and competitiveness	Investments in the physical assets of agricultural holdings; Investments in the physical assets of the processing and marketing of agricultural and fishery products.
Restoring, preserving, enhancing ecosystems	Agri-environmental measures and organic farming; Establishment and protection of forests.
Promoting social and economic inclusion	Farm diversification and business development; Preparation and implementation of local development strategies (LEADER).
Transfer of knowledge and innovation	Improvement in training; Advisory services; Technical assistance.

Source: ARDP 2014-2020.

In out of nine selected measures, more than 60% of the ARDP resources will be allocated to the measures under the priority one (enhancing farm viability and competitiveness). Budget concentration into the priority one was based on strengths, weaknesses, opportunities, and threats (SWOT) analysis of the Kosovo's agriculture and food processing sector.

2.8 Agricultural policy measures main characteristics and changes 2007-2012

The allocation of the annual budget for agriculture and rural development is granted by the total annual Kosovo consolidated budget. For the period of time 2008-2012, the average budget share for agriculture and rural development out of the total public expenditures was 1.15%.

Table 13: Kosovo's MAFRD budget in million EUR, 2008-2012

Year	2008	2009	2010	2011	2012
Budget in €	8.6	13.9	14.2	15.0	25.0

Source: Ministry of Economy and Finance, 2008-2012.

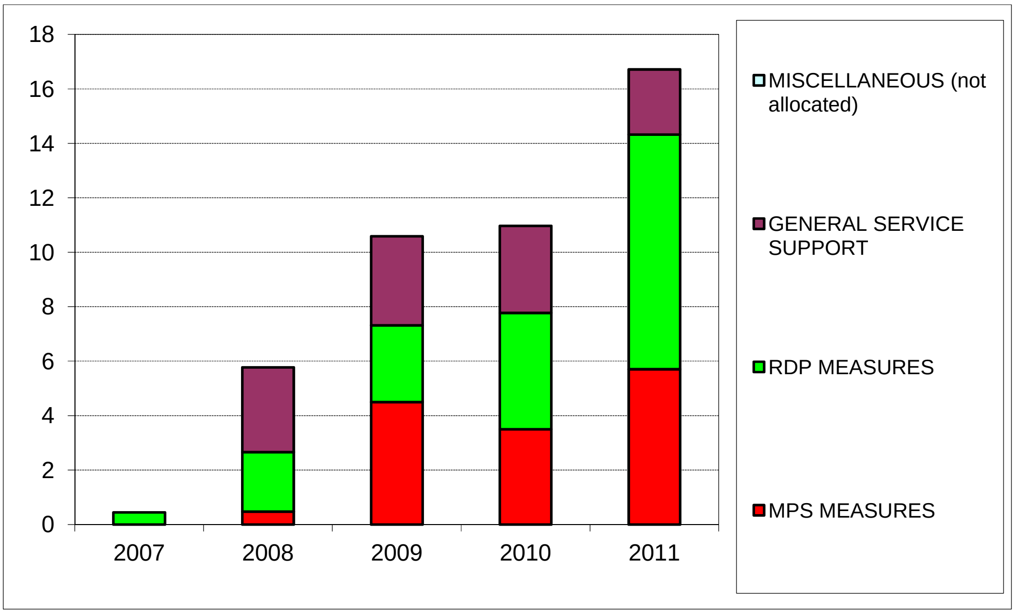


Figure 11: Budgetary expenditure for agri-food sector in rural areas (million EUR)

Source: FAO/SWG.

The aim of the direct support measures within ARDP was to increase agricultural production, farmers' income and to improve competitiveness of the agriculture sector relative to other sectors and to import. Direct payments firstly started in 2008 with the support of fuel for harvesting as input subsidy. In 2012, the allocated fund for the fuel support was 5.6% of the total expenses for direct payments (MAFRD, 2014). No other input subsidies such as for fertilizer and pesticides or for seed and seedling were implemented for the period 2008-2012. Within direct producer support measures the only supported measure was direct payment based on current cultivated area with wheat seed, maize, oil plants, wine grape, payment per head of dairy cow, sheep, goats, and beehives (MAFRD, 2014) .

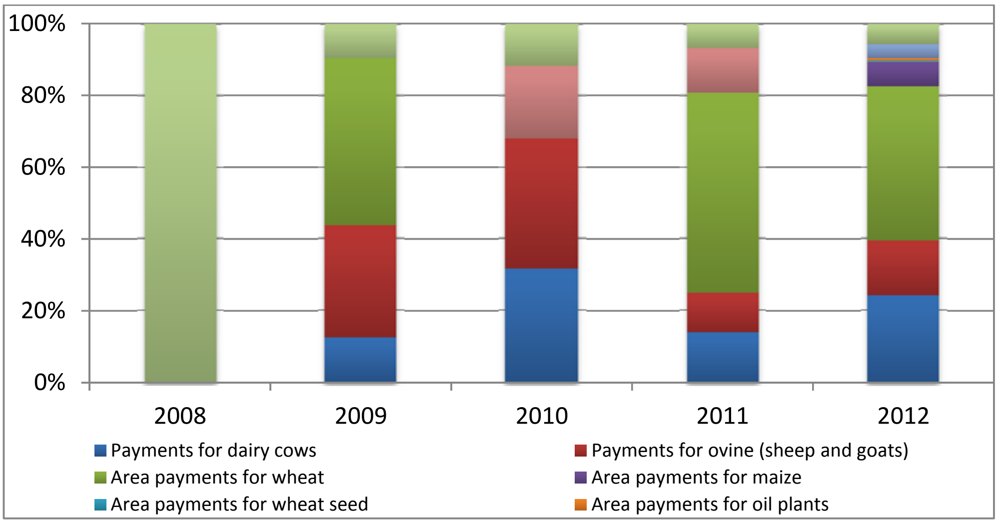


Figure 12: Structure of the direct payments based on area/animal 2008-2012, Kosovo

Source: MAFRD, 2008-2012.

Of the total budget spent on rural development measures, more than 95% of the budget spent was given for competitiveness and 1-2% on rural economy and population (Figure 13) (MAFRD, 2014). No founds were allocated for environment and countryside during the implementation of ARDP 2007-2013.

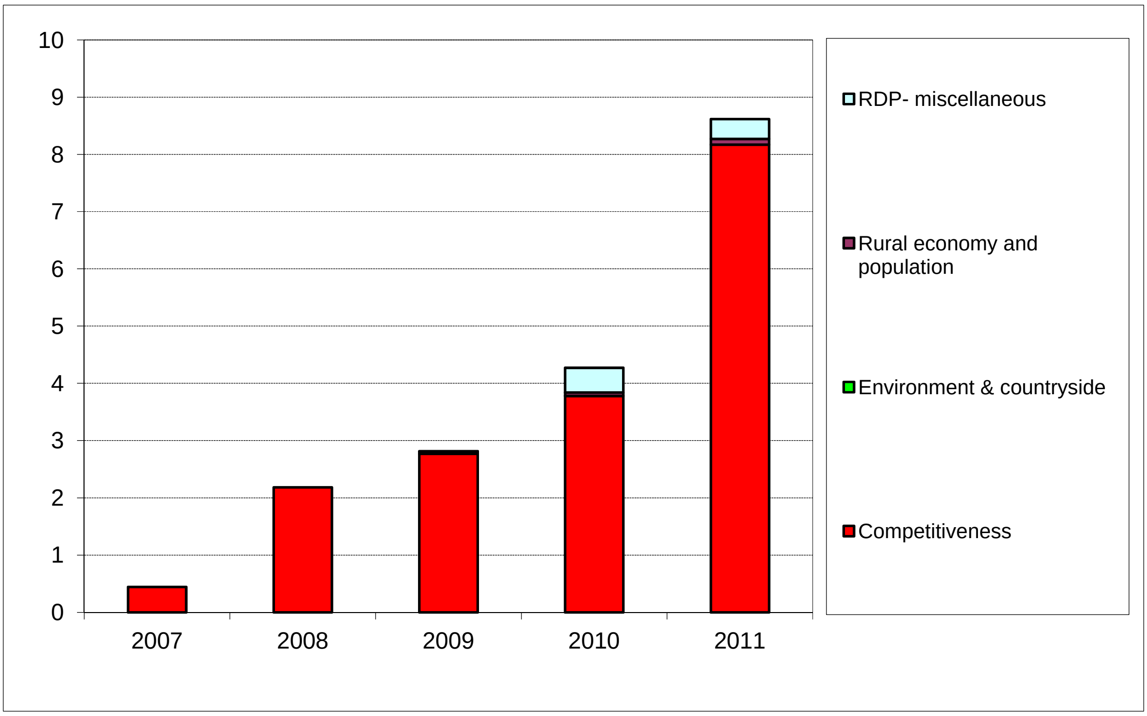


Figure 13: Budgetary expenditure for rural development measures (million EUR)

Source: FAO/SWG.

Out of the total budget spent on competitiveness, more than 80% constituted farm restructuring support (restructuring of the physical potential in the agri-rural sector, land consolidation, managing water resources for agriculture and other on farm support) and 10-20% forestry support (improving natural resource management) (Figure 13) (MAFRD, 2014). The structure of the budgetary expenditure on competitiveness changed significantly in 2011 and 2012, where more than 50% of the funds were spent on agri-food restructuring support (improving the processing and marketing of agricultural products and establishment of collecting centers) (MAFRD, 2014) .

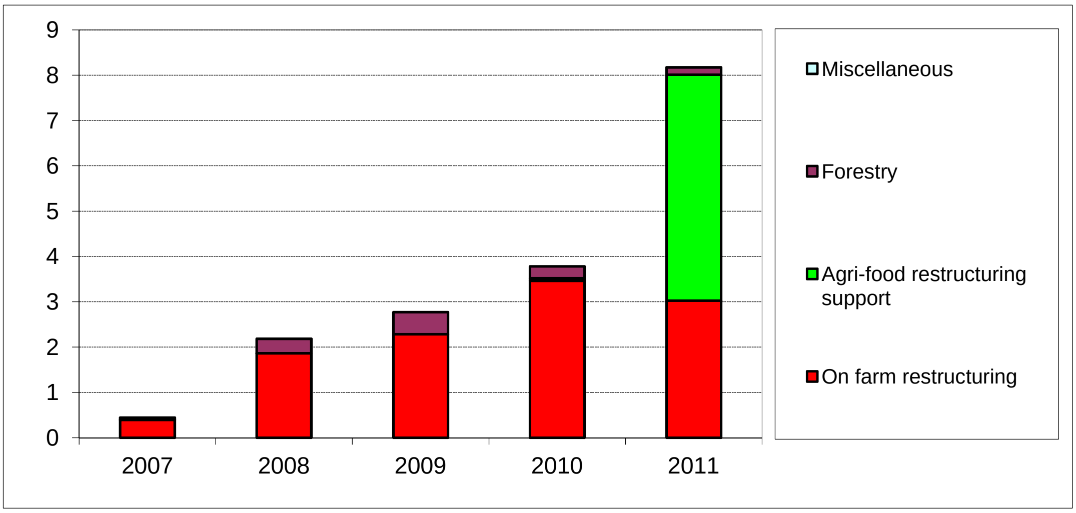


Figure 14: Budgetary expenditure for competitiveness (million EUR)

Source: FAO/SWG.

The initial implementation of the measure II on restructuring of the physical potential of the agri-rural sector started in 2007 with the sub-measure II on milk. In 2012, out of the total budget spent on measure II, 26.5% were allocated for sub-measure II (MAFRD, 2013). In 2008, the MAFRD started with the implementation of sub-measures II on eggs, vegetables and vineyards. The sub-measure II on vegetables covered the construction of new greenhouses, the expansion of existing greenhouses and modernization of equipment/machinery and other infrastructure aiming the improvement of quality and quantity of vegetable production. In 2012, this sub-measure had the highest percentage share (29.4%) of the total budget spent on measure II (MAFRD, 2013). Sub-measure II on vineyards aimed the improvement of quality and quantity of the table grape production as well as the expansion of the cultivated areas with the table grape production. In 2012, the investment granted on the sub-measure vineyards was 2.5% of the total budget expended on measure II (MAFRD, 2013). In 2009, out of the total sub-measures presented within the measure II, the only supported measures were sub-measures on vegetables and vineyards. In 2010, the MAFRD firstly started with the implementation of the sub-measure II on fruits. The aim of this sub-measure was to increase the domestic production and quality of apple and soft fruits. In 2012, the share of funds for this sub-measure was 20.9% of the total allocated found for measure II (MAFRD, 2013).

In 2008 and 2010, the measure on agricultural land consolidation was implemented through capital investment projects. The aim of this measure was to improve the agricultural structure, to build agricultural roads/paths and to protect land with a high level of biodiversity (MAFRD, 2013) .

The implementation of measure III on managing water resources for agriculture (axis 1 on competitiveness) started in 2007 and was under implementation during the whole period of time 2007-2012. The aim of this measure was to increase the productivity and the quality of agricultural products through the rehabilitation of the existing irrigation system as well as by constructing new capacities. In 2012, the amount of the budget spent on this measure was 62.5% lower compared to the previous year (MAFRD, 2013).

Measure IV on improving the processing and marketing of the agricultural products was under implementation in the period of time 2010-2012. This measure supported construction of centers for collecting, packaging and storing agricultural products. The measure covered dairy, meat, grains, the fruits and vegetables subsector, bottled water, wine and beer. Support is meant to improve the use of agricultural products through an enhancement of production of higher value added, the establishment of collection centers, and the introduction of systematic preventive approach to food safety Hazard Analysis and Critical Control Points (HACCP) in respect to food safety, and of the production line and related facilities to meet EU requirements.

Since 2007, regular founds were allocated for improving natural resource management (measure V). This measure was mainly focused on the reforestation of bare forest lands, and on monitoring and maintaining afforested areas. In 2012, the amount of budget spent on this measure was twice higher than the amount of budget expended in the previous year (MAFRD, 2013). According to the Mid-Term Evaluation (MTE) report, problems related to the property rights and taking care of saplings after planting need to be addressed rigorously to ensure that public money spent on this measure is yielding results.

From 2009, the MAFRD started with the support of public and private projects which had an impact on the improvement of living conditions of the rural population. Beneficiaries were Local Action Groups (LAG) registered in Kosovo according to the LEADER principles. LAG managers were responsible for the application and implementation of the projects that involve rural community. Due to the budgetary constraints, farm diversification and alternative activities in rural areas (measure VI) and improvement of rural infrastructure and maintenance of rural heritage (measure VI) were not implemented at all in ARDP 2007-2013 (MAFRD, 2014).

From 2008 to 2012 more than 95% of the budget spent on general services comprised expenses on food safety, particularly veterinary and phito-services, and a small percentage of the founds was spent on research and development, advisory and expert services (MAFRD, 2013). The measure on the development of vocational training to meet rural needs has been implemented since 2008. The aim of this measure was to introduce new agricultural production technology, environmental friendly production, and setting up networks and cooperation between farmers. Training courses were delivered by contracted private companies in close cooperation with the Municipal Agricultural Office (MAO). In 2012, the expended budget for vocational training was by 65% higher than in 2011, while compared with the year 2008 it is about five times higher (MAFRD, 2013). According to the MTE report vocational training measure contributed to an increased agricultural production, more efficient use of farm inputs, and more specialized farm activities (MAFRD, 2012).

3. LITERATURE REVIEW ON EFFICIENY

3.1 The efficiency concept and its interpretation

The efficiency concept is considered to be a core of economics (Leibenstein, 1966). As a criterion, it serves as bedrock for policy and planning approaches towards sustainable development. The etymological origin of the English word 'efficiency' is derived from Latin word 'efficientia' the present participle of the word 'efficere' meaning to accomplish, execute or produce (Skeat, 1961).

The concept of efficiency has a wide range of interpretations and represents a multiplicity of meanings derived from several disciplines such as thermodynamics, economics and lately ecological theory, providing a rich mix of the efficiency concepts. An interpretation of the efficiency term as "fitness or power to accomplish the purpose intended" (Simpson & Weiner, 1989) was taken from theological themes and in the context of the commercial activity of 18th century Europe applied it more widely to the transient world (Jollands, 2003). As a result, the key meaning of efficiency shifted from a theological basis to a logical positivist perspective (Jollands N., 2006).

The importance of the efficiency criterion was raised and acknowledged with the substantial increase of resource depletion and concerns for the efficiency of resource use. The term of efficiency is omnipresent, and it has never been as prominent in our language as it is today (Stein, 2001). In thermodynamic disciplines, energy efficiency is most commonly defined as the ratio of the useable energy output to energy input (Patterson, 1996). The interpretation of the economic efficiency measure is mostly related to the work of Vilfredo Pareto, to what is referred now as allocative efficiency. Even within economic context, the term 'efficiency' does not represent a single notion, rather it describes multidimensional interrelated concepts (Helm, 1988), which can be found in two main bodies of theory, namely production theory (technical efficiency, production efficiency) and welfare economics (allocative efficiency, intertemporal efficiency) (Jollands N., 2006).

“The world is complicated and no simple identity can capture everything” recognizing several dimensions of the efficiency concept and integrating them into broader considerations is crucial when analysing different aspects of the efficiency concept. In the principles of standard economics, economy is seen as an *“isolated system",* which is useless for studying relationships between economy and the environment (Daly, 1992).

Despite the multiplicity of meaning and the richness of the efficiency concept, for the purpose of this study, its interpretation will be narrowed down within disciplinary boundaries. “In the resource use context” potential interpretations of the efficiency term could be “from the ratio of work output/energy inputs to Pareto efficiency” (Jollands N., 2006).

The theoretical foundations that do exist were developed and encouraged by the idea that variation in efficiency might exist in some systematic fashion and be a phenomenon of consequences (Grosskopf, 1985). In general, efficiency means obtaining the maximum amount of output from a given set of resources, or production of a given output with minimum resources.

3.2 Economic Efficiency

Efficiency measurement and the interpretation of its behavior are of at most interest for business firms and policy makers. Such measurements take the variety of forms in customary analysis (e.g. cost per unit, profit per unit, etc.), and state them in the form of a OUTPUT/INPUT ratio (Cooper W., 2002). Single factor indicator measurement (also called partial measurement) shows the level of output produced by a asingle factor of production. It is estimated as the ratio of output to the value of a single input (factor) considered. Commonly a single factor indicator is calculated for labour and capital, as two types of output measures are used: gross output and value added (Cooper W., 2002).

The main advantages of this indicators are: data is generally available (at firm, sector and national levels), they are computed easily and can be used to determine the factor leading to the efficiency improvement. But if not analysed in combination with the other indicators they can produce misleading conclusions (Cooper W., 2002). Single input to single output measure can mistakenly impute gain to one factor that is attributable to some other inputs (e.g. rising output per worker may follow from additions to the capital stock) (Cooper W., 2002). Therefore, moving from "partial efficiency measure" to "total factor measures" by taking into account all outputs and all inputs, helps to avoid such problems and produces better indicator of the sector's efficiency. However, obtaining single input to single output ratios from all outputs and all inputs poses some difficulties, such as the selection of inputs and outputs to be considered and the weights to be used (Cooper W., 2002) .

The efficiency level varies depending on the production technology, production process and the environment where the production is realized (Porcelli F., 2009). The producers are considered to be efficient if they are able to produce as much output as possible with the inputs used and if the output produced is at minimum cost (Greene, 1997). The efficiency measure is only one of the components of performance measurement; the effectiveness is the other one that makes overall performance measure complete (Figure15).

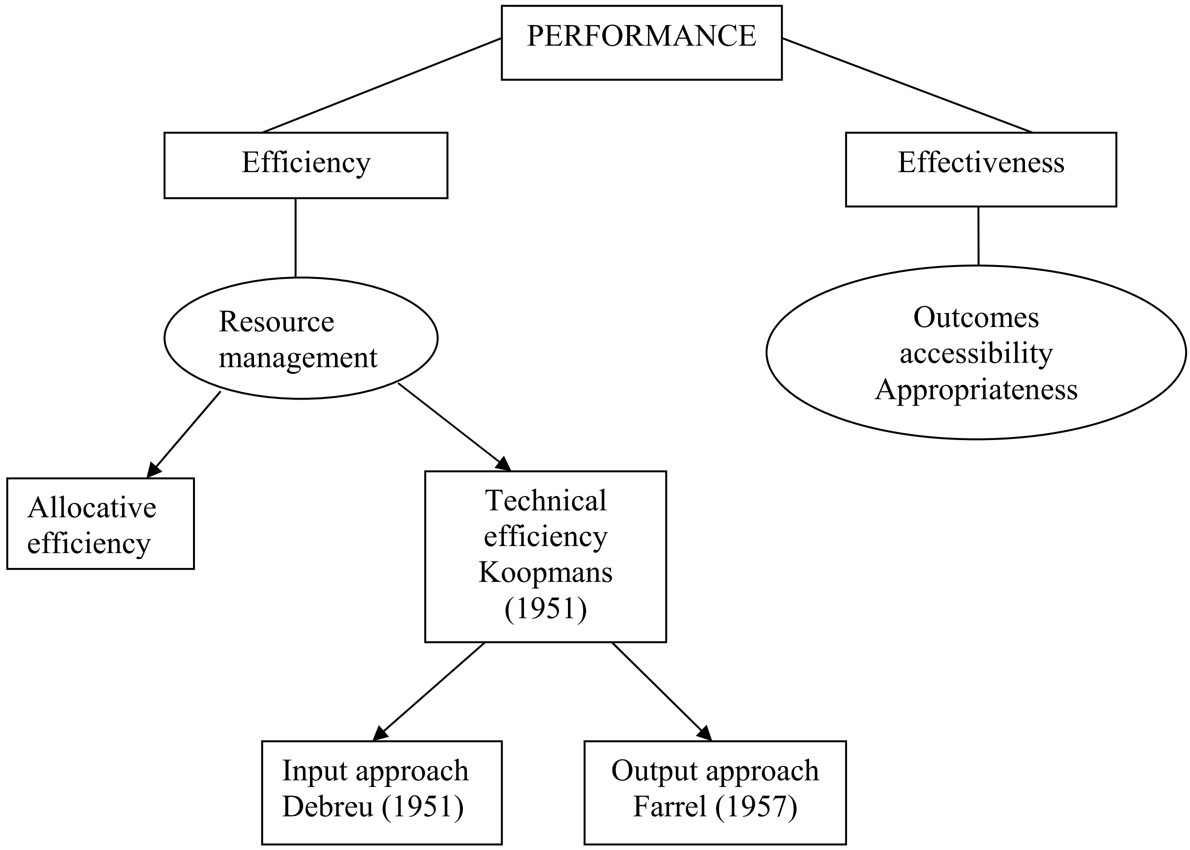


Figure 15: Framework for performance assessment

Source: (Porcelli F., 2009).

A variety of techniques has been developed to construct relevant and consistent measures of efficiency, ranging from simple partial ratio to the total factor measures. The two most well-known methodologies used for the estimation of distance functions/ frontier efficiency are:

1) Econometric or parametric estimation of the production function and can be grouped into the least squares econometric production models and stochastic frontiers; and
2) Non-parametric approach subdivided into total factor productivity indices and data envelopment analysis (Coelli T. P., 2005).

The two approaches use different techniques to envelop the data and they deal differently with the random noise effect and the functional form of the production technology (Greene, 1997). Applying one or the other approach has its advantages and disadvantages. The main advantage of the econometric approach is that the method seeks the distinction between the effect of noise and the effect of inefficiency. But as disadvantage is that it is a parametric method, meaning that it requires specification of the functional form of production (Greene, 1997). A misspecification of the functional form may lead to biased results of the efficiency scores (Barnes A.P., 2006). The main advantage of the non-parametric approach is that it does not require this specification and therefore is immune to misspecification of the functional form (Kelly E., 2012). The new approach embodied in Data Envelopment Analysis (DEA) is that there is no need to prescribe wights to be attached to each input or output, the variable weights are directly derived from the data (Cooper W., 2002). On the other side, the non-parametric approach does not include error term and it mixes the noise effect and the inefficiency effect under the voice of inefficiency (Coelli T. P., 2005) but this problem can be exceeded using a bootstrapping method by (Simar L., and Wilson W. P., 2007).

The method chosen for efficiency estimation also depends on the data availability. We used the DEA approach and its models to measure the distance functions/efficiency scores. The preference of DEA over the parametric approaches is that minimal assumptions are needed for the frontier estimates. In addition, the DEA is a flexible technique that can easily fit the specific purposes and needs of application as it approaches the valuation from a multidimensional perspective.

3.3 Application of DEA in efficiency measure

In recent years the DEA method has found a wide variety of applications from different entities involved in many different kind of activities (Cooper W., 2002). It is considered to be one of the most popular methods in operations research (Thanassoulis, 2001). It has offered a possibility for identifying better benchmarks in many applied studies (Cooper W. W., 2011). In DEA, the organization under study is called Decision Making Units (DMU) (Cooper W., 2002). In our efficiency measurement, the DMU is considered a farm as an entity that converts inputs into outputs. It is a linear programming optimization technique which measures the relative efficiency of a set of comparable units. Another advantage of the method is that it can handle many outputs and many inputs, relations (constraints) and loosens other requirements that come up when other techniques are used (Cooper W., 2002).

According to (Koopmans T. C., 1951) definition of what is now called technical efficiency, a feasible input-output vector is only technically efficient if it is technologically impossible to increase any output and or reduce any input, without simultaneously reducing at least one other output and or increasing at least one other input. Debreu (1951) was the first one providing an index of the technical efficiency with his *coefficient of resource utilization* (Debreu G., 1951). It is a radial measure of technical efficiency defined as one minus the maximum equiproportionate reduction in all inputs consistent with continued production of given outputs (Debreu, 1951). Farrell (1957) is considered to be the most influential by extending Koopmans and Debreu's work and was the first one to decompose overall efficiency into technical and allocative efficiency. Farrell's technical efficiency refers to the estimated efficiency measure based on the physical relation of inputs and outputs used in the production function. For a '*perfectly efficient firm the efficiency takes the value of unity or 100 per cent and it might become indefinitely small if the quantity of input per unit output become indefinitely large* (Farrell, 1957).' Initiated by the Farrell's work, the DEA became a new tool for measuring technical efficiency when Charnes, Cooper and Rhodes (1978) proposed the initial DEA model known as CCR model (Cooper W., 2002). The efficiency measure under the CCR model is obtained '*as the maximum ratio of weighted outputs to weighted inputs subject to the condition that similar ratios for every DMU will be less than or equal to unity'* (Charnes A. C., 1978), which takes the form as presented in the equations below:

(1)

$$max\ h_o = \frac{\sum_{r=1}^{s} u_r\, y_{ro}}{\sum_{i=1}^{m} v_i\, x_{io}}$$

subject to:

$$\frac{\sum_{r=1}^{s} u_r\, y_{rj}}{\sum_{i=1}^{m} v_i\, x_{ij}} \leq 1;$$

$j = 1, \ldots., n; \quad v_r, v_i \geq 0; \quad r = 1, \ldots., s; \quad i = 1, \ldots., m.$

Where, y_{rj}, x_{ij} are known outputs and inputs of the j DMU; $v_r, v_i \geq 0$ are wights to be assigned by the problem solution (Charnes A. C., 1978). The fractional linear program can be converted into linear form and the methods of linear programming can be applied (Boussofiane A., 1991). Therefore, the fractional program of CCR is equivalent of a linear program (Cooper W., 2002) which can be solved in *n* linear programs, one for each DMU (Charnes A. C., 1978).

(2)

$$h_o = Max \sum_{r=1}^{s} u_r \, y_{ro}$$

subject to:

$$\sum_{i=1}^{m} v_i \, x_{ij} - \sum_{r=1}^{s} u_r \, y_{rj} \geq 0, \qquad j = 1, 2, \ldots., n$$

$$\sum_{i=1}^{m} v_i \, x_{io} = 1,$$

$$u_r \geq 0 \quad for \, r = 1, \ldots, s,$$

$$v_i \geq 0 \quad for \, i = 1, \ldots, m.$$

The objective function of input-oriented approach of the CCR model is to minimize inputs while keeping the outputs levels constant, whereas the output-oriented approach seeks maximizations of the outputs with no additional inputs used (Cooper W., 2002). The two versions of the CCR model were developed under the assumption of Constant Returns to Scale (CRS). Under such assumption the activity *(x, y)* is feasible when, for every positive scalar *t*, the activity *(tx, ty)* is also feasible (Cooper W., 2002). It means that a proportional increase in the input level will proportionally increase the output level (Toloo M, and Nalchigar S., 2009).

Later the CCR model was extended by Banker, Charnes, and Cooper (1984) to a new model known as BCC model, which estimates pure technical efficiency of the DMU-s (Toloo M., 2009). The frontiers in the BCC model have piecewise linear and concave characteristics which leads to Variable Returns to Scale (VRS) allowing identification of a DMU that it is performing in increasing, decreasing, or constant returns to scale (Cooper W., 2002). '*Increasing Return to Scale (IRS) prevail if* $\beta > \alpha$*, and Decreasing Returns to Scale (DRS) prevail if* $\beta < \alpha$ (Cooper W. W., 2011).' Banker et al. (1984) and Banker and Thrall (1992) extended the concept of returns to scale from single output case to multiple-output using DEA (Cooper W. W., 2011).

The BCC model (Banker RD., 1984) assumes *n* DMU-s, (DMU_j: $j = 1, 2,\ldots, n$) use *m* inputs (x_i: $i = 1, 2,\ldots, m$) to produce *s* outputs (y_r: $r = 1, 2, \ldots, s$). The BCC input and output-oriented approaches take forms as presented in the equation 3 and 4:

(3)

$$maxz = \sum_{r=1}^{s} u_r\, y_{ro} - u_0$$

subject to

$$\sum_{r=1}^{s} u_r\, y_{rj} - \sum_{i=1}^{m} w_i\, x_{ij} - u_0 \leq 0, \quad j = 1, 2, \ldots, n$$

$$\sum_{i=1}^{m} w_i\, x_{io} = 1, \quad v_i \geq \varepsilon, \ u_r \geq \varepsilon$$

(4)

$$E_o = Min \sum_{i=1}^{m} w_i \, x_{io} - p_0$$

$$\sum_{r=1}^{s} u_r \, y_{rj} - \sum_{i=1}^{m} w_i \, x_{ij} + p_0 \leq 0, \quad j = 1, 2, \dots, n$$

$$\sum_{r=1}^{s} u_r \, y_{ro} = 1, \;\; u_r \geq \varepsilon, \;\; v_i \geq \varepsilon$$

Where x_{ij} and y_{rj} (all non-negative) are the inputs and outputs of the DMU_j, w_i and u_r are the input and output weights, x_{io} and y_{ro} are the inputs and outputs of DMU_o.

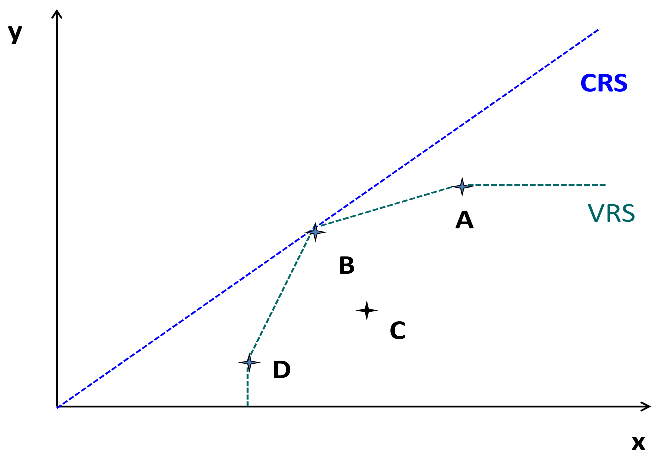


Figure 16: Production frontier of the single input and single output under CRS and VRS assumption for the DMUs A, B, C, and D

Source: (Ortner K., 2006).

The CCR efficiency measure under CRS assumption regardless of orientation (whether it is the input or output approach) yields equal efficiency scores for the same DMU (Sipiläinen T., and Huhtala A., 2011), which is not the case for the BCC model (Adler N., 2002).

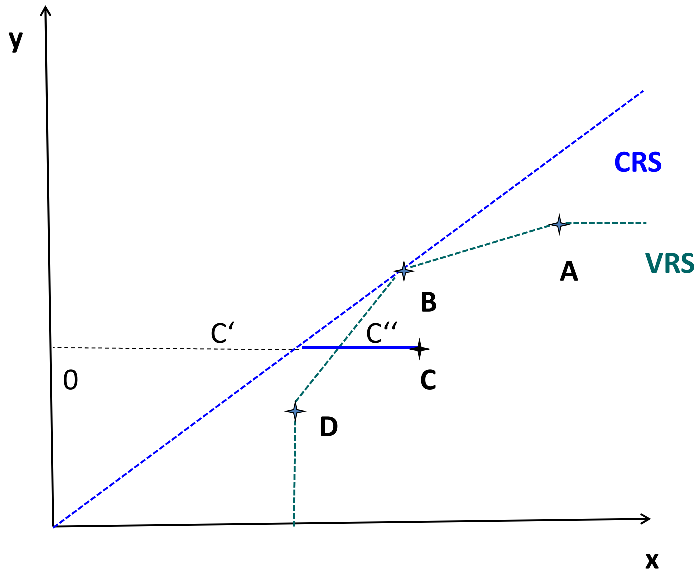


Figure 17: Technical efficiency

TE = 0C'/0C

Source: (Ortner K., 2006).

The obtained efficiency scores imposing CRS and VRS assumptions permits the estimation of Scale Efficiency (SE) for each DMU as follows (Coelli T., 2002):

(5)

$$SE = \frac{TE_{CRS}}{TE_{VRS}}$$

where TE_{CRS} is Technical Efficiency of a farm i under CRS, and TE_{VRS} indicates the technical efficiency of a farm i under VRS assumption. If the value of SE is equal to one it indicates that the farm is operating at an optimal scale and at SE < than one farm is scale inefficient and this may come either due to the existence of IRS or DRS. The estimated technical efficiency scores imposing Non Increasing Returns to Scale (NIRS) TE_{NIRS} provides an indication if the scale inefficiency is due to the DRS which means that farm is larger than optimal scale ($TE_{NIRS} = TE_{VRS}$), or as a result of the IRS, meaning that the farm is operating at smaller scale than optimal ($TE_{NIRS} \neq TE_{VRS}$) (Coelli T., 2002).

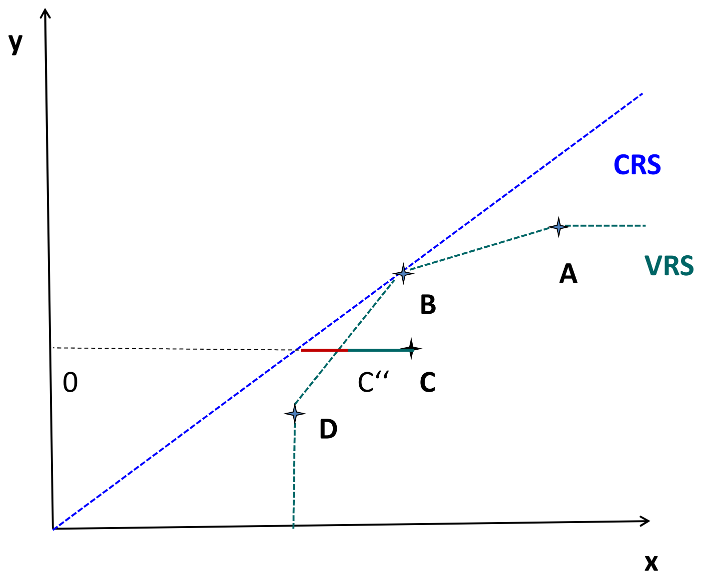


Figure 18: Pure technical and scale efficiency

Pure Technical Efficiency (PTE)*= 0C‘‘/ 0C*

Scale Efficiency (SE) *= 0C‘ / 0C*

TE* = *SE* * *PTE

Source: (Ortner K., 2006).

Based on the basic models of CCR and BCC, other DEA models have been developed and appeared in the literature (Cooper W W., 2000). The extended DEA models used different assumptions related to the nature of returns to scale in the production frontiers. Shortly after the BCC model's appearance, (Charnes A., 1985) introduced additive models to the DEA. The additive models treat the slacks (the input excesses and output shortfalls) directly in the objective function and combine input and output-oriented models into a single model (Cooper W., 2002). According to the additive model definition the DMU is only fully efficient if there are zero slacks in both inputs and outputs used in the production function (Cooper W., 2002). Thus, a weakly efficient DMU (referring to Farrell's efficiency) will be evaluated as an inefficient DMU in the additive models, due to the presence of input or output-oriented slacks (Adler N., 2002). Other features of the additive models are coordinate-free and are invariant in regard to the translation of the coordinate system (Cooper W., 2002), but have no scalar measure (ratio efficiency) (Tone K., 2001).

Another model for measuring the efficiency with a close connection to CCR and BCC models is a Slacks Based Measure (SBM) of efficiency (Tone K., 2001). Earlier attempts were made by Russell, 1988; Lovell and Pastor, 1995; Cooper and Pastor, 1997; Cooper and Tone, 1997 to evaluate inefficiency based on slacks (Tone K., 2001). The SBM measure is interpreted as a product of input and output inefficiencies; it also allows for adding in economic aspects (information on costs and prices) since the model maximizes the virtual profit instead of virtual ratio of the CCR model (Tone K., 2001).

The cross-evaluation matrix was firstly developed in 1986 by Sexton et al. (Adler N., 2002). Later, Doyle J. and Green R. elaborated understanding of cross-efficiency in the concept of peer-appraisal, differently from self-appraisal by simple efficiency (Doyle J., and Green R., 1994). 'The cross-efficiency measure uses the set of weights chosen for a particular DMU to weight the inputs and outputs for each of the other DMUs and calculates the cross efficiency of each of the other DMUs based on the original DMU (Doyle J., and Green R., 1994).' Doyle and Green stressed out that the cross-efficiency method as a peer-appraisal has less of the arbitrariness of additional constrains and is considered to be more connected to democratic process compared to the simple efficiency (self-appraisal). Its main advantages are: (a) ability to order DMUs and (b) the possibility to eliminate unrealistic weight schemes with no placement of weight restrictions from application area experts (e.g. Anderson et al. 2002) (Cook D.W., and Zhu J., 2015). The cross-efficiency measure is mainly used as a complementary method to the simple efficiency, rather than in pure self-evaluation mode (Cook D.W., and Zhu J., 2015).

A new method for ranking the efficiency of DMUs called super-efficiency was developed by Andersen and Petersen (1993). The super-efficiency model is similar to the BCC model, with the difference that the DMU under evaluation is not included in the reference set (Anderesn P., and Petersen N., 1993). This method allows distinction between efficient and inefficient units; the unit under assessment is compared to a point in the efficient subset created from all other observations in the sample (Anderesn P., and Petersen N., 1993). The index obtained through this method can be interpreted as 'the maximum possible proportional decrease in the input vector nedeed to make the observation efficient' and it can takes the values equal to or larger than one for the efficient observation (Anderesn P., and Petersen N., 1993). Some issues were raised in regard to the methodology used in supper-efficiency estimation, e.g. giving "specialized" DMUs an excessivelly high ranking or the problem of infeasibility, meaning that if it takes place, the super-efficiency technique can not give a complete ranking of all DMUs (Adler N., 2002). In regard to the first concern (high ranking), Sueyoshi (1999) set up specific bounds on the weights in the super-efficiency ranking method, whereas, concerning the problem of infeasibility, Sueyoshi (1999) limited the super-efficiency scores to a scale with a maximum of 2 by introducing an Adjusted Index Number (Adler N., 2002).

In addition to the models presented so far, other DEA models were developed and introduced to the subject of efficiency ranking units e.g. Torgersen et al. (1996) developed a method for the complete ranking of efficient DMUs through measuring their importance as a benchmark for inefficient DMUs (Adler N., 2002). Others, like Zhu (2003a, 2009) provided DEA models which are useful in performance evaluation and benchmarking (Cooper W. W., 2011). The DEA method was also extended to another new model called Imprecise DEA (IDEA) which allows treating not only the exact data but also imprecise data which are known only ordinally or within prescribed bounds (Cooper WW., 2001). Moreover, Cooper et al. (2001) demonstrated 'how conditions on the variables (*Assurance Region* (AR-IDEA) as in Thomson et al. 1990, 1995) as well as the data, including variable-data transformations as applied by Charnes et al. (1990) in the cone-ratio envelopment, could be treated in the same manner.'

An additional approach which deals with the imprecise inputs and outputs in DEA models is the 'fuzzy DEA' method (Lertworasirikul S., 2003). This method takes the form of fuzzy linear programming which is assisted by other methods to rank fuzzy sets i.e. the possibility approach which transforms fuzzy DEA models into possibility DEA models where constraints are treated as fuzzy events (Lertworasirikul S., 2003). In an attempt to narrow the gap between DEA and the classical statistical approaches, many other additional methods were introduced and used in efficiency ranking of the units under the study e.g. '*multivariate statistics in the DEA context, canonical correlation, linear discriminant, discriminant analysis of ratios for ranking, DEA and multi-criteria decision making units* (Adler N., 2002).'

3.4 Environmental Efficiency

3.4.1 Definition and concept of externalities

Economic value of a good is revealed and takes place in the market, but in many cases contribution of the environmental goods and services are not channeled via functioning markets and are missing markets (Pearce D. & Barbier E., 2000). Market competition leads to some extent of social optimality. However, perfect market competition fails to fulfill some of the imposed specific assumptions associated with rivalry, excludability, appropriability and externalities (Just R., 2004). Therefore, public policy intervention can potentially improve the market's allocation and reach Pareto optimality.

'The *economic* assumptions to which the proofs of efficiency called attention concerned the absence of externalities and public goods (Szenberg M. & Ramrattan L., 2004).' A *pure public good* is a good that is both non-excludable (once a good is available for consumption by one individual, then others cannot be excluded from consuming it) and non-rival (the consumption of the good by one individual does not prevent other individual's enjoyment of consuming that good) (Just R., 2004).

A pure private good is considered to be a good the production or consumption of which does not destruct or help individuals that are not directly involved in its production or consumption (Mankiw G., 2000). However, some private goods cannot be considered as pure private goods as they do comprise externalities (Mankiw G., 2000). In the presence of externalities, society's interest in a market outcome includes the well-being of bystanders affected from buyers and sellers in the market (Mankiw, N. G., 2007). An externality occurs when a person or economic agent engages in an activity that influences the well-being of another and yet does not pay or receive any compensation for that effect (Mankiw, N. G., 2007).

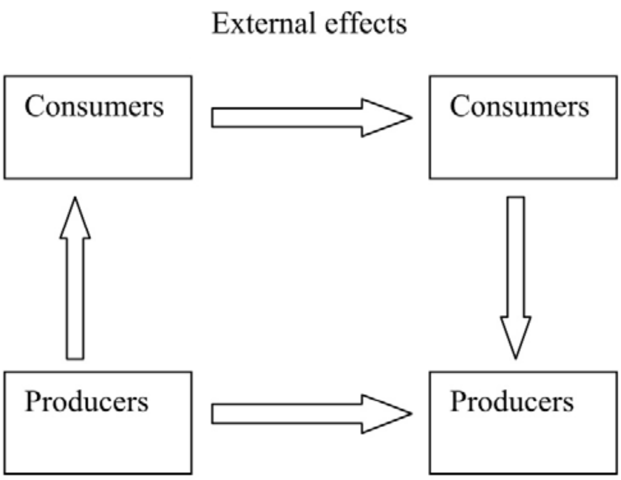


Figure 19: Classification of external effects

Source: (Bator, 1958).

The figure 19 shows the classification and the direction that the externalities can be imposed from producers to consumers, consumers to consumers, consumers to producers and producers to producers (Just R., 2004). It also indicates that externalities in one way can be associated with the production of goods but also with the consumption of goods and services. The most well-known external effects that received a lot of attention are those on consumers caused by producers (Just R., 2004). Whereas, in terms of the variety, externality may be adverse, in which case it is called a negative externality or beneficial, known as positive externality (Just R., 2004).

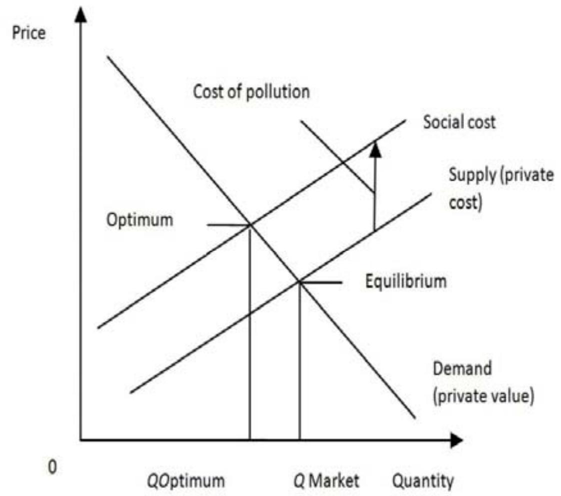


Figure 20: Negative externality in a single commodity market

Source: (Mankiw, N. G., 2007).

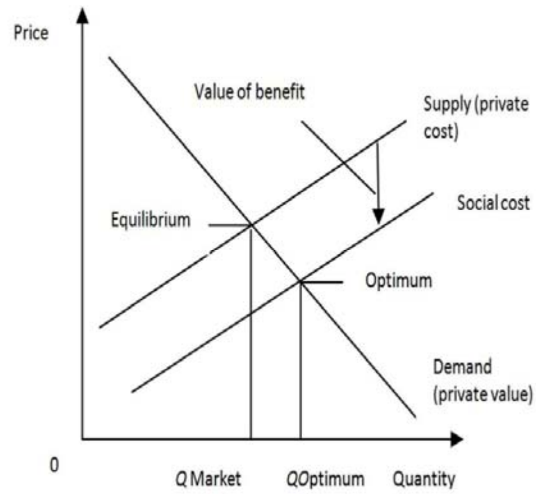


Figure 21: Positive externality in a single commodity market

Source: (Mankiw, N. G., 2007).

In the case of negative externality (Figure 20) the market equilibrium quantity (*Q* Market) is larger than the socially optimal quantity (*Q* Optimum), and this inefficiency takes place as the market equilibrium considers only the private costs of production (Mankiw, N. G., 2007). Therefore, the overproduction of goods that generate negative externalities happens as the marginal private costs of production are lower than the marginal social costs of production (Mankiw G., 2000). Some of the negative externalities are often due to the presence of *'common pool resources'* which leads to the situation of over used resources (e.g. community owned pastures) (Mankiw G., 2000). Comparable to the previous figure, in the case of positive externality (Figure 21), the social cost of production reflected in the supply curve is lower than the private (Mankiw, N. G., 2007). As the marginal private benefit is lower than the marginal social benefit, there is less incentive to generate positive externalities, which therefore are generally under supplied by the market (Mankiw G., 2000).

There are various actions taken by private actors and public policymakers in response to the externalities. In some situations, the problem of externalities is solved with moral codes and social sanctions (private solution) (Mankiw, N. G., 2007). But private negotiation does not adequately internalize all types of externalities without government intervention (Stavins R., 2004). The Coase theorem (private solution) approach assumes that there are zero transaction costs, no income effects, private goods (not public goods) and no third party impacts (Revesz R. & Stavins R., 2004). Such assumptions are questioned, particularly from environmental scientists and are often considered as virtually impossible (Rutherford D., 2007). In public policy, there are mainly two types of policy approaches to the problem of externalities; *the first one* is the market failures approach that follows the work of neoclassical economist Arthur Pigou (1932), which aims to identify such externalities and internalize them through regulatory measures e.g. *command control, tradable emission permits, taxes* for negative externalities and *subsidies* for positive externalities (Oates W. & Portney P., 2003); and *the second one* is associated with the 'Chicago School' of economists and focuses on the creation and distribution of clearly defined '*property rights*' (Hodgson G., 1999). Each of these two approaches face inherent difficulties in addressing the problem of externalities; Pigovian's approach needs detailed expert information on externalities that often is difficult to obtain, while the property rights approach often has a deficiency of clearly defined property rights (Hodgson G., 1999). In addition to the economic instruments, non-economic instruments, communicative policies and a combination of all (e.g. agri-environmental schemes), there are other sets of instruments which are used to compensate for market failures (Schader Ch., 2009).

Agriculture in addition to its multifunctional role associated to economic, food security, social and cultural role (FAO, 1999), also affects other multiple ecosystem functions e.g. biodiversity, water and soil quality (Waldhardt R. et al., 2010). Such functions are considered to be unintended by-products, or externalities generated by agriculture, the economic values of which markets do not take into account (FAO, 2001). Unlike other sectors, agriculture can produce both positive and negative environmental externalities, and this depends on the demand for its products. e.g. to a large extent on farmer production practices (Hayo M.G. van der Werf and Petit J., 2002). Agriculture intensification contributes to the loss of biodiversity or increases water pollution through the emission of agro-chemicals and animal waste (Blandford D., 2011). For most of these externalities farmers do not directly bear any costs for generated negative externalities or directly benefit from positive externalities (Cooper J. C., 2001). The unintended agriculture externalities have an impact on people other than the producer of that externality (Cooper J. C., 2001). Therefore, agriculture policy makers should find out if agriculture gives more or less of the positive or negative externalities than the land use pattern that would exist without policy intervention (Cooper J. C., 2001).

Table 14: List of frequently cited positive and negative externalities provided by agriculture

Environmental amenities (positive externalities)	Environmental disamenities (negative externalities)
Open space, scenic vistas, isolation from congestion, watershed protection, flood control, ground water recharge, soil conservation, biodiversity, wildlife habitat.	Odour, nutrient/pesticide runoff, reduced watershed protection, reduced flood control, soil erosion, biodiversity loss, wildlife habitat loss.

Source: (Cooper J. C., 2001).

Many studies have been focused on negative externalities generated from agriculture (e.g. Weaver R.D., 1997; Weaver R.D. and Kim T., 1999; Reinhardt S. A. et al., 2000; Hayo M.G. van der Werf and Petit J., 2002; Ball V.E et al., 2004; Garcia A.F and Shively G. E., 2010; Ullah A. and Perret S.R., 2014). However, few studies considered positive externalities produced by agriculture (e.g. Sipiläinen T. et al., 2008; Solovyeva I. and Nuppenau E.A., 2012), and they did not appear until the 1980s, when the Japanese pioneered allocating monetary values to rice paddies (Soda O., 2003).

The total economic value of a good or service consists of two main components: 1) its use value (the value derived from its direct use); and 2) the non-use value which involves no actual interaction between people and the environment and can be the value given for its existence, inheritance value (the value given by current generation from knowing that the resource is conserved for future) and option value (future use value) (Mendelsohn R. & Olmstead S., 2009).

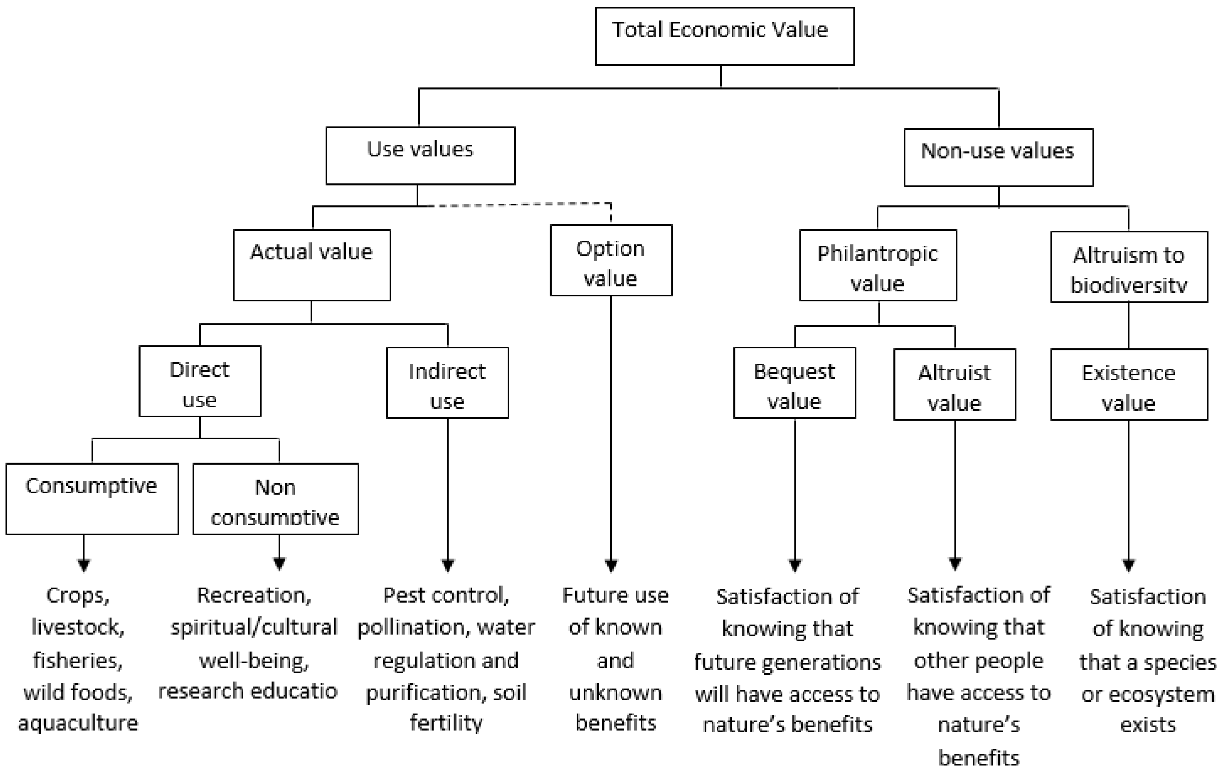


Figure 22: Typology of the total economic value approach

Source: (Brander L., Gómez-Baggethun E., Martín-López B., Verma M., 2010).

3.4.2 Methods for assessing agriculture externalities

Due to the socio-demographic and environmental differences, weights given to the positive or negative externalities by society differ among the developed and developing countries (Cooper J. C., 2001). In general, their economic value tends to be unknown as they do lack a developed market and do not have prices in the market (FAO, 2001). This situation compelled environmental economists to use non-market valuation techniques to estimate the economic value of environmental costs and benefits (Feather P., 1999). The most common methods used in the valuation of the environmental goods and services can be grouped in:

1. Direct market valuation methods;
2. Revealed preference methods; and
3. Stated preference methods;

The *direct market valuation methods* use different approaches such as *(a) market price-based approaches, (b) cost-based approaches, and (c) approaches based on production functions* (Brander L., Gómez-Baggethun E., Martín-López B., Verma M., 2010). The market price-based approach is usually used to attain the value of provisioning services, as goods produced by provisioning services are sold on the market (Brander L., Gómez-Baggethun E., Martín-López B., Verma M., 2010). The cost-based approach estimates the raised costs if ecosystem service benefits needed to be recreated from artificial means and it includes the avoided cost method, replacement cost method and restoration cost method (Garrod, 1999). The approaches based on the production function, estimates the contribution of ecosystem services to the improvement of economic welfare or productivity (Pattanayak S. & Kramer R., 2001), or the contribution of a given ecosystem service to the delivery of a commodity tradable in the market (Brander L., Gómez-Baggethun E., Martín-López B., Verma M., 2010). The main advantage of these methods is that they are based on the market's data e.g. prices, quantities and costs, which are available and rather easy to obtain (Brander L., Gómez-Baggethun E., Martín-López B., Verma M., 2010). However, the use of such methods is limited, particularly in the evaluation of environmental goods and services that do lack data in the market. Therefore, the policy decisions based on such methods can lead to wrong decisions as they can provide biased and not reliable information (Barbier E. B., 2007).

The *revealed preference methods* are based on the observation of individual choices in actual markets associated to the ecosystem service in the focus of valuation (Brander L., Gómez-Baggethun E., Martín-López B., Verma M., 2010). This group of methods consists of different models such as *(a) travel cost models, (b) hedonic property models, (c) hedonic wage models* and *(d) averting behavior models* (Mendelsohn R. & Olmstead S., 2009). The travel cost method uses the travel costs people have to pay traveling to the sites and it is utilized as a proxy for the unobservable price of natural resource (Kriström B., 1990). Travel cost models build the demand function for any good or service based on the empirical relationships between travel cost and visitation rates (Clawson M., 1959). Travel cost models are very popular and widely used in the valuation of recreational demand which is an important part of the total economic value for many natural goods and services (Mendelsohn R. & Olmstead S., 2009). It is considered to be a more objective valuation method, but also has limitations as it is applicable only in cases where people in one way or another already pay for the environmental goods and services (Brander L., Gómez-

Baggethun E., Martín-López B., Verma M., 2010). The main weak point of such models is that many important factors are left out and therefore the generated results can be biased e.g. opportunity cost of a travel time or multipurpose trips (Mendelsohn R. & Olmstead S., 2009). The hedonic pricing approach uses the price of a good compounded from a sum of the implicit prices for each characteristic of the marketed commodity e.g. the change in the value of a house situated in a view on a nice landscape reflects the value of a change in biodiversity or ecosystem services (Brander L., Gómez-Baggethun E., Martín-López B., Verma M., 2010). The Ricardian model of agricultural land is one of the hedonic property approaches that evaluates the effect of climate on the value of a farm land (Mendelsohn R. & Olmstead S., 2009). The averting behavior models employ the avoidance costs of people to partially estimate the value of the damages from pollution (Mendelsohn R. & Olmstead S., 2009). The hedonic property and wage models are mainly suitable for work-related hazards and for assessing the impact of environment on property values, whereas averting behavior models are mostly utilized in evaluating the effect of pollution on peoples' health (Barbier E. B., 2007). The revealed preference methods are incapable of assessing non-use values, which is considered to be the main disadvantages of such methods (Kontoleon A., 2007). In addition, the technical assumptions made about the relationship between the environmental good and the surrogate market good, create a dependency of the estimated values (Kontoleon A., 2007).

The *stated preference methods* create hypothetical markets in order to obtain the values through the use of a designed surveys that asks directly individuals how much they are willing to pay for the value of environmental goods and services (Mendelsohn R. & Olmstead S., 2009). The stated preference methods include (a) contingent valuation methods, (b) conjoint analysis and (c) choice experiments (Barbier E. B., 2007). The contingent valuation method starts with the clear description of the amenity considered for evaluation and the policy change suggested; it proceeds with a set of choice questions that ask an individual to set a value on the amenity, followed by the assessment of a set of questions associated to the socioeconomic characteristics of the individual that could potentially explain the variation of the stated value (Young RA., 2005). The contingent valuation method relies on the subjective valuation of the environmental issues, as it asks respondents directly about their willingness to pay for the environmental goods and services (Kriström B., 1990). The advantages of the stated preference methods are their ability to value environmental goods and services at levels of quality that are currently not existing and the possibility to detain non-use values (Mendelsohn R. & Olmstead S., 2009). However, difficulties are faced in the implementation phase of such methods, as giving the values on natural ecosystem services requires information that allows a clear description of the changes of services that people care about (Heal G.M., 2005). In addition, understandable explanations of the survey instrument must be supplied, so people may become more familiar with valuation of changes in natural ecosystem services and do not reject the valuation scenario (Heal G.M., 2005).

3.4.3 The DEA method for environmental performance valuation

The measurement of environmental performance at micro and macro level has recently received great attention due to the increased concern associated with environmental issues and sustainable development (Zhou P., 2016). A 'non-parametric approach can easily take on the derivation of environmental performance indicators into efficiency measures (Tyteca D., 2006).' Therefore, the DEA is considered to be a useful alternative method for environmental performance valuation of the units at different levels. In comparison to its use in other fields, such as applied economic sciences, agricultural economics, development economics, financial and public economics, its application in the field of environmental economics was less widely dispersed (Kuosmanen T. & Kortelainen M., 2004). In traditional measure of the productivity and efficiency, the *joint production* of good and bad outputs is usually ignored due to the absence of prices for such outputs (Chung H. Y., Färe R. and Grosskopf S., 1997). In this regard, the advantage of the DEA method is that it allows inclusion of variables of different nature (independent of units measurement) (Lovell K., and Pastor J., 1995), and of the outputs without the presence of market, hence without price, such as the generation of employment, quality indicators and environmental measures (Antonio F. Amores F.A. and Contreras I., 2009). The unique valuation feature of the DEA method is that it is independent of stated or revealed preferences, as it turns the value problem the other way around and asks what kind of prices would favour that particular good or service (Kuosmanen T., 2009). In the conventional DEA models, all outputs are assumed to be desirable outputs (producing more outputs given the constraints of inputs) whereas, this assumption does not hold in the case of undesirable outputs and it needs to be differently incorporated into the DEA (Zhou P., 2016). Cropper and Oates used economic arguments to treat detrimental variables as inputs, as both inputs and detrimental variables convey costs for a firm and commonly the interest of firms is to decrease both types of variables (Kuosmanen T., 2005).

In the frame of the DEA method different approaches were developed and used in regard to the inclusion of desirable and non-desirable outputs into the economic-environmental context analysis. The approaches which treat undesirable outputs as inputs can be grouped in two methods: (1) methods based on the translation invariance, where undesirable outputs are multiplied by "-1" and after adding to the value obtained a number which is sufficient to make all the undesirable outputs positive; (2) methods based on the concept of weak disposable reference technology introduced by Färe et al. (1989) (Zhou P., 2016). In the Färe et al. (1989) approach, the undesirable outputs were modelled either as weakly disposable outputs or as inputs (Sipiläinen T., and Huhtala A., 2011). Weak disposability means that there are possibilities to decrease emissions of undesirable outputs and other detrimental side-effects, through decreasing production activities (Kuosmanen T., 2005). Whereas, on the technical side, emissions to the environment usually are considered as outputs for a company (Kuosmanen T., 2005).

The extended Färe et al. (1989) hyperbolic efficiency measure allowed to obtain an equiproportionate increase in desirable outputs while reducing the level of undesirable outputs (Reinhard S., 1999). The approaches by Färe et al., (1993) and Hetemäki (1993) revealed technical efficiency scores and shadow prices for undesirable outputs through a Trnaslog output distance function estimation (Mulugeta E., 2013). Lovell et al. (1995) used the reciprocal of the undesirable output as DEA output which means 'the undesirable output is modeled as desirable (f $((f\ (u_i^k) = 1/u_i^k$, where u_i^k is one of the elements of the matrix *U* of the undesirable outputs *i* of the DMU k (Gomes EG., and Lins MPE., 2007).' Rheinhard et al. (1999) calculated a non-radial environmental efficiency index estimated as the input oriented technical efficiency of a single detrimental input (e.g. nitrogen surplus from a farm) (Reinhard S., 1999). For additive and BCC models Ali and Seiford (1990) have demonstrated how 'the translation of the data values does not change the efficient frontier and therefore the ranking of DMUs is translation invariant (Ali I. A., and Seiford M. L., 1990).' Sheel (2001) incorporated undesirable output as a normal output after the transformation of the data (Sipiläinen T., and Huhtala A., 2011). In DEA, there are three cases of invariance in data transformation: *(1) classification invariance, (2) ordering* *invariance, (3) solution invariance* (Seiford M. L., and Zhu J., 2002). Seiford and Zhu based on the first case of invariance *'classification invariance'* developed a model which incorporates desirable and undesirable factors under the context of the BCC model.

The estimation of environmental DEA technology is more widely applied in modeling environmental performance e.g. Zhou P., 2016; Solovyeva I., and Nuppenau A. E., (2013); Sipiläinen T., et al. (2008); Kiatpathomchai S., (2008); De Koeijer et al. (2002) etc. In the environmental DEA efficiency measures most of the studies assume technology that show constant returns to scale (Zhou P, 2006). However, there are cases where production technology exhibits variable returns to scale (Tyteca D., 2006). Tyteca (1996) adopted an aggregated concept into the DMU environmental performance and emphasized that the developed models would be inadequate at the process or product level such as those in the life cycle analysis or for the companies that simply have to report their environmental impacts to the environmental audit. Concerning the environmental DEA technology measures imposing variable returns to scale assumption other authors (Scheel H., 2001) and (Färe R. and Grosskopf S., 2004) developed models that allow joint environmental technology measures. Scheel (2001) concludes that in the new "nonseperated" measures the DMUs will be less efficient as compared to the trigonal measures which treats desirable and undesirable variables separately.

Mainly, most of the environmental DEA models incorporate undesirable outputs into the classic Farrell's framework of the efficiency analysis, thus by adding the quantities of these detrimental variables denoted by vector *w*, to the general production possibility set $T^{ENV} = \{(x, y) | inputs\ \boldsymbol{x}\ can\ produce\ outputs\ \boldsymbol{y}\}$, this production possibility set can be redefined as $T^{ENV} = \{(x, w, y) | inputs\ \boldsymbol{x}\ can\ produce\ outputs\ \boldsymbol{y}\ and\ waste\ \boldsymbol{w}\}$ (Kuosmanen T. & Kortelainen M., 2004). There are different orientations (environmental, input-environmental, output-environmental, hyperbolic, and directional) used in the measurement of environmental performance as distance to the environmental technology (Kuosmanen T. & Kortelainen M., 2004). When it comes to the choice of orientation, Kuosmanen and Kortelainen emphasize that it is advisable to consider constant factors that the firm cannot control and decrease or increase factors which are under the firm's control. Other measures or indicators in a more aggregated method were suggested for measuring environmental or eco-efficiency e.g. Net

Value Added (*NVA*) which indicates the difference between annual Value Added (*VA*) and the Value Lost (*VL*) which gives environmental performance indicator as ε=*NVA/VA*, *pollution performance index of a firm, pollutant risk, pollutant intensity index, overall pollution index* etc. (Tyteca D., 2006). Eco-efficiency can be attributed to commodities and also organizations and it means '*producing outputs with less natural resources and environmental degradation*' (Kuosmanen T., 2005). Another approach which is different from the environmental performance measures of production economic approaches was developed by Kortelainen M. and Kuosmanen T. (2004). This approach is more ecologically oriented as it focuses on environmental pressures rather than specific undesirable outputs and it is defined as '*production activity is eco-efficient if and only if it is not possible to decrease any environmental pressure without simultaneously increasing another pressure or decreasing the economic value added*' (Kortelainen M., and Kuosmanen T., 2004). Following this definition, Kortelainen and Kousmanen's eco-efficiency measure was presented as the ratio of economic value added to the index of environmental pressure denoted as D (Z_n). The D (Z_n) index was constructed by using *benefit of the doubt* weighting scheme which gives weights that maximize the relative eco-efficiency of the evaluated activity compared to the maximum potential eco-efficiency (Kortelainen M., and Kuosmanen T., 2004).

4. DATA COLLECTION AND DESCRIPTIVE STATISTICS

4.1 The study area

Kosovo is a small country with a total area of 10,908 km^2, situated in the center of the Balkan, between the Mediterranean Sea and the mountainous regions of Southeast Europe. According to the latest census conducted in 2012, the country's total population, which is the youngest in Europe (with an average age of 30.2), was counted at 1,815,606 inhabitants. Compared to other Western Balkan countries Kosovo has the highest population density (177.4 inhabitants/km^2). The majority of the population (61%) is living in rural areas and the average household size in 2012 was estimated to be 5.85 members.

Kosovo lies between N43°16´; S41°53´; E21°16´; W19°59´ and is divided in two main plains, the Dukagjini plain in the west and the Kosovo plain in the east. The lowest point of altitude is 265 m above the sea level located at "Drini i Bardhë" at the border to Albania and raises up to 2,656 above the sea level which is located in the southern part of Kosovo called Gjeravica. In total, approximately 80% of the entire area lies below 1,000 m. On June 2008, the Assembly of Kosovo adopted the Law No.03/L-041 on Administrative Municipal Boundaries and on the basis of this law the country composes of 5 regions, 38 municipalities and 1,469 settlements (KAS, Statistical Yearbook of the Republic of Kosovo, 2014).

The Kosovo plain embraces the Ibar Valley which is influenced by continental air masses. Therefore, winters in the Kosovo plain are much colder when compared to the Dukagjini plain, which is influenced by air masses which cross the Adriatic Sea, and the temperatures during the winter seasons vary between –10 °C down to –26 °C. The summers are usually very hot and the temperatures vary in from 20 °C up to 37 °C. The climate in the Kosovo plain is moderately dry with an average annual precipitation of 600 mm per year. In the Dukagjini plain, winters are milder and the monthly mean temperatures vary in the range of 0.5 °C up to 22.8 °C. The average annual precipitation of the Dukagjini plain is about 700 mm per year.

According to a digital map on soil types (scale 1:50000) produced by the Chair of Soil Science of the University of Prishtina "Hasan Prishtina" and referring to the WRB-soil classification

(IUSS Working Group WRB 2006), more than 80% of the agricultural used area are cambisols, vertisols, fluvisols, and regosols soil type (Table 15) (Elezi, Halimi, & Zogaj, 2004a), forming a complex and small-scale pedological pattern (Figure 23). It is estimated that 15% of Kosovo's soil is of high quality, 29% is medium and are mainly distributed in the Kosovo plain and 56% is of poor quality mostly found on hill and mountainous areas (MAFRD, 2013).

Table 15: Distribution of Kosovo's total area and agricultural used area by soil types

Soil type	Total area (%)	Agricultural used area (%)
Dystric cambisols	26.0	8.6
Eutric cambisols	16.0	20.3
Umbric leptosols	11.2	0.3
Vertisols	10.0	19.1
Fluvisols	7.7	17.5
Dystric regosols	6.4	15.2
Stagnic podzolluvisols	3.7	8.0
Others	19.0	11.0
Total	100	100

Source: (Elezi Xh., Zogaj M., Halimi A. , 2004b)

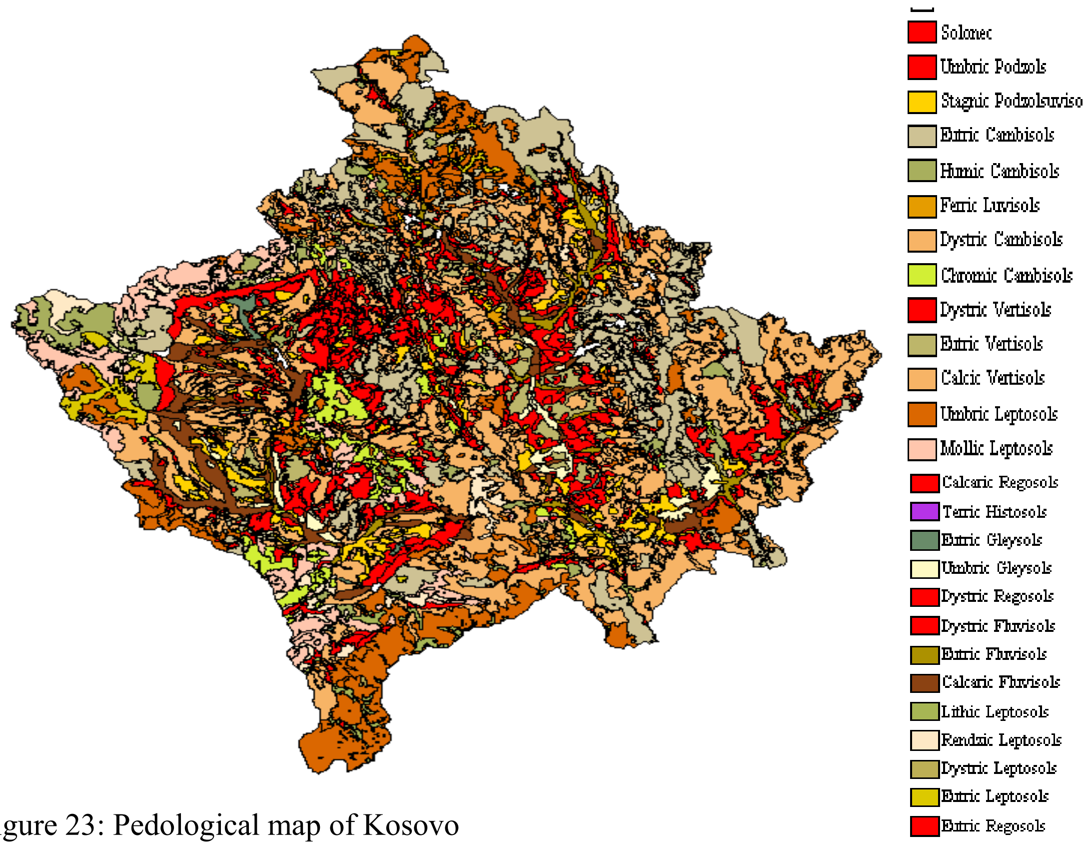


Figure 23: Pedological map of Kosovo

Source: (Elezi, Halimi, & Zogaj, 2004a)

The study was carried out in three regions Prizren, Gjilan and Pejë, respectively at eight different municipalities (Mamushë, Suharekë, Ferizaj, Rahovecë, Istog, Klinë, Viti, Ferizaj, Shtime.

4.1 Data collection, sampling procedure and the analysis performed

The data set used in this study is entirely primary data and consists of two parts: (a) the data covering information on household and farm characteristics and (b) the data associated with agri-environmental issues, particularly with soil quality on the farm and the ecological aspect of biodiversity generated by farms. Different data collection approaches were needed for each objective stated in the study. The designed research for the study was conducted in three stages:

First stage: *Preparing and conducting a survey with farmers*

In the first phase of the study a survey was conducted with horticultural farms where tomato is the main crop, intensively cultivated in greenhouses (cold poly-tunnels), grape-growing farms, and apple farms. A structured questionnaire (Annex 2) was developed and used as an instrument for data collection and it covered information on household and farm characteristics. The head of the family members which in most of the cases was also the manager of the farm was included in the interviewing process. The designed questionnaire comprised of five different sections and within each section different questions were asked and measured on continuous, dichotomous, multiple choice, open ended and rank order scale. The selection of the farms was performed based on the registered farm list provided by the MAFRD. The farms were randomly selected from the farm list. Initially, the total sample size comprised of 120 farms, which was equally distributed for each selected crop in the study (40 per each crop). Later, in the phase of data processing and analysis, 106 farms remained in the data set (38 tomato, 34 apple and 34 grape farms) and 14 were removed due to either weak information provided by the farmers or detected as outlier observation in the data set.

Table 16: Information on the data obtained through the survey and the analysis performed

Section	Data	Analysis	Software used
1: Demographics data on composition of the farm household	Age, education and profession of the farm household head and other family members; household size; and the duration in years living in the same village.	Descriptive statistics; Analysis of Variance (ANOVA); Chi-square test.	Statistical Package for the Social Sciences (***SPSS***), version 21
2: Employment status, sources and composition of the income	Number of the household members employed in and out of the farmstead; number of the household members working out of the country; composition and the sources of income.	Descriptive statistics; ANOVA; Chi-square test; Correlation.	***SPSS*** version 21
3: Farm and land use	Experience in farming; reasons getting involved in farming activities; farmer's satisfaction with farming activities; cultivated land in ha (owned and leased land); number of land parcels, and farmer's interest to cultivate more land.	Descriptive statistics; ANOVA; Chi-square test; Correlation.	***SPSS*** version 21
4: Crop production	Number of cultivated crops; land allocated to each cultivated crop.	Descriptive statistics;	***SPSS*** version 21.

5: Yields, inputs used in the production process, costs and gross revenue.	Yields for considered crops in the study; quantity of inputs used such as seeds/seedlings, fertilizers, pesticides, packaging, fuel, labor, machinery.	Descriptive statistics; efficiency analysis including technical, scale, cost, revenue and allocative efficiency; truncated regression analysis.	***SPSS*** version 21 for descriptive statistics; Performance Improvement Management Software (***PIM-DEA V3)*** for efficiency analysis; ***Eviews*** version 9 for truncated regression analysis.

To ensure that the content of the developed questionnaire covers all information needed to address the study objectives and it is functioning well in general, the validity of the instrument was conducted using experts and field test.

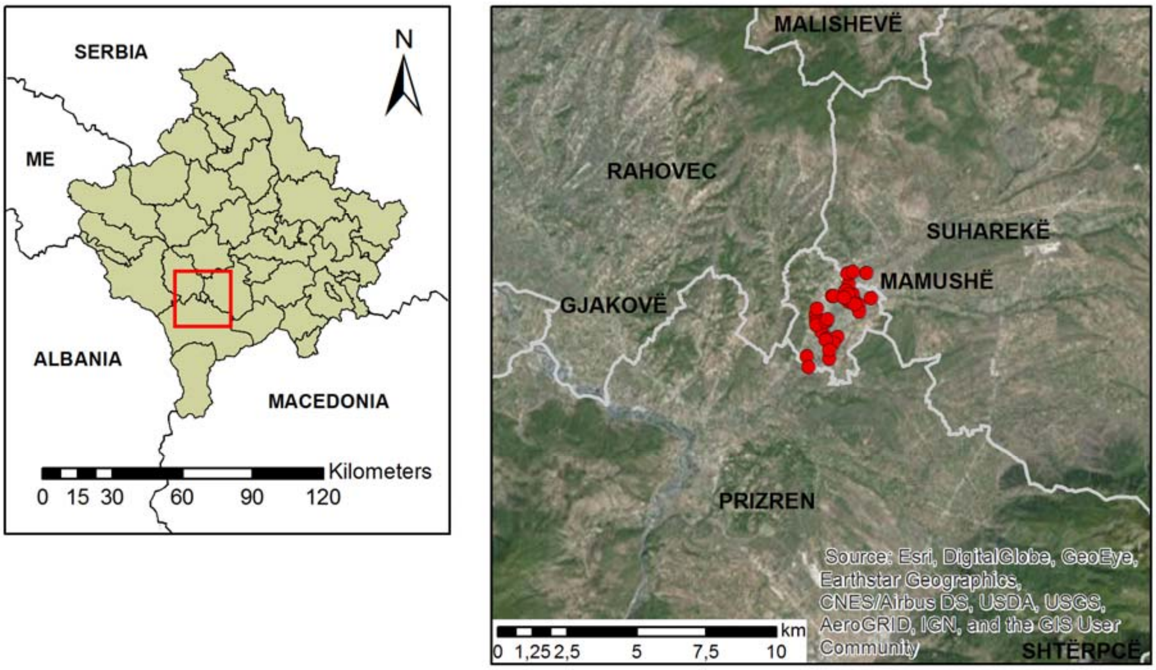


Figure 24: Location of the sampled tomato farms

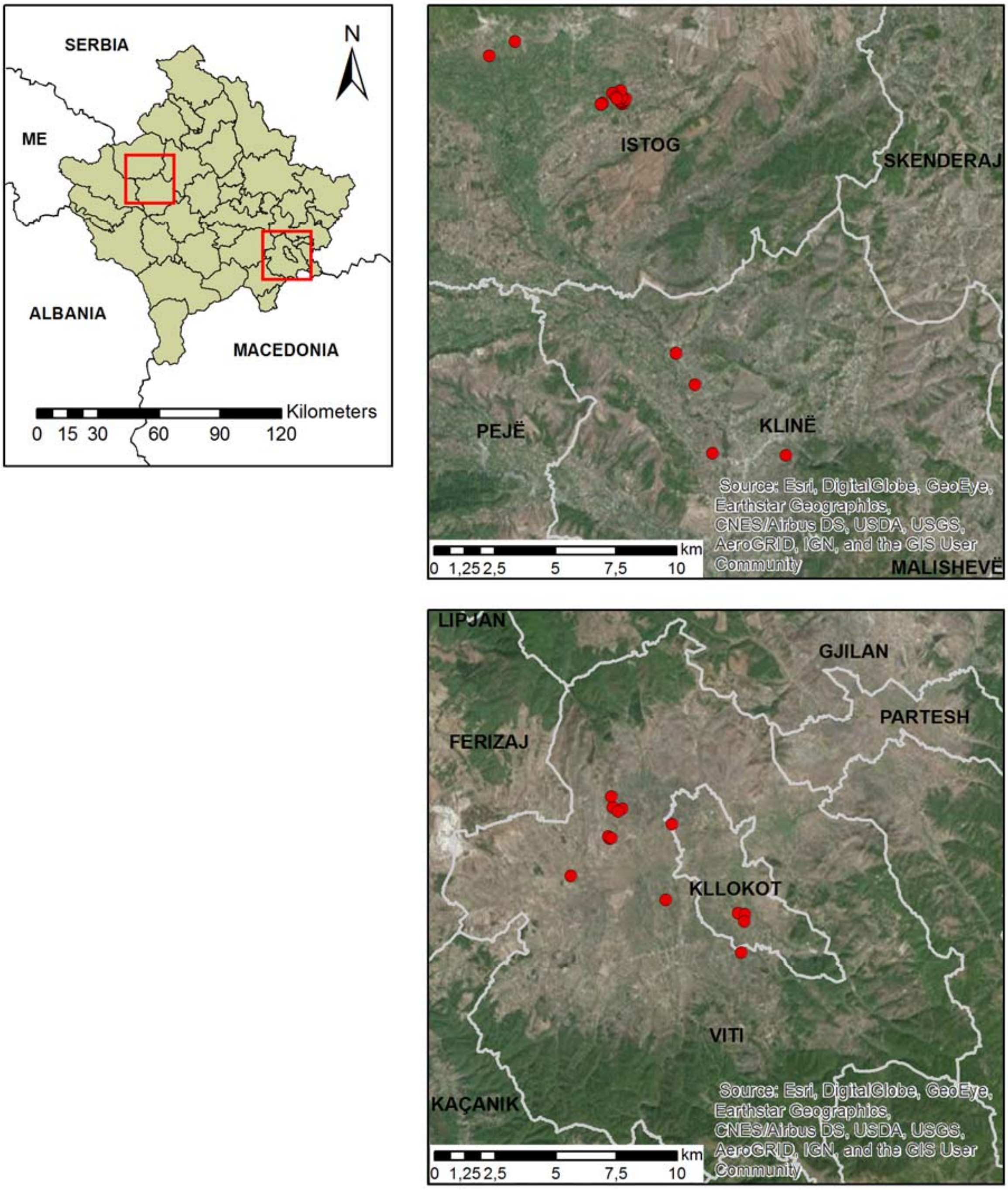


Figure 25: Location of the sampled apple farms

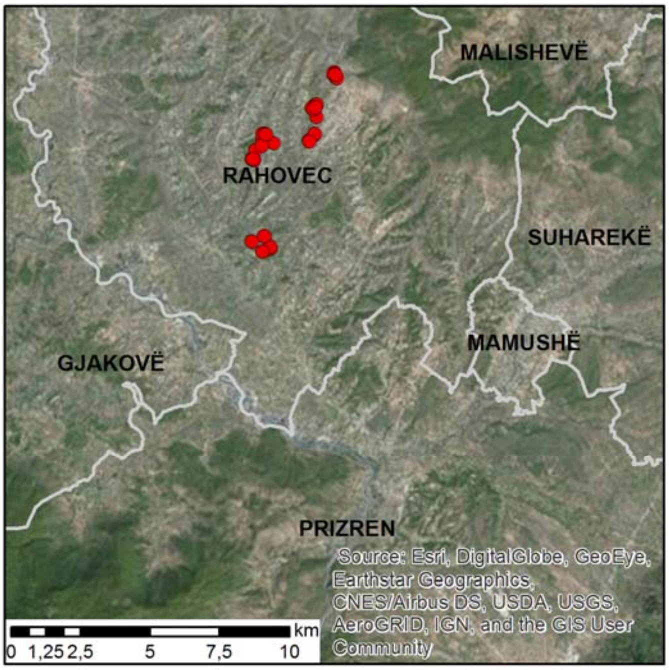


Figure 26: Location of the sampled grape farms

<u>Second stage:</u> *Soil sampling and soil analysis*

In the second stage of the study, soil samples were collected for each considered crop in the study. In order to avoid the fall of sampling points in a straight line and to ensure that the entire plot is represented, a grid pattern was applied as a scheme as it is shown in the Figure 27.

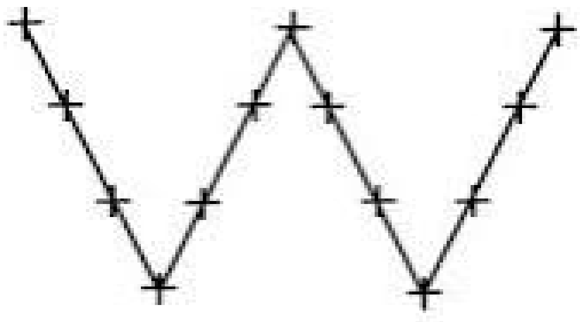


Figure 27: Scheme of the soil sampling

Soil samples for all selected crops where taken in a depth of 35cm from the surface, which essentially represents the root zone where the plant can absorb soil nutrients. For the tomato farms at each cold-poly tunnel with the dimension of 3*10m, five soil samples were collected and merged as a composite sample per one cold-poly tunnel. The total number of cold poly-tunnels at tomato farms was varying between 3 minimum to a maximum of 18, depending on the farm size. Out of the total number of tunnels per farm, 2-3 tunnels were randomly selected and included in the soil sampling procedure and the chemical soil valuation. Thus, in the end of the process 2-3 replicates were obtained per each farm. In addition, five soil samples at the same depth (35cm) were collected from uncultivated agricultural land situated near each farm and later pooled as one composite sample representing uncultivated soil. For perennial trees (apple and grape), replicates of the soil samples varied according to the orchard size. Similar to the tomato farms, a grid pattern of the soil sampling was applied. In addition, a composite sample from five soil samples representing uncultivated soils near each orchard (apple and grape) was collected. In total (including replicates) 304 soil samples were attained for soil quality valuation.

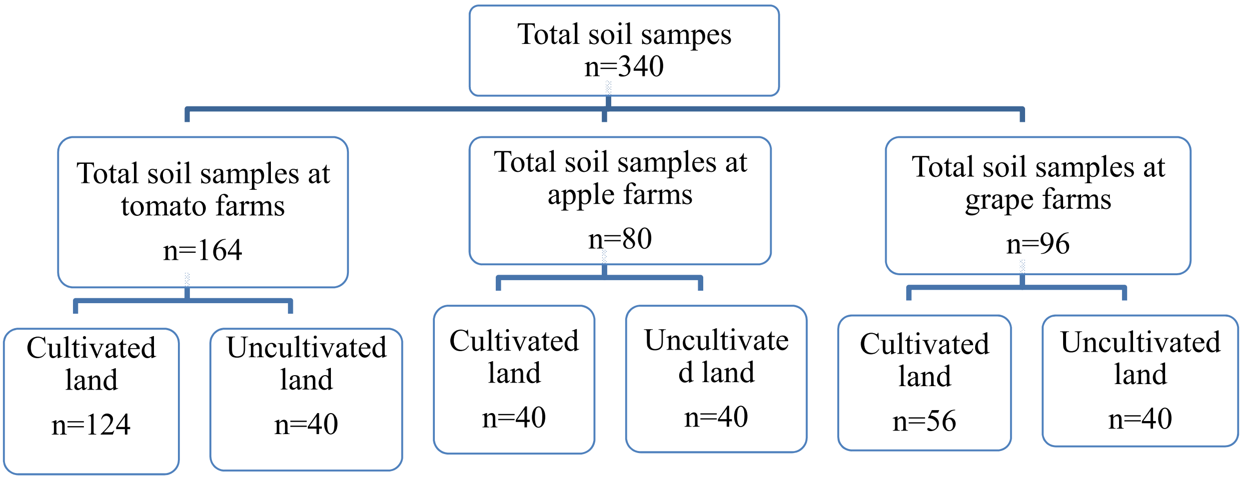


Figure 28: Distribution of the total soil samples among farms in cultivated and uncultivated land

Laboratory chemical analysis were carried out in order to be able to describe internal soil nutrition. Collected data based on laboratory chemical measurements were further aggregated into one soil quality index (SQI) (Amacher, 2007) which was later used as a soil quality indicator for cultivated and uncultivated land of each farm.

Table 17: Parameters related to farm soil quality

Agri-environmental issue	Indicator	Analytical soundness	Level of aggregation
Soil	1. Salinization or 2. Acidification; 3. Organic matter; 4. Productivity	pH humus C:N ratio P K Ca	Farm level

Table 18: Data and analysis performed to describe soil quality at farm level

Data	Analysis	Indicator	Software used
pH humus C:N ratio P K Ca	Principle Component Analysis (PCA); Normative method	Soil Quality Index (SQI) in cultivated and uncultivated farm land	SPSS

Third stage: *Assessing ecological aspect of biodiversity provided by farm*

In the third stage of the research, data associated with the habitat quality of cultivated farm land was collected and considered as an indicator of the ecological aspect of biodiversity provided by on-farm management practices.

Table 19: Data and analysis performed to assess agri-biodiversity provided by farms

Agri-environmental issue	Indicator	Analytical soundness	Level of aggregation
Biodiversity	1. Number of cultivated varieties within a crop 2. Ecological aspect of biodiversity	Shannon's Diversity Index (SHDI) % of open soil % of annual species % of perennial species % of grasses % of herbs	Farm level

4.2 Descriptive analysis

The first part of the results provide figures and analysis of the data set obtained from 102[1] family farms. Descriptive statistics, Analysis of Variance (ANOVA) and Chi-square test is used to describe and relates the main household characteristics age, household size, and education with other socio-economic factors. The next section proceeds with farm characteristics, land use, and crop production.

[1] 8 farms were excluded from the data analysis due to missing data.

4.2.1 Household characteristics

The overall household size is relatively large, with an average of 9.76 (Standard Deviation (SD) = 5.29) family members per household. On average, the household size of the farms oriented in tomato production is significantly ($p < 0.001$) larger than the farms oriented in apple and grape production. Study results showed a very high degree of inequality in regard to gender of the farm household head where, 99% of the farms were male-headed. All family farms (in total 102) were living in the same village since the head of the family farm was born. The average age of the farmers from the entire sample is 46.75 (SD = 11.11) years old. On average, farmers oriented in tomato production were significantly ($p < 0.05$) younger and considerably less educated ($p < 0.01$) compared to the apple and grape producers. The number of tomato farmers having additional profession aside from a farmer was different and significantly (x^2 = 9.13, df = 2 $p < 0.05$) lower compared to the two other group of farms. The likelihood of having additional profession aside from a farmer was statistically proven to be dependent on the farmer's education level (x^2 = 14.49, df = 2 $p < 0.01$). This result corresponds with the statistical test performed for differences in terms of education, where tomato farmers were significantly less educated among the three group of farms.

Table 20: Summary statistics of the farm household characteristics

Farm household characteristic	Mean	SD	Min	Max
HH size at tomato farms	12.16	6.18	4	26
HH size at grape farms	9.40	4.96	4	27
HH size at apple farms	7.23	2.67	3	14
HH size for entire farms	9.76	5.29	3	27
Farmer's age at tomato farms	43.11	7.51	31	65
Farmer's age at grape farms	48.40	13.44	25	84
Farmer's age at apple farms	49.30	11.01	30	72
Farmer's age for entire farms	46.75	11.11	25	84
Farmer's education at tomato farms	9.89	2.87	4	20
Farmer's education at grape farms	11.97	2.94	8	18
Farmer's education at apple farms	13.83	2.30	8	18

Farmer's education for entire farms	11.76	3.15	4	20

Note: HH-household; SD-standard deviation

Similar significant differences ($p < 0.001$) were observed in terms of the number of the family members employed. Family farms which were oriented in tomato production tend to have significantly higher number of the family members working fully in the farmstead. Different to this, apple oriented farms had significantly higher number of family members employed outside of the farmstead. Out of all interviewed family farms, 25.5% stated that they do have at least one family member working outside the country, mainly in Western European countries. No significant differences were observed among the three groups of family farms in regard of having family members working outside of the country.

Table 21: Summary statistics of employment status of the family farms

Employment	Mean	SD	Min	Max
Total employment at tomato farms	6.05	3.30	1.00	16.00
Total employment at grape farms	4.57	2.20	1.00	12.00
Total employment at apple farms	3.43	1.79	1.00	9.00
Total employment for entire farms	4.77	2.75	1.00	16.00
Employment in the farmstead at tomato farms	5.91	3.26	1.00	16.00
Employment in the farmstead at grape farms	3.48	1.65	1.00	8.00
Employment in the farmstead at apple farms	2.00	1.05	1.00	5.00
Employment in the farmstead for entire farms	3.93	2.76	1.00	16.00
Employment out of the farmstead at tomato farms	0.37	0.75	0.00	3.00
Employment out of the farmstead at grape farms	1.08	1.40	0.00	6.00
Employment out of the farmstead at apple farms	1.43	1.47	0.00	6.00
Employment out of the farmstead for entire farms	0.93	1.29	0.00	6.00

Note: SD-standard deviation

The farm business as a source of income plays a very important role in the welfare of tomato farm households. Approximately 90% of the interviewed tomato farms considered self-employment income from the agriculture sector as the main source of income in the household.

Only 8.1% of the tomato family farms, income flows from self-employment excluding agriculture and touristic sector was the main contribution of the household income. Grape family farms choose to diversify more income sources in order to support living standards. In comparison to the tomato farms, a smaller percentage (74%) of the grape family farms declared that the generated income from agriculture activities is the main source of income for their livelihood. A survey conducted in Albania reported that 60% of the farm household incomes come from farming activity and 22% of the income derives from self-employment or waged labor (Wehinger & Zhllima, 2013).

For other grape farms, wage income excluding agriculture and the tourist sector (14.3%), self-employment income excluding agriculture and touristic activities (5.7%) and other income sources like private and public transfers (5%) were considered to be the main source of income. A completely different situation can be found for most of the apple producers where the farm household wellbeing is mainly based on off-farm activities. Only 23.3 % of apple producers earn income mainly from the agriculture activities. Majority (43.3%) make a living from wage income and 33.3% from self-employment excluding agriculture and the tourist sector. For most of the apple producers income from agriculture is an additional source of income with the purpose to diversify and stabilize their household income.

Farm household income sources were further examined to see how the income pattern relates to the other farm household characteristics. Study results did not show a significant association between the sources of income and the age groups of farmers. Household size (all family members dependent on the household financial support including students away at school), farm size (all cultivated land including owned and leased land) were not shown to be significant determinant factors for the household income sources. Farmer's education level and experience in terms of the number of years active in farming were significantly correlated and the main factors contributing to the income source determination of farm household. In terms of education level, similar patterns were found in the study conducted by (Zezza, 2007) in cross comparison of fifteen developing countries. Households with lower levels of education are likely to be more engaged in on-farm activities and rely more on agriculture income. Study results from (Estudillo & Otsuka, 2010) showed that secondary and tertiary education was positively corralled to non-farm income. Another study conducted by (Miftari & Gjonbalaj, 2013) showed that the higher the education level the higher probability that farm households will engage in non-farm activities, having positive effect on household's non-farm diversification as well as improved household welfare.

Table 22: Correlation of the farm household income sources with farm characteristics

	Farm household income sources			
Farm characteristics	x^2	Df	p-value	Cramer's V
Farmer's age	9.18	9	0.42	0.17
HH size	10.78	9	0.29	0.18
Farm size	9.00	6	0.17	0.29
Education	27.10	6	0.00	0.51
Experience	19.17	6	0.00	0.30

Note: HH size- household size.

Income of farm households and its contribution to the total household income varies according to the farm typology and commodity. On average, tomato farms were having the highest share of income from agriculture and compared to the two other groups of farms, the difference was proved to be statistically significant ($p < 0.001$). For farmers oriented more on apple production the average farm income contribution to the total household income was 55% (SD 30%). The level of income earned from non-agricultural activities (mainly as wage or self-employment income) was considerably higher for apple farm households. The average contribution of farm income to the total income was slightly higher for grape producers 58% (SD 28%). However, for tomato producers, farm income was the main contributor to the total household income with 83% and the level of income from agriculture activities was significantly higher compared to grape and apple farms ($p < 0.05$). Another part of income for tomato farms was mostly coming from private (remittances) or public (pensions) transfers. The composition of human and natural assets at farm household was a key determinant for the income level. The household size, number of family members working actively on farm and farm size, were all positively and significantly associated with the farm income. The Person's correlation coefficient of household size and income was r = 0.198, $p < 0.05$, for employment r = 0.207, $p < 0.05$ and farm size r = 0.496 $p < 0.001$. No significant correlations were observed between farmer's age, education, and experience in agriculture with the total income of farm household.

Table 23: Annual income of farm households by source of income

Source of income	Mean	SD	Min	Max
Total income at tomato farms	19,322	11,467	5,580	71,680
Total income at grape farms	21,883	20,112	3,600	92,000
Total income at apple farms	21,121	14,722	3,500	70,000
Total income for entire farms	20,730	15,700	3,500	92,000
Income from agriculture at tomato farms	14,456	6,466	725	30,000
Income from agriculture at grape farms	10,366	9,142	1,200	40,000
Income from agriculture at apple farms	9,494	7,978	1,000	35,000
Income from agriculture for entire farms	11,593	8,133	725	40,000
Income from non-agricultural activities at grape farms	6,310	2,569	2,400	14,400
Income from non-agricultural activities at apple farms	12,976	8,447	1,500	40,000

Note: Descriptive statistics of the income from non-agricultural activities for tomato farms were not reported as only 5 household farms out of 37 were generating income from non-agricultural activities.

4.2.2 Farm characteristics

The average size (in terms of physical measure-the number of hectares) of an apple farm was 6.32 ha (SD = 5.10). About 25% of the total apple farms were smaller than 3 ha and 75% lay below 7.25 ha. The ANOVA test showed that on average, apple farms were significantly bigger compared to the grape and tomato farms ($p < 0.05$). The average size of grape farms was 4.13 ha (SD = 3.33), which is significantly smaller than apple farms but bigger than tomato farms with 3.30 ha (SD = 1.92). The size of tomato farms was ranging from 0.5 up to 8 ha.

Most of the farms are considered to be well established farms, as on average they were active in farming for 28.46 years (SD = 15.57). The smallest mean of farming experience was for apple producers 18.90 years (SD = 15.47), followed by tomato producers 28.53 years (SD = 12.57) and the grape producers 36.57 (SD = 14.63). The mean of farming experience has been proven to be statistically different among the three groups of farms ($p < 0.001$). No significant relationship was observed between farming experience and farm size. The table 24 presents the distribution of total farms by farming experience.

Table 24: Distribution of the farms by farming experience

Farming experience in years	1-10	< 10 -20	< 20-30	< 30
Frequency in %	20.6	11.8	27.5	40.2

The main reason for getting engaged in agriculture activities was differing among the three groups of farms. A majority (63%) of the grape producers stated that "tradition" is the main reason they got involved into farming. About 33% of the apple producers stated that "income generation" is the only reason they were engaged in farming activities and an approximately equal percentage (32%) of grape producers gave the same answer. The main stated reason differed for tomato producers, where 43% declared that "no other opportunity" was the main reason getting involved in farming activities and just about 22% because of income generation. A smaller number out of the interviewed farmers stated other reasons, e.g. "because of hobby". The stated reason of getting engaged to farming was significantly different among farmers grouped by education level (x^2 = 15.27, DF = 4, $p < 0.01$) and farming experience (x^2 = 15.82, DF = 8, $p < 0.05$). Whereas, farmers with primary education were involved in agriculture mainly because of income generation or as there was no other opportunity for them, for those with secondary and tertiary education "tradition" was the most affirmed reason. No statistically significant dependency was examined between the farm size and farmer's age with the stated reason of getting involved into farming activities. Figure 29 presents the satisfied level of farmers in farming activities. The satisfaction level was proclaimed in the scale of 1-not satisfied at all to 5-very satisfied.

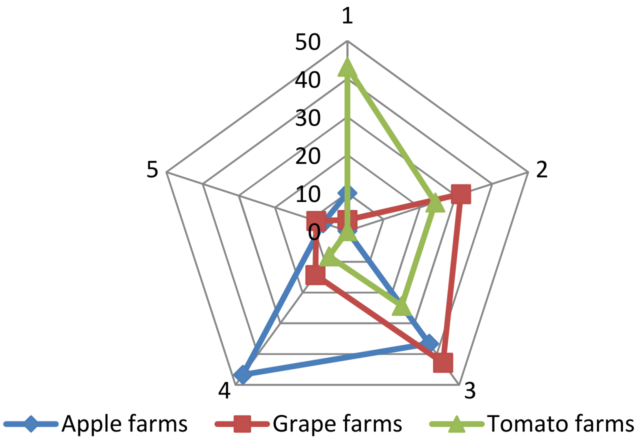


Figure 29: Satisfied level of farmers in farming activities

4.2.3 Land use and soil quality

The proportion of tomato farmers leasing land from other landowners was 59.5%. This proportion was approximately the same for grape (20%) and apple farms (23.3%). The main reason of leasing land for agriculture purposes is that this was the easiest way for farmers to expand their agriculture business without high capital investment costs like buying additional land. The rental price was varying from region to region and it was dependent on many different factors like location, soil type, productivity and water availability. The minimum to maximum annual price paid for leasing land was 100 to 200 EUR per ha. The price was significantly higher in Mamusha region (500-1000 EUR per ha) as in the surrounding area where most of the tomato farms were located, there is no much land available for renting, due to its intensive use for vegetable production. For the entire sample, the farm land is considered to be very fragmented and scattered over a wide area. There was no significant difference in the possession of land plots between the three groups of farms ($p > 0.05$). The overall mean of the land plots was 5.47 (SD =2.87), where 25% of the total farms were having less than 4 land plots and 75% up to 7 plots. The number of land plots in the farm was positively and significantly correlated to the farm size ($r = 0.42$, $p < 0.001$).

4.2.4 Assessment of soil quality

Soil is considered to be a crucial component not only for producing food and fibers, but also for maintaining local, regional and global environmental quality (Glanz AA., 1995). In addition to the food and fiber production, high quality soil plays a key role in stabilizing natural ecosystems and improving air and water quality (Gregorich E., 1993). There is a high level of interaction between the environment and the production and therefore proper agricultural land management practices improve the quality of soils and other environmental goods (Cooper T., 2009). The level of soil quality is evaluated based on several indicators which include the proportion of organic matter, its vulnerability by wind and water, structure and capacity for infiltration the health of its biota and the level of contamination (SoCo, 2009). The soil quality concept is considered to be a helpful tool in assessing the impact of land use and soil/crop management practices on biological, chemical and physical components of the soil (Masto R.E., 2008). Reduction in the crop yield is often attributed to land degradation caused by various factors and one of them is also inability of small-scale farmers to adopt technologies that improve soil fertility and conservation (Mbaga-Zemgawale Z., and Folmer H., 2000). Soil chemical parameters were also shown to be significant determinants for floristic composition-phytodiversity (Wellstein C., Otte A., and Waldhardt R., 2007). Soil quality variations at farm level may be attributed from two possible sources: 1) natural differences in soil properties, and farm-made differences due to the different farm practices such as fertilizers application, soil conservation techniques etc. (Masterson T., 2007). Therefore, it is important that farmers get motivated to follow farming practices to maintain and manage natural resources such as soil (Cooper T., 2009). Cross compliance as a horizontal tool for pillar I and II plays a crucial role in protection, conservation and improvement of soil (SoCo, 2009).

In our study, the soil quality assessment at the farm level refers mainly to the chemical parameters. Several studies have shown that soil quality significantly determines technical efficiency of agriculture (Nowak A., 2015). Nowak A., et al (2015) regressed soil productivity index as independent variable and found out that variation on technical efficiency at farm level was significanlty determined by soil productivity index. A study conducted by Karimov A. (2013) showed that farmers with higher soil fertility index were attaining higher technical efficiency scores, and suggests that further actions are needed towards preserving the soil quality and improvement of land tenure system (Karimov A., 2013). Overall technical efficiency of sugar cane farmers in Central Negors was positivelly related to soil type (Padilla-Fernandez M. D., and Nuthall L. P., 2009). Statistically significant difference was also observed in the means of soil quality indices between the farmers obtaining higher technical efficiency scores compared to those defined as technically inefficient (Kelly E., 2012). It is understandable that farmers with poor soil quality may attempt to increase yields through additional use of inputs e.g. fertilizers and pesticides and as result achieve lower technical efficiency scores.

The Soil Quality Index (SQI) for each production system for cultivated and uncultivated land was calculated using two different methods:

1. Principle Component Analysis (PCA), and
2. Normative approach (NA).

Chemical soil parameters used in SQI valuation: Total nitrogen (N_t) and total carbon (C_t) levels were assessed using a CN-analyzer; the AL-method described by (Egner, Riehm, & Domingo, 1960) was used in estimating levels of plant available phosphorus (P_{ALM}) and potassium (K_{ALM}); pH values were determined in water (1:2.5, soil water ratio) and $CaCl_2$; The Weight Loss on Ignition method was used for measuring organic matter in the soil.

The obtained laboratory values of soil chemical parameters were aggregated into one index value.

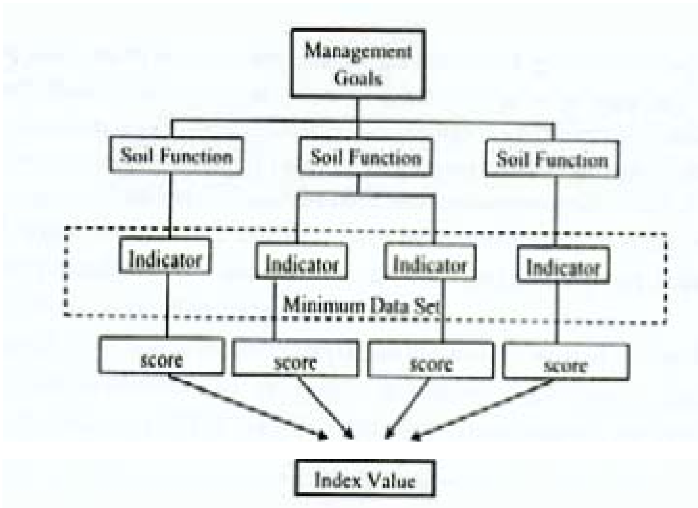


Figure 30: A generalized framework for developing soil quality indices (from Karlen et al. 2001)

1. Soil quality estimation using PCA approach: in the first phase the values of thresholds presented in the table 26, chemical soil parameter values were altered into unit less scores (0-1).

A Linear scoring function (LSF) as presented below was used to calculate the scores for each soil property value (Masto R. E., 2008). In the case when soil chemical parameter was considered to be as *'more is better'* the following LSF was used:

(6)

LSF (LS) = (SPV – LTV) / (UTV – LTV)

whereas, in the case when soil chemical parameter was considered to be as 'less is better' the following LSF was used:

(7)

(LS) = 1 – (SPV – LTV) / (UTV – LTV),

where *LS* stands for the linear score, *SPV* indicates chemical soil property value, *LTV* the lower and *UTV* the upper threshold values. The combination of two equations (6 and 7) was used in the case of optimum scoring function e.g. pH. If the calculated score was >1.0 it was considered as 1.00. (Masto R. E., 2008)

In the second phase, the obtained scores using equations 6 and 7 for highly weighted chemical parameters in PCA analysis, were integrated into the SQI as in the following:

PCA based SQI

(8)

$$\mathrm{SQI} = \sum_{i=1}^{n} \mathrm{PW_i} \times \mathrm{LS_i}$$

where *PW* is the principal component analysis (PCA) weighting factor for the *i* soil property value and *LS* is the indicator score obtained through LSF for the *i* property value. Principal components (PCs) with Eigenvalue ≥ 1 (Kaiser, 1960) were examined. Following Masto R. E., (2008) approach, under each particular PC, only soil chemical parameters with a high loading factor (>0.40) and not correlated in particular component were considered as important and kept for the quality indexing .

Table 25: Selected chemical soil quality indicators and scoring functions

Indicator	Scoring curve	Lower threshold	Upper threshold	Optimum
pH	Optimum	4	9	7
N (%)	More is better	0.0	1.1	-
C (%)	More is better	0	13	-
C/N	Optimum	0	57	10
mgP_2O_5/100g	More is better	0	40	-
mgK_2O/100g	More is better	0	50	-

Zogaj M. 2013.

PCA results for cultivated land at tomato farms

Figure 31: PCA scree plot of soil chemical parameters in cultivated land at tomato farms

Table 26: Pattern matrix of soil chemical parameters in cultivated land at tomato farms

Soil chemical parameter	Component		
	1	2	3
C total %	**.961**	.094	.096
C/N %	**.887**	-.217	-.279
N total %	**.745**	.286	.309
mgP_2O_5/100g	-.131	**.904**	-.151
mgK_2O/100g	.159	**.779**	.047
pH (H_2O)	-.026	-.121	**.975**

Note: SPSS software has been used to perform PCA analysis.

Bold and underlined soil chemical parameters in components 1, 2 and 3 were showing high loading factor (>0.40) and before considering for the soil quality indexing, a correlation matrix was performed as presented in the table 27.

Table 27: Correlation matrix of the soil chemical parameters in cultivated land at tomato farms

		N total %	C total %	C/N %	mgP_2O_5/100g	mgK_2O/ 100g	pH(H_2O)
N total %	Pearson Correlation	1	.896**	.364*	.219	.346*	.244
	Sig. (2-tailed)		.000	.023	.181	.031	.134
C total %	Pearson Correlation	**.896****	1	**.726****	.059	.296	.117
	Sig. (2-tailed)	.000		.000	.722	.067	.480
C/N %	Pearson Correlation	.364*	.726**	1	-.153	.080	-.119
	Sig. (2-tailed)	.023	.000		.353	.629	.470
mgP_2O_5/ 100g	Pearson Correlation	.219	.059	-.153	1	**.452****	-.106
	Sig. (2-tailed)	.181	.722	.353		.004	.519
mgK_2O/ 100g	Pearson Correlation	.346*	.296	.080	.452**	1	.061
	Sig. (2-tailed)	.031	.067	.629	.004		.710
pH(H_2O)	Pearson Correlation	.244	.117	-.119	-.106	.061	1
	Sig. (2-tailed)	.134	.480	.470	.519	.710	

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

In the first component C total (%), C/N (%) and N total (%) were the highest loading factors, but in the correlation matrix (Table 27) we can observe that C total (%) was statistically significantly correlated with C/N (%) and N total (%). Therefore, only C total (%) from the first component was considered in soil quality indexing. In the second component $mgP_2O_5/100g$ and $mgK_2O/100g$ were highly weighted factors, however the Pearson's correlation coefficient between this two variables was statistically significant and therefore only $mgP_2O_5/100g$ was considered in indexing. In the third component only pH was highly weighted and included in the index calculation.

Table 28: Calculation of the soil quality index at tomato farms

SQII	$SQII = (PWI_{Ctotal\ \%} * LSI_{Ctotal\ \%}) + (PWI_{mgP2O5/100g} * LSI_{mgP2O5/100g}) + (PWI_{pH} * LSI_{pH})$ SQII = (0.961*0.090) + (0.904*0.658) + (0.975*0.380) = 1.053 SQII was normalized to get the maximum value of 1 as in the following formula: NSQII = ΣSQII/ΣLSI; NSQII = 1.053/1.130 = 0.932
SQIO	$SQIO = (PWO_{Ctotal\ \%} * LSO_{Ctotal\ \%}) + (PWO_{C/N\ \%} * LSO_{C/N\ \%}) + (PWO_{pH} * LSO_{pH}) + (PWO_{mgK2O}/_{100g} * LSO_{mgK2O/100g})$ SQIO = (0.965*0.075) + (0.843*0.116) + (0.885*0.342) + (0.623*0.155) = 0.570 NSQIO = ΣSQO/ΣLS; NSQII = 0.570/0.689 = 0.827

Note: SQII stands for soil quality index in cultivated land; SQIO is soil quality index in uncultivated land; NSQI indicates normalized soil quality index; PWI is PCA weighting factor for soil chemical parameters in cultivated land; PWO is PCA weighting factor for soil chemical parameters in uncultivated land; LSI stand for linear scoring in cultivated land and LSO for linear scoring in uncultivated land. Same calculation was performed for apple and grape farms.

As it can be seen from the calculations (table 28) the soil quality index in cultivated and uncultivated land was composed of different soil chemical parameters. Therefore, it was not considered an appropriate approach to be compared for the differences between the SQII and SQIO. As a result, a normative approach was considered as presented in the following formula.

2. Soil quality estimation using normative approach:

The individual index values for all chemical soil parameters were summed to give a total SQI:

$$\textit{Total}\ \text{SQI} = \Sigma\ \textit{individual soil property index values}$$

The maximum value that SQI could take was 12, which is calculated based on the six chemical parameters measured. The total SQI is then expressed as a percentage of the maximum possible value of the total SQI for the soil parameters measured (Amacher M. C., 2007).

(9)

$$SQI\ in\ \% = \left(\frac{Total\ SQI}{Maximum\ possible\ total\ SQI\ for\ parameteres\ measured}\right) * 100$$

Table 29: Soil quality index values and soil parameter threshold values and interpretations

Parameter	Level	Interpretation	Index
mgP2O5/100g	0 up to 10	Low-possible deficiencies	0
	> 10 up to 20	Moderate-adequate levels	1
	> 20	High-excellent reserve	2
mgK2O/100g	0 up to 10	Low-possible deficiencies	0
	> 10 up to 20	Moderate-adequate levels	1
	> 20	High-excellent reserve	2
mgCa/100g	up to 20	Low-possible deficiencies	0
	>20 up to 400	Moderate-adequate levels	1
	> 400	High-excellent reserve	2
C% total	>0-1	Very low	0
	>1-2	Low-possible deficiencies	1
	>2-3	Moderate-adequate levels	2
	>3-13	High-excellent reserve	2
N% total	>0-0.1	Very low	0
	>0.1-0.2	Low-possible deficiencies	1
	>0.2-0.3	Moderate-adequate levels	2
	>0.3-1.1	High-excellent reserve	2
pH	3.1-4.0	Strongly acid	0
	4.01-5.5	Moderately acid	1
	5.51-6.8	Slightly acid	2
	6.81-7.2	Near neutral	2
	7.21-7.5	Slightly alkaline	1
	7.51-8.5	Moderately alkaline	1
	>8.5	Strongly alkaline	0

Source: (Amacher M. C., 2007).

4.2.5 Results of the soil quality index under three different production systems

As the SQI was calculated for cultivated and uncultivated lands in three production systems, we distinguished SQI into SQII, standing for cultivated land, and SQIO for uncultivated land. The average $SQII_{PCA}$ for tomato farms was estimated to be 0.80 (SD = 0.18) with a range from minimum 0.32 to maximum 0.95. The $SQIO_{PCS}$ was slightly smaller than $SQII_{PCA}$ with an average of 0.75 (SD = 0.04), a minimum of 0.64 and maximum of 0.84. Different SQI results were obtained with a normative approach (Table 30).

Table 30: The SQII and SQIO of tomato farms using normative approach

SQI	Mean	SD	Minimum	Maximum
$SQII_{NA}$	0.63	0.12	0.33	0.92
$SQIO_{NA}$	0.57	0.13	0.33	0.83

Note: Subscript NA stands for normative approach.

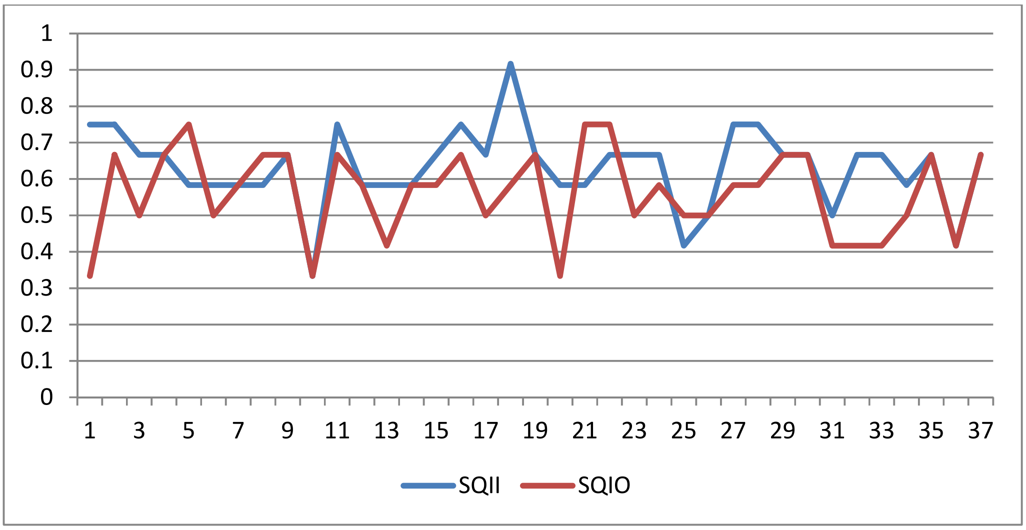


Figure 32: Comparison of the estimated SQI for cultivated and uncultivated land of tomato farms using a normative approach

The average $SQII_{PCA}$ for grape farms was estimated to be 0.970 (SD = 0.05) with a range from minimum 0.619 to maximum 0.987. The $SQIO_{PCS}$ was slightly smaller than $SQII_{PCA}$ with an average of 0.937 (SD = 0.08), a minimum of 0.544 and maximum 0.975. The table below present results for the SQI of grape farms obtained using a normative approach.

Table 31: The SQII and SQIO of grape farms using a normative approach

SQI	Mean	SD	Minimum	Maximum
$SQII_{NA}$	0.46	0.16	0.16	0.83
$SQIO_{NA}$	0.41	0.14	0.08	0.66

Note: Subscript NA stands for normative approach.

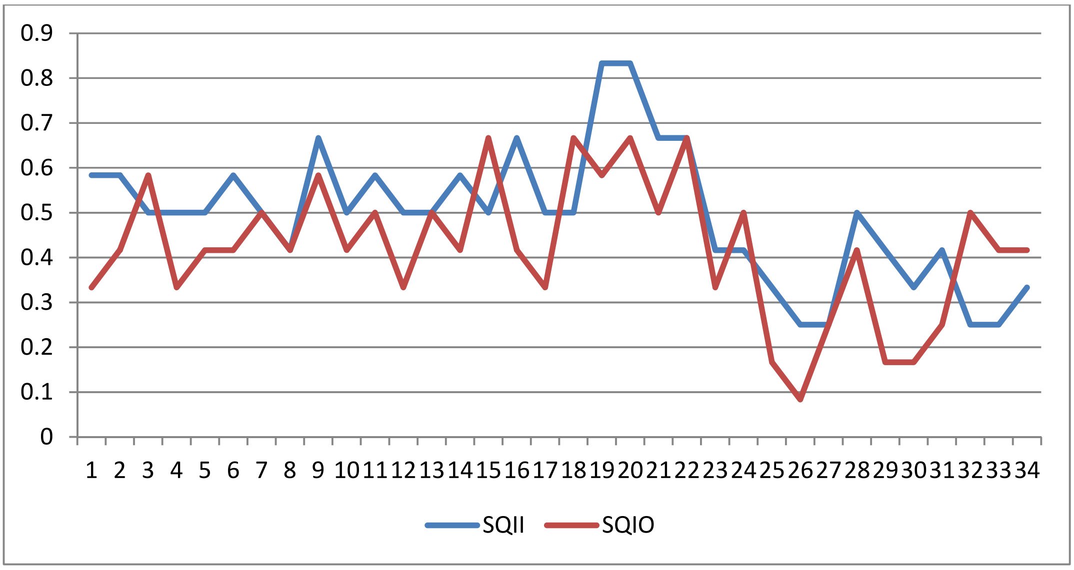


Figure 33: Comparison of the estimated SQI for cultivated and uncultivated land of grape farms using a normative approach

Table 32: The SQII and SQIO of apple farms using principle component analysis and a normative approach

SQI	Mean	SD	Minimum	Maximum
$SQII_{PCA}$	0.62	0.03	0.50	0.71
$SQII_{NA}$	0.62	0.11	0.33	0.83
$SQIO_{PCA}$	0.70	0.11	0.18	0.79
$SQIO_{NA}$	0.62	0.13	0.33	0.91

Note: Subscript PCA stands for principle component analysis, NA-normative approach.

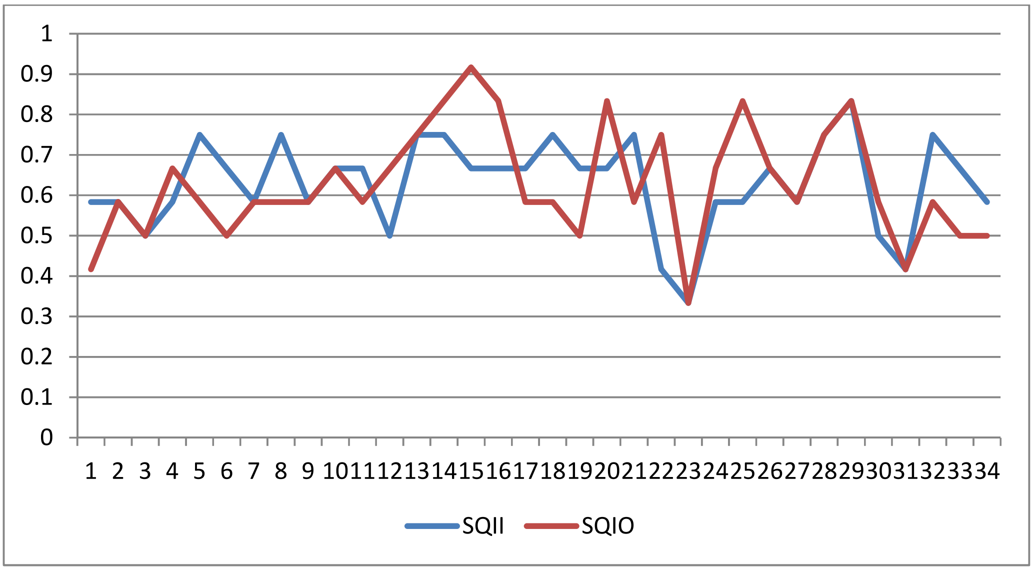


Figure 34: Comparison of the estimated SQI for cultivated and uncultivated land of apple farms using a normative approach

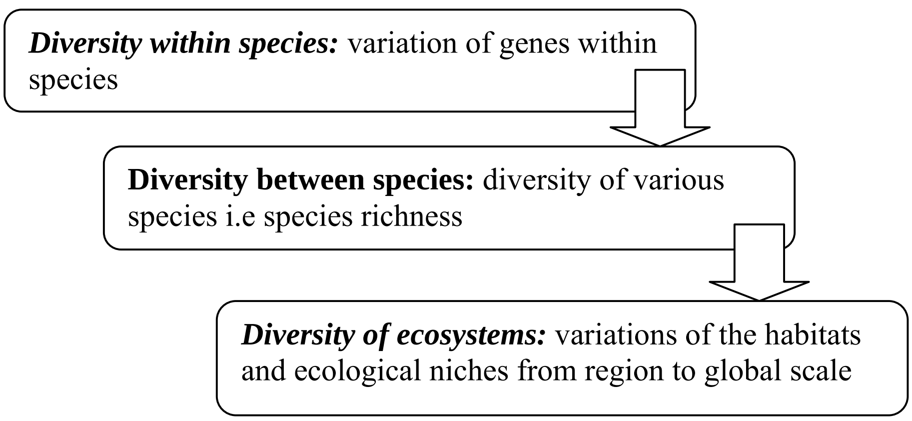
In the PCA method, the aggregated SQI was composed from different soil chemical parameters which were selected based on the loading factor produced from PCA analysis. As the idea was to use SQIO as an input and SQII as an output in the farm efficiency estimation, the SQI produced with the PCA method was not considered appropriate indicator for this situation. Therefore, SQI calculated with a normative approach was used for further analysis in efficiency measurement.

4.3 Biodiversity definition and its importance

A considerable number of studies highlight that the term "*biological diversity*" came into prominence in the early 1980s. Magurran (2004) relates its earliest reference to Gerbilskii and Petrunkevich (1955, p.86) who used this term in the context of intraspecific variation in the behavior and life history (Magurran A. , 2004). Haper and Hawksworth (1995) date its first use back to the 80s when Lovejoy used it to indicate the number of species present and to Norse et al. (1986), who firstly dissected biological diversity into three levels: genetic (within species), species (species numbers) and ecological (community) diversity (Aswathanarayana, 2012). The biodiversity concept is widely used; (Callicot, 1999) distinguishes it between *compositionalism* which is based on a biological hierarchy of organisms in species populations interacting in biotic communities and *functionalism* which is based on thermodynamic energy flows and nutrient cycles and the ontology of processes and functions. The United Nations Conventions on Biological Diversity defines it as:

'the variability among organisms from all sources, including inter allia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of each they are part; these include diversity within species, between species, and of ecosystems' (UNEP, 1992).

This involves three main hierarchical levels of biodiversity (Lévéque C., & Mounolou J. C., 2003):



According to (Wilson, 1988) definition it is 'the variety of life at every hierarchical level and spatial scale of biological organizations: genes within populations, populations within species, species within communities, communities within landscapes, landscapes within biomes, biomes within biosphere'. Biodiversity also refers to the totality of the species across the full range of terrestrial organisms (i.e. invertebrate animals, protists, bacteria and fungi, above and below ground and vertebrates and plants which constitute the main concerns of biodiversity conservation (Swift M.J, 2004).

Taking into consideration that biological diversity implies different levels, from genes to species to ecosystems, the value of biodiversity can be defined in a number of different ways (Waldhardt R., and Otte A. , 2003). A hierarchical characterization of biodiversity that identifies the major components at several levels, provides a useful conceptual framework to assess the overall status of biodiversity (Noss F. R. , 1990). *'The hierarchical concept recognizes that the effects of environmental stresses will be expressed in different ways at different levels of biological organization and the effects at one level can be expected to reverberate through other levels* (Noss F. R. , 1990).' According to Noss (1990), habitat variables presented in the scheme (Annex 1) were assumed to be important to the species and it obviates the need to monitor the populations. However, habitat valuation data was not further used in the environmental efficiency estimation.

The most important functions that biodiversity can provide to humankind can be grouped into *utilitarian* also called direct use, indirect and *intrinsic* known also as non-use values using total economic value framework (Brander L., 2010). Direct use value is mainly derived from goods that can be extracted, consumed and enjoyed directly, whereas indirect, also known as a non-extractive use value, is mainly derived from the services the environment provides (Dixon J., Pagiola S., 1998). Non-use or intrinsic values include existence value, which ensures the survival of biological sources (Pearce R. K., Turner D. W., 1990) and relates to human cultural, social and ethical values (Swift M.J, 2004). Biodiversity contributes to ecosystem life support functions and the preservation of ecological structure and integrity, which is the *functional* value of diversity, recognized lately in the economic literature (Kerry-Turner, 2004). Biodiversity performs fundamental life-support services without which human civilization would cease to thrive (Daily G. C. & et al, 1997).

(Vandermeer J., 1998) defines the role of biodiversity in agro-ecosystems and links between diversity and function in three main hypotheses: 1) Biodiversity enhances ecosystem function because different species perform different functions and thus redundancy is built into the system; 2) Biodiversity is neutral or negative as there are more species compared to functions; 3) Biodiversity enhances ecosystem function as those components appearing redundant at one point in time become important when environmental changes occur.

In agriculture systems, land use changes and agriculture intensification through specialization in one or few productive plant or animal species of value to humans often reduces diversity to genetically homogenous species. In systems (Swift, 1996) distinguishes *planned diversity,* implying the plants and livestock are purposely retained and managed by the farmer and *associated diversity* related to the composition of planned diversity which influences the nature of the associated biota like plants animal microbes.

Biodiversity is usually higher on farmland that is managed at low intensity (Beaufoy G., 2007). Landscapes rich in biodiversity are in benefit also for soil conservation, which is being lost mainly due to the intensive farming practices (Beaufoy G., 2007). In Europe, starting from the early 1990s it has been acknowledged that maintain of low intensive farming practices that co-creates landscapes and biotopes is important for biodiversity conservation (O'Rourke E. and Kramm N., 2012). The relatively new concept known as High Nature Value (HNV) farming systems have a tendency to yield lower incomes from the market and receive income payments from CAP 'Pillar 1' (O'Rourke E. and Kramm N., 2012). The aim of this concept is to distinguish extensive farming systems to intensive farming systems that degrade nature (Solovyeva I. and Nuppenau A. E., 2013) and to link ecology, farming and public policies components and management practices that promote HNV farming systems (Beaufoy G., 2007). Furthermore, the

HNV farming concept supports a holistic system of extensive land use practices including the connectivity between farming and nature (Solovyeva I., and Nuppenau E. A., 2012).

The biodiversity as a multifunctional use of an ecosystem is economically valuable to communities and to society as whole and therefore is of high importance (Balmford A., 2002). Valuation of biodiversity and its recognition as a good that society esteems ensures better balance in the decision-making and orientation of policy makers concerning biodiversity use and its management. Impact assessment in a decision making system and management utilizing trade-off analysis is essential for the sensible use of ecosystem sources (Müller F., 2010).

4.4 Measurement of biodiversity

The quantitative measurement of biodiversity is considered to be essential in understanding how biodiversity contributes to ecosystem functioning, enhances human well-being and the services that are being lost when biodiversity declines. The two main classes, ecological and economic, traditionally employed different concepts for biodiversity measurement. Ecologists weight species according to the relative abundance, while economists argue that in diversity measurement, different species should be weighted differently according to the attributes they possess (Baumgärter, 2005). No single unified approach and measure of biodiversity exists. Therefore it is difficult and quite challenging to identify proper indicators. Ecologists employ different concepts in regard to this measure, like species richness, Shannon-Wiener-entropy, Simpson's index, and the Berger-Parker index, economists in general employ pairwise-dissimilarity between species or weighted attributes of species.

In agricultural systems, intensification and specialization derived by market demands and land use changes and often influenced by subsidies are considered to be influencing factors of the biodiversity loss. In this regard, does the divergence between those who influence the provision of services and those who benefit from this services bring up the issue of externality? Farming activities may provide positive or negative effects which markets failed to internalize and therefore farmers do not pay or get compensated in the case of negative or positive provisions. Ecologists have quantified the species level of biodiversity in two ways: *richness* - the number of species in a given area and *evenness* - how evenly balanced are the abundances of each species, where the abundance of species is the number of individuals present (Armsworth P. R., 2004). A considerable number of environmental economic studies have quantified evenness and richness of diversity using the Shannon-Weiner diversity index (SHDI) e.g. (Pacini C., 2003) (Miettinen, 2004) (Di Falco S., and Perrings C., 2005) (Sipiläinen T., 2008) (Sipiläinen T., and Huhtala A., 2011). In our economical production theory we use *planned diversity,* more specifically diversity within species, as a positive by-product output in addition to yielding marketable outputs such as in the tomato, grape and apple production.

The SHDI adapted from information theory measures both richness and evenness:

(10)

$$SHDI = -\sum_{i=1}^{S}(P_i * lnP_i),$$

Where S is the number of cultivated varieties within a given species, p_i indicates the proportion of the area covered by a specific variety within given species, and *ln* is the natural logarithm. The index equals zero if the farmer is cultivating only one variety of a given species and it increases with the number of cultivated varieties. The index reaches its maximum if the varieties are cultivated in equal shares $P_i = 1/S$ (McGarical K., Marks B. J., 1995). The obtained results of the SHDI for each crop are presented the following graphical summary figures.

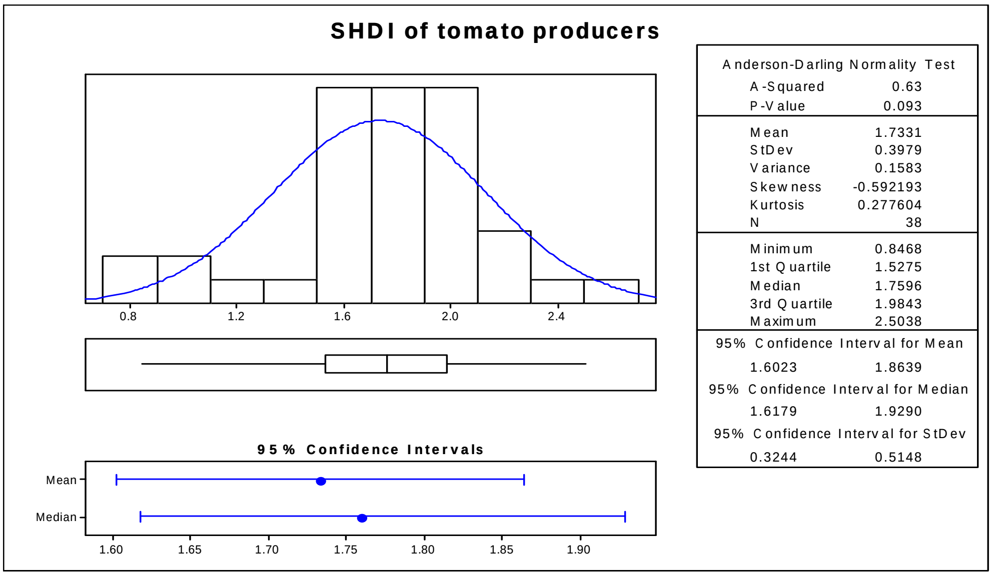


Figure 35: SHDI graphical summary of tomato producers

Note: Minitab software was used to produce a graphical summary of SHDI.

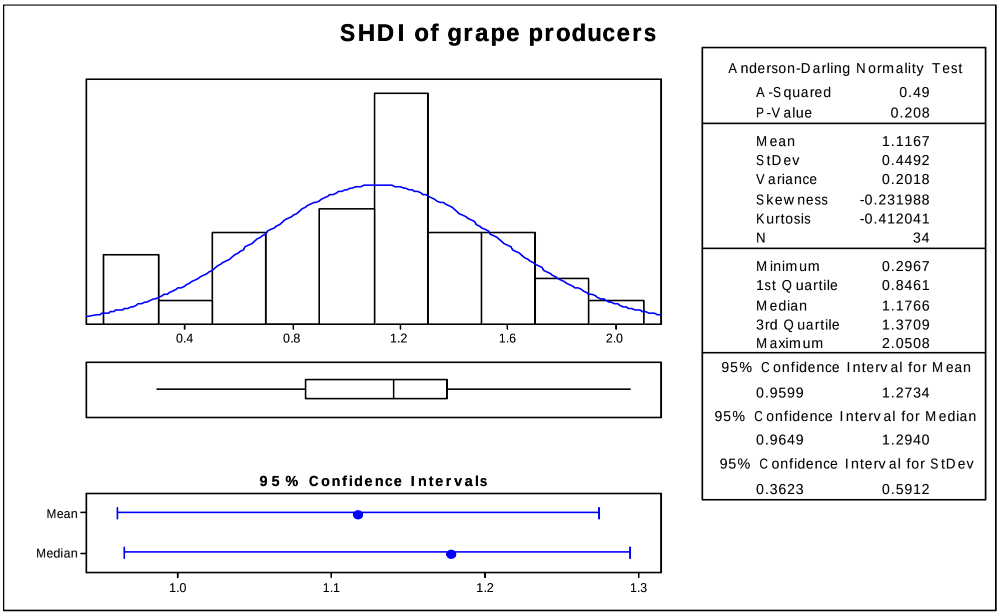


Figure 36: SHDI graphical summary of grape producers

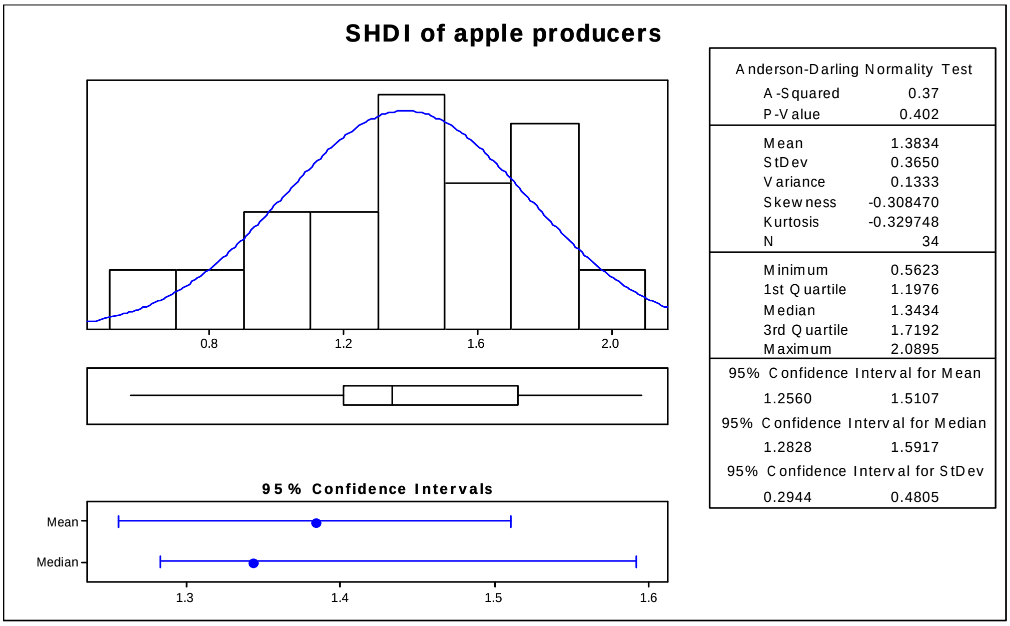


Figure 37: SHDI graphical summary of apple producers

The differences in the mean of SHDI between tomato, grape and apple producers were tested and statistically significant differences at 5% level were observed among the three groups (F-statistic = 21.01, p = 0.000). The SHDI of tomato producers was the highest among the three groups followed by apple and grape producers. Due to many reasons, production systems under perennial trees offer less possibilities to quickly change the compound and distribution of varieties within a given species.

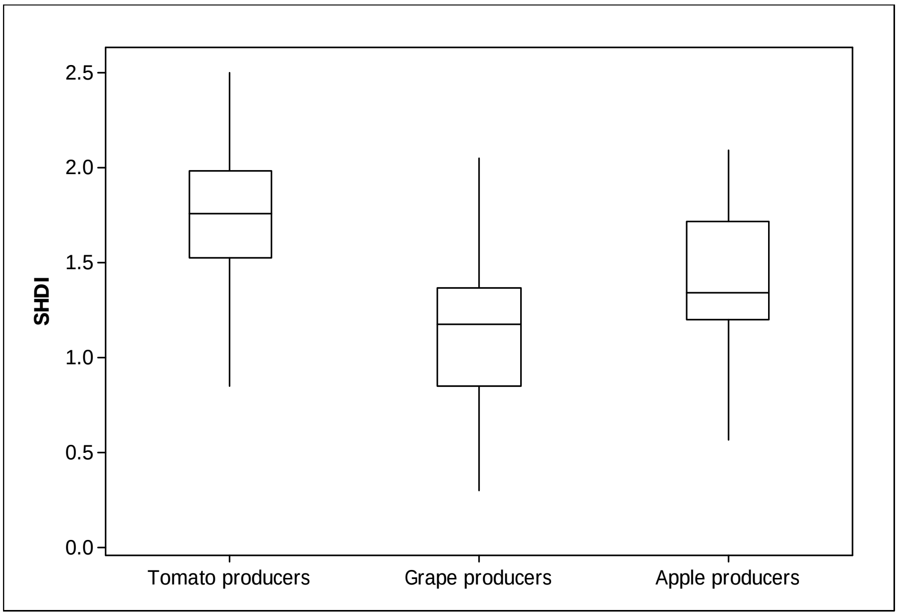


Figure 38: Box-plot of SHDI of tomato, grape and apple farms

5 ECONOMIC EFFICIENCY ANALYSIS

Both input and output are relevant for evaluating the efficiency of DMU (Decision Making Unit). This chapter presents the results of the efficiency measure including technical, cost, revenue and allocative efficiency of the three different crops selected in the study. A set of linear programs are presented and solved for all types of the efficiency estimations. Non-parametric method DEA input and output oriented approaches were used to analyze the efficiency estimates of the farms oriented towards tomato, grape and apple production. The obtained efficiency scores from DEA analysis were further examined using truncated regression analysis to reveal the relationships and determine how the variation of the efficiency scores can be explained by factors describing farm characteristics.

5.1 Efficiency estimation

5.1.1 Technical efficiency estimation

Input oriented approach: Using the DEA input oriented model specification and assuming that all farms are operating at an optimal scale, accounting for Constant Returns to Scale (CRS) situation as defined by (Charnes A. C., 1978) and (Coelli T. P., 2005), the technical efficiency scores for a given farm *i* is obtained by the following linear program (LP) problem:

(11)

$Min_{\theta,\lambda}\ \theta,$

$Subject\ to\quad -q_i + Q_\lambda\ \geq 0,$

$\theta x_i - X\lambda \geq 0,$

$\lambda\ \geq 0,$

where I farms with K inputs and M outputs, presented by the vectors x_i - K x 1 vector of inputs of the i-th farm; q_i is a M x 1 vector of outputs of i-th farm; X is a K x I input matrix; Q is a M x I output matrix; θ is a scalar and λ is an I x 1 vector of constraints.

The aim of the input oriented model is to minimize the input vector x_i while satisfying at least the given output levels. By virtue of the constraints, the optimal objective value of the scalar θ is at most 1, meaning that the DMU is efficient if θ=1, otherwise the DMU is inefficient. The input oriented model under CRS assumes that every increase in all inputs will result in a proportional increase of the output. At CRS all farms are assumed to operate at an optimal scale. Results of the Technical Efficiency (TE) measures under CRS specification will be confounded by Scale Efficiency (SE), if not all farms are operating at an optimal scale. Therefore, calculation of the TE scores under Variable Returns to Scale (VRS) assumption permits TE measures free of these SE effects.

At VRS model as used by (Banker RD., 1984), additional constraint is added to the LP problem, where $N1'\lambda = 1$ replaces the constraint $\lambda \geq 0$. This approach shapes a convex hull of intersecting facets which envelops data more tightly than the CRS conical hull and as a result the technical efficiency scores are greater or equal to those calculated using the CRS model (Coelli T. P., 2005). The technical efficiency scores using VRS model are expressed in the following LP problem:

(12)

$Min_{\theta,\lambda}\ \theta,$

$Subject\ to\quad -q_i + Q_\lambda \geq 0,$

$\theta x_i - X\lambda \geq 0,$

$N1'\lambda = 1,$

$\lambda \geq 0,$

Where N1 is a new matrix *I* x *1* vector of ones. The VRS model assumes that an increase of inputs will not proportionally increase the output level.

If there is a difference in the efficiency scores obtained under two alternatives of the returns to scale (CRS and VRS), it indicates the presence of the scale inefficiency. In the TE measures both input and output oriented CRS and VRS models were performed. As there were differences in the obtained efficiency scores under the two different assumptions, it reveals that farms are not operating at an optimal scale. Taking this into a consideration, Scale Efficiency (SE) is estimated by the following ratio expressed below (Färe & Roos, 1998):

(13)

$$SE(x,q) = \frac{d_i(x,q|VRS)}{d_i(x,q|CRS} = \frac{TE_{CRS}}{TE_{VRS}}$$

Where x is input vector, q is output vector, TE_{CRS} is technical efficiency of a farm *i* under constant returns to scale assumption and TE_{VRS} is technical efficiency under variable returns to scale.

In addition, efficiency scores under the assumption of Non-Increasing Returns to Scale (NIRS) are performed to see if the inefficiency scale is due to increasing returns to scale (IRS) (too small farms) or decreasing returns to scale (DRS) (too big farms). At NIRS the convexity constraint $N1'\lambda = 1$ is modified to $N1'\lambda \leq 1$ and the NIRS model is computed following the LP presented below (Coelli T., 2002):

(14)

$Min_{\theta,\lambda}\, \theta,$

$Subject\ to \quad -q_i + Q_\lambda \geq 0,$

$\theta x_i - X\lambda \geq 0,$

$N1'\lambda \leq 1,$

$\lambda \ \geq 0,$

Output oriented approach: As previously mentioned both approaches are important in efficiency measure, hence in addition to the input oriented model, output oriented TE measure is performed for the three types of crops. Regardless of the orientation chosen, the TE scores are identical under CRS assumption, therefore only an output-oriented model under the assumption of VRS was calculated by solving the following LP problem (Coelli T. P., 2005):

(15)

$Max_{\theta,\lambda}\, \theta,$

$Subject\ to \quad -\theta q_i + Q_\lambda \ \geq 0,$

$x_i - X\lambda \geq 0,$

$N1'\lambda = 1,$

$\lambda \ \geq 0,$

where $1 \leq \theta < \infty$, and $\theta - 1$ is the proportional increase in outputs that could be achieved by the i-th farm, given fixed inputs quantities.

5.1.2 Cost, revenue and allocative efficiency estimation

Input oriented approach: As input and output prices were available and behavioral assumption like cost minimization or revenue maximization were made, the farm performance was estimated by incorporating this information into the efficiency measurement. For the case of VRS cost minimization, the input oriented DEA is conducted following the LP solution (Coelli T. P., 2005):

(16)

$Min_{\lambda,xi*}\, w_i'\, x_i^*$

$Subject\ to \quad -q_i + Q_\lambda \geq 0,$

$x_i^* - X\lambda \geq 0,$

$N\lambda = 1,$

$\lambda \ \geq 0,$

where w_i represents the vector of input price in the farm i, x_i* is the cost-minimising vector of input quantity in the farm i, given the input price w_i and the output level y_i. The constraint $N1'\lambda = 1$ ensures the calculation of the minimum total costs for the farm *i* under VRS scale. The Cost Efficiency (CE) for each farm is then calculated using the following ratio:

(17)

$$CE = \frac{\text{wi}'\text{xi}*}{\text{wi}'\text{xi}}$$

where, the numerator $\text{wi}'\text{xi}*$ is the minimum total cost obtained for the farm i and the denominator $\text{wi}'\text{xi}$ is the actual total costs observed in farm i.

The calculation of the allocative efficiency in the input-mix is presented in the equation below:

(18)

$$CAE = CE/TE_{input\text{-}oriented}$$

where CAE is the cost allocative efficiency. The CE is the product of both TE and AE represented as CE = TE*AE (Farrell, 1957).

Output oriented approach: For the case of VRS revenue maximization, the following LP problem was solved:

(19)

$$Max_{\lambda, y_{i^*}} \; p_i' \, q_i^*,$$

$$Subject\ to - q_i^* + Q_\lambda \; \geq 0,$$

$$x_i - X\lambda \geq 0,$$

$$N1'\lambda = 1,$$

$$\lambda \; \geq 0,$$

where p_i is a vector of output prices in the farm i, q_i^* is the revenue maximizing vector of output quantities for farm *i* given the output prices p_i and the input levels x_i.

The overall revenue efficiency (RE) is calculated as the ratio of observed revenue to the maximum revenue for the farm *i* (Coelli T. P., 2005).

(20)

$$RE = \frac{\mathrm{pi'qi}}{p_i' \, q_i^*}$$

Revenue allocative efficiency in output-mix can be calculated as ratio of the RE and output oriented TE of the farm i.

(21)

$$RAE = RE/TE_{output\text{-}oriented}$$

Note: Performance Improvement Management DEA (PIM-DEA) software was used to obtain scores of TE, SE, CE, CAE, RE and RAE efficiency scores.

5.2 Efficiency analysis

5.2.1 Technical efficiency of tomato farms

The data set used in the technical efficiency estimation is a combination of common inputs used in the tomato production process. Technical efficiency scores were obtained using tomato saplings, fertilizer (artificial, crystal and manure), packing, machinery and labor as inputs and tomato yields as output. In practice, very often farmers are not able to report all required input or output variables. Descriptive statistics of variables used in the technical efficiency estimation for tomato farms are presented in the table 33.

Table 33: Descriptive statistics of the input and output variables for TE estimation of tomato farms

Variable	Unit	Mean	SD	Minimum	Maximum
Inputs					
Saplings	Saplings/ha	30,755.07	6,602.09	20,000.00	42,553.19
Artificial fertilizer	Kg/ha	1,137.71	782.64	199.00	4,000.00
Manure	Kg/ha	65,112.54	45,174.87	3,999.00	204,255.32
Crystalline fertilizer	Kg/ha	761.97	1,024.30	61.50	6,153.85
Packing	Boxes/ha	25,280.26	9,627.56	1,050.00	42,857.14
Machinery	Fuel/ha	1,419.99	809.98	239.17	3,570.00
Labor	Working days/ha	569.68	229.40	280.00	1,244.00
Output					
Tomato yield	Kg/ha	144,462.41	37,320.62	77,777.78	245,000.00

Note: SD-standard deviation.

The share of tomato farms operating under input-oriented variable returns to scale and fully TE is 67%, which is considerably higher than constant returns to scale model 47%.

Table 34: Average input oriented technical efficiency scores for tomato farms

Efficiency	Mean	SD	Minimum	Maximum
TE_{CRS}	0.889	0.135	0.583	1
TE_{VRS}	0.957	0.075	0.731	1

The average $TE_{Input\text{-}Oriented}$ score for tomato farms under the assumption of VRS was estimated to be 0.957, which indicates that on average tomato producers could further reduce the level of inputs used and still remain at the same level of output produced. The quantity of inputs used by technically inefficient farms was significantly higher compared to those $TE_{Input\text{-}Oriented}$. This applies particular to artificial fertilizer (46%), manure (13%) and fuel for machinery (12%). As the $TE_{Input\text{-}oriented}$ scores are calculated under two different scenarios CRS and VRS, scale efficiency (SE) is estimated to examine if the tomato farms are operating at optimal scale. The $SE_{Input\text{-}Oriented}$ score ranges from 0.592 up to 1, with an average score of 0.926 showing that tomato farms are operating close to optimal scale. No more than 18 out of 38 tomato farms were operating at fully optimal scale. In addition, efficiency scores under the assumption of non-increasing returns to scale (NIRS) are performed to see if the inefficiency scale is due to increasing returns to scale (IRS) (too small farms) or decreasing returns to scale (DRS) (too big farms). The estimated results under the NIRS scenario show that a majority (18 out of 20) of the tomato farms are operating inefficiently at scale due to being too small.

Given that efficiency scores are too sensitive to measurements and sampling errors, the real efficiency scores may be lower than those obtained. Boostrapping procedure permits valid inference and improves statistical efficiency in the second-stage regression (Simar L., and Wilson W. P., 2007). Simar and Wilson (2007) argue that two-stage approach may be invalid as it does not describe the data-generating process in the model and it suffers from serial correlation of the estimated efficiencies. Simar and Wilson (2007) show that 'truncated regression combined with bootstrapping as a resampling technique best overcomes the unknown serial correlation (Wanke P., 2016). Therefore, bootstrapping for $TE_{Input\text{-}Oriented}$ measures was performed, to encounter such problems by estimating confidence intervals and bias-corrected $TE_{Input\text{-}Oriented}$ scores.

Table 35: Bias-corrected efficiency scores for tomato farms under VRS assumption

Orientation	Bias-corrected efficiency score	Bias-corrected 95% CI†	SD of bias-corrected efficiency score
Input	0.954	0.942-0.958	0.078

Note: CI-confidence interval; † 2000 replications were used for bootstrapping (Simar L., and Wilson W. P., 2007) .

Bias-corrected efficiency scores presented in the table above shows that there is a little more space for performance improvement of the tomato farms. Slacks of the bias-corrected scores were further examined to identify inputs that needs to be reduced disproportionally. This scalar measure deals directly with the input excesses or output shortfalls of the DMU concerned (Tone K., 2001). All inputs used for estimation of the $TE_{Input-Oriented}$ scores except labor were generally used in excess by tomato farms. The table 36 presents descriptive statistics of the slacks for each input used excessively by technically inefficient farms.

Table 36: Descriptive statistics of the input slacks for tomato farms

Variable	Unit	Mean	SD	Minimum	Maximum
Inputs					
Saplings	Saplings/ha	3347.04	5,185.29	201.26	1,1043.57
Artificial fertilizer	Kg/ha	674.75	385.28	223.24	1372.47
Manure	Kg/ha	26,256.89	20894.55	3308.81	61900.66
Crystalline fertilizer	Kg/ha	422.25	262.68	124.12	694.47
Packing	Boxes/ha	3679.81	2435.38	1957.74	5401.89
Machinery	Fuel/ha	628.73	519.38	83.11	1636.56

Note: SD-standard deviation.

Considering slacks for all inputs used by technically inefficient farms, crystalline fertilizer on average was the largest, (expressed as a percentage of the input level used 52.6), followed by artificial fertilizer (43.3%), fuel for machinery (33.2%) and manure (30%). Two other inputs used in the $TE_{Input-oriented}$ estimation were considerably lower with an average share of slack of 11.7% for packaging and 8.8% for tomato saplings.

Choosing the output-oriented approach, study results showed that tomato farms are technically efficient with an average $TE_{Output-oriented}$ score of 0.926 (SD = 0.118). It indicates that on average tomato farms could have increased their output by 7.32%, by improving resource use efficiency given agricultural technology. Only 34.2% of the tomato farms were not fully $TE_{Output-oriented}$, with the minimum efficiency score of 0.654. The 95% confidence intervals of bias-corrected efficiency scores presented in the table below show that tomato producers could have increased output from 7.4 up to 10.3%.

Table 37: Bias-corrected efficiency scores for tomato farms under VRS assumption

Orientation	Bias-corrected efficiency score	Bias-corrected 95% CI†	SD of bias-corrected efficiency score
Output	0.920	0.897-0.926	0.125

Note: CI-confidence interval; † 2000 replications were used for bootstrapping (Simar L., and Wilson W. P., 2007) .

5.2.2 Technical efficiency of grape farms

Taking physical production relationships, in the technical efficiency estimation into account, four different inputs and one output were used to obtain TE scores for grape producers. Both approaches were considered: achievement of the maximum potential output given the amount of inputs used and minimum potential inputs used given the fixed level of output. Table 38 shows the descriptive statistics of inputs and output used in the TE estimation for grape producers.

Table 38: Descriptive statistics of the inputs and output used for TE estimation of the grape farms

Variable	Unit	Mean	SD	Minimum	Maximum
Inputs					
Fertilizer (NPK)	Kg/ha	475.06	324.64	80.00	1,257.14
Machinery	Fuel/ha	236.959	102.445	76.5	586.666
Marketing	Fuel/ha	38.254	34.754	6.451	138.888
Labor	Working days/ha	45.633	17.923	19.166	92.265
Output					
Grape yield	Kg/ha	13,014.95	3,525.98	6,774.194	19,750.0

The share of grape farms being fully efficient was 35.3% under CRS assumption and 58.8% under VRS. The average $TE_{Input\text{-}Oriented}$ score under CRS assumption was 0.834 (SD=0.181) and 0.905 (SD=0.148) for VRS assumption. It can be seen that grape farmers use more inputs than were needed to obtain the same amount of output. On average grape producers could have reduced the quantity of inputs used by a maximum of 16.6% and still gain the same level of output. The average SE score was estimated to be 0.920, indicating that most of the grape producers were operating at relatively high optimal scale. The scale inefficiency was present at 64.7% or 22 out of 34 grape farms. The estimated results under NIRS model showed that scale inefficiency was mainly coming from small holder farms.

Table 39: Bias-corrected efficiency scores for grape farms under VRS assumption

Orientation	Bias-corrected efficiency score	Bias-corrected 95% CI†	SD of bias-corrected efficiency score
Input	0.897	0.871-0.906	0.156

Note: CI-confidence interval; † 2000 replications were used for bootstrapping.

DEA bootstrapping method indicates that the efficiency estimates for grape farms are likely to vary from 0.871 to 0.906, which also illustrates the sensitivity of efficiency estimates to variations in sample composition. The LP solution presented above may not always identify all efficiency. Therefore, after the efficiency scores were obtained, slacks were calculated and examined for the farms being in the best practice frontier. The main intention was to find out the presence of grape farms being weakly efficient and see the possibilities of further reduction of any individual input at different proportion. The calculated slacks showed that there was no chance to further reduce any of the individual inputs as 58.8% of the farms being fully efficient had zero slacks. Nine out of fourteen or 64% of the inefficient grape farms were using fertilizer NPK in excessive amounts.

In the output-oriented approach, the average $TE_{Output\text{-}oriented}$ score under VRS model was estimated to be 0.906 (SD = 0.144) with a minimum $TE_{Output\text{-}oriented}$ score of 0.512. This result shows that grape producers on average could have increased the level of output by 9.4% and still keep the same level of inputs used.

Table 40: Bias-corrected efficiency scores for grape farms under VRS assumption

Orientation	Bias-corrected efficiency score	Bias-corrected 95% CI†	SD of bias-corrected efficiency score
Output	0.898	0.877-0.906	0.151

Note: CI-confidence interval; † 2000 replications were used for bootstrapping.

No difference is observed between input-oriented and output-oriented approaches of the TE scores, suggesting that farms do not vary in terms of production assortment and quality.

5.2.3 Technical efficiency of apple farms

The estimated TE scores of the apple farms were obtained using four different inputs and one output. Both input and output oriented models under CRS and VRS assumptions were performed. Descriptive statistics of the inputs and output used in the estimation of TE at apple farms is presented in the following table.

Table 41: Descriptive statistics of the inputs and output used for TE estimation of the apple farms

Variable	Unit	Mean	SD	Minimum	Maximum
Inputs					
Fertilizer (NPK)	Kg/ha	744.59	406.14	200.00	1,250.00
Machinery	Fuel/ha	204.40	231.86	23.14	958.33
Marketing	Boxes/ha	1,399.70	1,042.13	4,250.00	220.00
Labor	Working days/ha	61.22	36.14	17.26	154.00
Output					
Apple yield	Kg/ha	54,339	38,795.60	10,000	170,000

The share of apple farms being technically efficient under CRS assumption was 23.52 %. The share of technically efficient farms was shown to be higher under VRS assumption 41.17%. The mean of $TE_{\text{Input-oriented}}$ score under CRS was 0.695 (SD = 0.242) and ranges from 0.254 and 1.00. The average of $TE_{\text{Input-oriented}}$ under VRS was estimated to be 0.876 (SD = 0.163) with the range of 0.428 and 1.00. This result indicates that apple producers on average could reduce the amount of inputs used by 12.38% and keep the same level of the output produced. The mean of SE is 0.799 (SD = 0.22) with the range of 0.254 to 1.000. The percentage of farms operating at an optimal scale was 25.8, for the majority of the farms 51.6% the scale inefficiency was due to being too small. The percentage of the farms being scale inefficient due to being too big in size was smaller (22.5%).

Table 42: Bias-corrected efficiency scores for apple farms under VRS assumption

Orientation	Bias-corrected efficiency score	Bias-corrected 95% CI†	SD of bias-corrected efficiency score
Input	0.862	0.826-0.876	0.172

Note: CI-confidence interval; † 2000 replications were used for bootstrapping.

Slacks were calculated and examined further for the farms being in the best practice frontier. The number of total farms being technically efficient in VRS input oriented model was 11 and out of them 2 were found to be weakly technically efficient having slacks in the same inputs (labor and machinery). The table below presents descriptive statistics of the slacks found at each input used excessively by the technically inefficient farms.

Table 43: Descriptive statistics of the input slacks at apple farms

Variable	Unit	Mean	SD	Minimum	Maximum
Inputs					
Fertilizer (NPK)	Kg/ha	195.58	98.32	64.55	291.92
Machinery	Fuel/ha	160.69	241.11	7.67	699.23
Marketing	Boxes/ha	312.99	434.53	5.73	620.25
Labor	Working days/ha	17.97	13.83	1.33	43.02

The average TE score of the output oriented VRS model was estimated to be 0.848 (SD = 0.19) with a minimum efficiency score of 0.312 to maximum 1.000. This result revealed that apple producers on average could have further increased yields given the quantity of inputs used.

Table 44: Bias-corrected efficiency scores for apple farms under VRS assumption

Orientation	Bias-corrected efficiency score	Bias-corrected 95% CI†	SD of bias-corrected efficiency score
Output	0.832	0.791-0.849	0.201

Note: CI-confidence interval; † 2000 replications were used for bootstrapping.

5.2.4 Cost and revenue efficiency of tomato farms

In the analysis of cost efficiency (CE) estimation, the efficiency scores were obtained by solving a cost-minimizing LP model. This means the DEA model performed here is input-oriented, assuming that farmers produce tomato at minimum cost level and still attain the same level of output. Price information is added to each input used in the CE estimation. The table below presents descriptive statistics of all inputs and output used in the CE and RE estimation.

Table 45: Descriptive statistics of the input and output variables for CE and RE estimation of tomato farms

Variable	Unit	Mean	SD	Minimum	Maximum
Inputs					
Saplings	EUR/ha	3,947.63	1,058.97	2,418.98	7,500.00
Fertilizers	EUR/ha	2,464.82	1,666.06	362.5	10,769.23
Irrigation	EUR/ha	384.32	353.31	53.00	1,800.00
Marketing	EUR/ha	9,311.95	2,946.02	2,167.90	16,000.00
Machinery	EUR/ha	1,305.37	730.13	421.00	5,030.74
Labor	EUR/ha	6,921.69	3,096.53	3,700.00	17,074.47
Output					
Tomato sales	EUR/ha	36,771.25	9,299.75	19,444.44	61,250.00

Note: SD-standard deviation.

Table 46: Descriptive statistics of the cost efficiency scores of tomato farms

Efficiency	Mean	SD	Minimum	Maximum
CE_{CRS}	0.681	0.122	0.493	1
CE_{VRS}	0.781	0.119	0.589	1

Note: CE-cost efficiency; VRS-variable returns to scale; CRS-constant returns to scale; SD-standard deviation.

The mean CE score under VRS assumption is 0.781, which implies that given the input prices, tomato farmers could minimize total costs by 31.9%, without worsening the current level of output. The share of CE farms under VRS is relatively small, only 10% or 4 out of 38 tomato farms were fully costly efficient. Comparing input by input, CE farms were having in general lower input costs than the mean input cost of the total sample.

Table 47: Descriptive statistics of allocative (input-mix) efficiency scores of tomato farms

Efficiency	Mean	SD	Minimum	Maximum
CAE_{CRS}	0.771	0.108	0.570	1
CAE_{VRS}	0.816	0.108	0.589	1

Note: CAE- cost allocative efficiency; VRS-variable returns to scale; CRS-constant returns to scale; SD-standard deviation.

The mean of cost allocative (input-mix) efficiency (CAE) score under VRS assumption across farms is 0.816, indicating that there is sufficient space (18.3%) for performance improvement through the use of inputs in optimal proportions, given their prices and the production technology. The correlation coefficient of CE_{VRS} scores with AE_{VRS} is stronger (0.847, p=0.000), compared to $TE_{Input\text{-}OrientedVRS}$ scores (0.455, p=0.004), demonstrating that improvements in $AE_{Input\text{-}Mix}$ would have higher impact on CE improvements. The table below presents the distribution of the input-oriented technical, cost and cost allocative efficiency scores for 38 tomato farms.

Table 48: Distribution of the input-oriented efficiency scores of tomato farms

Efficiency range	TE_{VRS} no. of farms	%	CE_{VRS} no. of farms	%	CAE_{VRS} no. of farms	%
=1	25	65.7	4	10.5	4	10.5
>0.9 < 1.0	5	13.1	2	5.2	4	10.5
>0.8 < 0.9	6	15.7	10	26.3	13	34.2
>0.7 < 0.8	2	5.2	8	21.0	10	26.3
>0.6 < 0.7	0	0	12	31.5	6	15.7
>0.5 < 0.6	0	0	2	5.2	1	2.6
<0.5	0	0	0	0	0	0
	38	100	38	100	38	100

The efficiency scores were further investigated in regard to the size-efficiency relationships. The obtained correlation coefficients did not show significant relationships between farm size and $TE_{Input\text{-}oriented}$, CE and CAE efficiency scores.

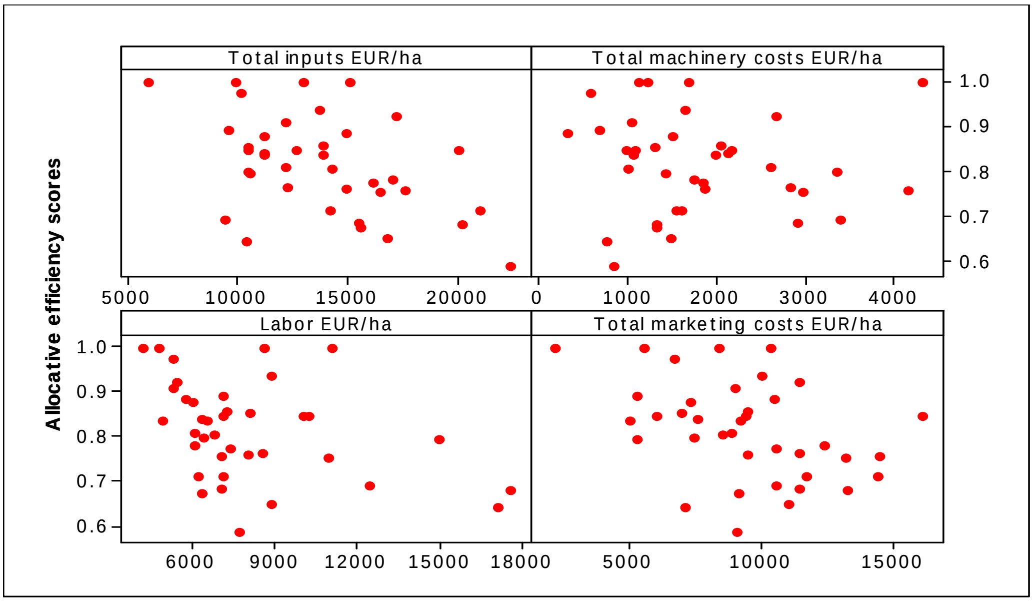


Figure 39: Scatter-plot of the CAE scores and inputs used by tomato farms

The revenue efficiency was estimated from the perspective of output based models. The method sought to identify inefficiency of the tomato farms as proportional increase in output production, by holding inputs fixed.

Table 49: Descriptive statistics of the revenue efficiency scores of tomato farms

Efficiency	Mean	SD	Minimum	Maximum
RE_{CRS}	0.863	0.137	0.598	1
RE_{VRS}	0.926	0.124	0.603	1

Note: RE-revenue efficiency; VRS-variable returns to scale; CRS-constant returns to scale; SD-standard deviation.

The mean of RE score under VRS assumption is 0.926, indicating that on average tomato producers could maximize their revenues by 7.4%, given the input costs. On average, tomato farms have a tendency to be more technical efficient followed by scale, revenue, cost allocative having the lowest average on cost efficiency.

Table 50: Distribution of the output-oriented efficiency scores of tomato farms

Efficiency range	TE_{VRS} no. of farms	%	RE_{VRS} no. of farms	%
=1	25	65.78	26	68.42
>0.9 < 1.0	3	7.89	2	5.26
>0.8 < 0.9	1	2.63	2	5.26
>0.7 < 0.8	6	15.78	4	10.52
>0.6 < 0.7	3	7.89	4	10.52
>0.5 < 0.6	0	0	0	0
<0.5	0	0	0	0
Total	38	100	38	100

It can be seen from the distribution of TE_{VRS} input and output oriented efficiency scores that there is no significant difference among the efficiency ranges. In both approaches, 25 farms appeared to be fully technically efficient, with slight changes in other efficiency classes. The distribution of farms completely changes when cost-minimization and revenue-maximization objective functions were imposed. In this regard, tomato farmers were performing perfectly in marketing their product. The situation is notably different when CE_{VRS} was estimated, where only 4 or 10.5% of the farms belonged to the fully cost efficient class. Taking into a consideration that many of the farms were full TE and RE but few of them CE, it demonstrates that input prices were playing an important role on farm performance when cost-minimization objective function was considered.

5.2.5 Cost and revenue efficiency of grape farms

Similar to the section above, cost minimization and revenue maximization LP-s for grape producers were solved, by adding up prices to the inputs used and output produced. Variables included in the CE and RE analysis are presented in table 51.

Table 51: Descriptive statistics of the input and output variables for CE and RE estimation of grape farms

Variable	Unit	Mean	SD	Minimum	Maximum
Inputs					
Fertilizer (NPK)	EUR/ha	203.05	155.82	32.73	666.67
Machinery	EUR/ha	290.87	128.13	91.80	704.00
Marketing	EUR/ha	93.93	68.942	22.00	300.00
Labor	EUR/ha	683.34	266.84	267.50	1,365.00
Output					
Grape sales	EUR/ha	4,113.31	1,435.87	1,913.33	7,258.00

Note: SD-standard deviation.

Table 52: Descriptive statistics of the cost efficiency scores of grape farms

Efficiency	Mean	SD	Minimum	Maximum
CE_{CRS}	0.424	0.156	0.237	1
CE_{VRS}	0.689	0.189	0.334	1

Note: CE-cost efficiency; VRS-variable returns to scale; CRS-constant returns to scale; SD-standard deviation.

The obtained CE_{VRS} scores, show that on average, grape farmers could reduce total costs by 31% without any reductions in the output level. The share of grape farms operating on the production frontier and having zero slacks was 8.8%.

Table 53: Descriptive statistics of allocative (input-mix) efficiency scores of grape farms

Efficiency	Mean	SD	Minimum	Maximum
CAE_{CRS}	0.519	0.184	0.270	1
CAE_{VRS}	0.766	0.178	0.334	1

Note: CAE- cost allocative efficiency; VRS-variable returns to scale; CRS-constant returns to scale; SD-standard deviation.

This cost inefficiency is primarily due to cost allocative inefficiency. The correlation coefficient of CE_{VRS} scores and CAE_{VRS} (r = 0.74) was significantly stronger compared to the CE_{VRS} and TE_{VRS} correlation (r = 0.50), suggesting that improvements in CAE would have greater impact on CE improvements.

Table 54: Distribution of the input-oriented efficiency scores of grape farms

Efficiency range	TE_{VRS} no. of farms	%	CE_{VRS} no. of farms	%	CAE_{VRS} no. of farms	%
=1	20	58.8	3	8.8	4	11.7
>0.9 < 1.0	3	8.8	2	5.8	5	14.7
>0.8 < 0.9	4	11.7	6	17.6	7	20.5
>0.7 < 0.8	3	8.8	6	17.6	5	14.7
>0.6 < 0.7	2	5.8	4	11.7	6	17.6
>0.5 < 0.6	2	5.8	6	17.6	4	11.7
<0.5	0	0	7	20.5	3	8.8
	34	100	34	100	34	100

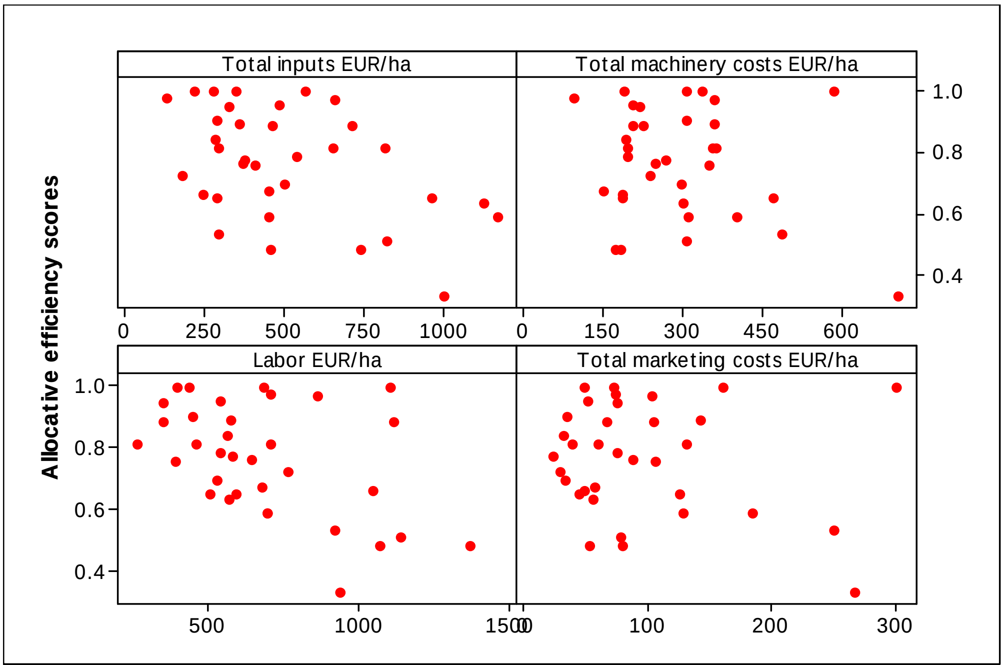


Figure 40: Scatter-plot of the $CAE_{Input-Mix}$ scores and inputs used by grape farms

Table 55: Descriptive statistics of the revenue efficiency scores of grape farms

Efficiency	Mean	SD	Minimum	Maximum
RE_{CRS}	0.693	0.208	0.301	1
RE_{VRS}	0.840	0.193	0.429	1

Note: RE-revenue efficiency; VRS-variable returns to scale; CRS-constant returns to scale; SD-standard deviation.

The mean RE score under VRS assumption is 0.840. This reveals that grape producers on average could increase their revenues by 16% and still use the same amounts of inputs. Put in order, the estimated efficiency scores indicate that grape producers tend to be very scale efficient, followed by technical, revenue and cost allocative efficient. On average, the cost efficiency was the lowest out of all and this could be explained with the variation of market prices between less attractive vine varieties and those which are more attractive. Farmers cultivating vine varieties less attractive for vine processors had significantly lower price per unit of output and less revenue which on the other side increased the costs per unit of output and also decreased the average cost efficiency score.

Table 56: Distribution of the output-oriented efficiency scores of grape farms

Efficiency range	TE_{VRS} no. of farms	%	RE_{VRS} no. of farms	%
=1	20	58.82	16	47.05
>0.9 < 1.0	3	8.82	3	8.82
>0.8 < 0.9	3	8.82	2	5.88
>0.7 < 0.8	4	11.76	4	11.76
>0.6 < 0.7	2	5.88	4	11.76
>0.5 < 0.6	2	5.88	2	5.88
<0.5	0	0	3	8.82
Total	34	100	34	100

An almost similar distribution is shown between TE input and output scores among different efficiency classes. In total 20 out of 34 farms were fully technical efficient in input and output oriented approach. The distribution of the efficiency scores changes slightly for the revenue maximization approach. A smaller number of farms belongs to the range fully efficient and movement of the farms towards lower RE efficiency scores is mainly due to price variations among the grape varieties farmers cultivate. The cost-minimization approach presents a different situation, where only 3 out of 34 farms belongs to the full cost efficient class. As for tomato producers, input costs are a determinant factor for the farm performance level.

5.2.6 Cost and revenue efficiency of apple farms

In the cost efficiency measure, the objective function was to minimize the costs of the inputs used given the same level of output. Price information was added to each input used in the TE measure. The table 57 presents descriptive statistics of the costs of all inputs and output used in the CE and RE estimation.

Table 57: Descriptive statistics of the input and output variables costs of apple farms

Variable	Unit	Mean	SD	Minimum	Maximum
Inputs					
Fertilizer (NPK)	EUR/ha	349.04	239.49	60	976.56
Machinery	EUR/ha	245.28	278.23	27.77	1,150
Marketing	EUR/ha	663.87	517.96	110	2,125
Labor	EUR/ha	895.84	505.28	258.9	1,970
Output					
Apple sales	EUR/ha	1,8061.56	1,1853.57	3,300	53,833.33

Note: SD-standard deviation.

The overall mean of the CE score in VRS model was estimated to be 0.613 (SD = 0.241) with the minimum range of 0.211. On average, apple producers could have decreased the input costs by 38.7% and still achieve the same level of output. The share of apple farms being fully cost efficient with zero slacks was 9.6%. The average CAE score in the VRS model was 0.697 (SD = 0.230) and the minimum score was 0.214, showing that apple producers on average could have improved their performance with a better mix of inputs and the prices.

Table 58: Distribution of the input-oriented efficiency scores of apple farms

Efficiency range	TE_{VRS} no. of farms	%	CE_{VRS} no. of farms	%	CAE_{VRS} no. of farms	%
=1	14	45.16	3	9.67	3	9.67
>0.9 < 1.0	3	9.67	0	0.00	2	6.45
>0.8 < 0.9	5	16.12	5	16.12	10	32.25
>0.7 < 0.8	5	16.12	4	12.90	4	12.90
>0.6 < 0.7	2	6.45	6	19.35	1	3.22
>0.5 < 0.6	0	0.00	4	12.90	4	12.90
<0.5	2	6.45	9	29.03	7	22.58
	31	100	31	100	31	100

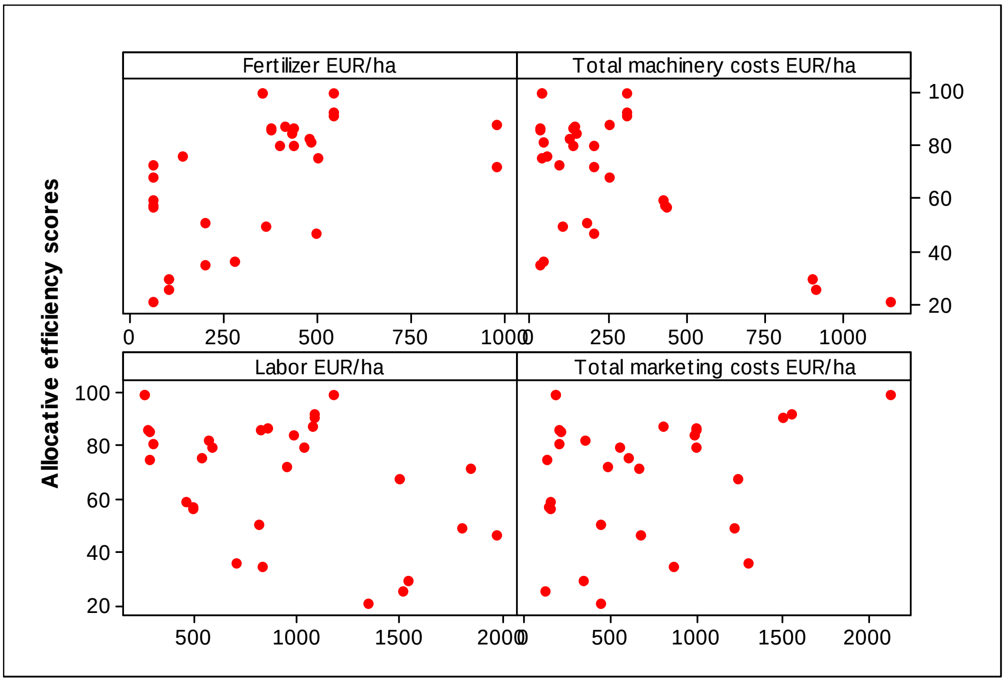


Figure 41: Scatter-plot of the CAE scores and inputs used by apple farms

The average of the RE score in the VRS model was 0.848 (SD = 0.190) with a minimum of 0.321. Based on the obtained results we could say that apple producers can improve their farm performance through further increase of revenues given the input costs. The share of farms being fully revenue efficient was 45.16%. Looking at all estimated efficiency scores, it is shown that apple producers on average are performing relatively well in terms of technical efficiency which was the highest on average, followed by revenue efficiency and scale efficiency. The average cost efficiency score was the lowest, indicating high variation of market input output prices among the farmers.

5.3 Regression analysis

5.3.1 Regression analysis of tomato farms

Regression analysis was performed to find out how the variation of the efficiency scores could be explained by other farm characteristics. The truncated regression model is presented in the following function:

(22)

assume that $\mu_i = x_i' \beta$ is the deterministic part of the classical regression model. Then

$y_i = x_i' \beta + \varepsilon_i$, *i=1,....,n*

where

$\varepsilon_i \mid x_i \sim N\,[0, \sigma^2]$,

so that

$y_i \mid x_i \sim N\,[x_i' \beta, \sigma^2]$.

The interest here is on the distribution of y_i *given that* y_i *is greater than the truncation point a. The conditional mean is therefore a nonlinear function of a, σ, x, β.* In the given model y_i

represents the efficiency score of the farm i; β_n are unknown parameters to be estimated; x_{in}=1 to n are explanatory variables for the farm; and ε_i is an error term which is independently and normally distributed with mean 0 and constant variance σ^2 (Greene H.W., 2003). Truncated regression analysis were performed using EViews (version 9) software.

The variables used to explain the variation of the efficiency scores were: 1. farmer's age (in years); 2. education (in years); 3. household size (number of the family members living regularly at farm house); 4. employment (number of the family members working regularly at farm); 5. number of income sources; 6.experience in agriculture (number of years active in farming); 7. farm size (in ha); 8. number of parcels; and 9. number of cultivated crops. After testing, redundant explanatory variables were omitted from the initial model. Regression coefficients of the best fitted model for tomato farms are presented in the table 59.

Table 59: Regression results of the efficiency scores and other tomato farm characteristics

Independent variables	Coefficient TE_{VRS}	Coefficient CE_{VRS}	Coefficient CAE_{VRS}	SE
Household size	0.004266 *	0.007252 *	-	-
	(0.002107)	*(0.003132)*		
Number of income sources	0.000536	-0.001093	-0.001389	0.025762
	(0.000752)	*(0.001100)*	*(0.001038)*	(0.021644)
Number of parcels	-0.005013	-	-	-
	(0.003727)			
Farmer's age	-	0.002800	0.002751	-0.002807
		(0.002373)	*(0.002247)*	*(0.002210)*
Number of cultivated crops	-	-0.016443 *	-0.016044	-
		(0.007377)	*(0.009240)*	
Employment	-	-	-	-0.012816
				(0.007057)
Farm size	-	-	0.014255	0.028582 *
			(0.012501)	*(0.011803)*
Experience	-	-	-	-0.001691
				(0.001472)
Constant	0.931762	0.692866	0.768795	1.033831
	(0.030978)	*(0.120397)*	*(0.111843)*	*(0.101204)*
Σ	0.078780	0.116465	0.110163	0.102695
Log-likelihood	44.20566	30.32861	32.38696	34.74596

Note: TE, technical efficiency; CE, cost efficiency; CAE, allocative efficiency; SE, Scale efficiency; VRS, variable returns to scale. Asterisks *, represent statistical significance at the 5% level. Number in parenthesis and italics are standard errors.

The obtained coefficient with truncated regression analysis shows that household size was positively correlated and significantly determined TE_{VRS} and CE_{VRS} scores of the tomato farms. The TE_{VRS} scores were negatively correlated with the number of parcels in the farm, indicating that the smaller the number of parcels, the higher TE_{VRS} scores were for the farm. A significant negative effect on technical efficiency captured by Simpson's index and the number of plots was also found in the study by Sauer J., et al., 2014 and Di Falco et al., 2010. The number of income sources of the farm was positively correlated with the TE_{VRS} scores, even though this has not been proven to be statistically significant. Besides household size, number of cultivated crops on the farm had significant but negative impact on the CE_{VRS} scores. This indicates that diversified farms tend to have greater economic inefficiency than those specialized in smaller number of cultivated crops. The other remaining factors of the CE_{VRS} model had no significant effects on the CE scores variation. Farm size in terms of cultivated ha is the only explanatory variable that has a significant positive effect on the SE scores. Showing that farm size significantly determines the scale operation of the farm. This was also demonstrated by the estimated efficiency scores under NIRS scenario.

5.3.2 Regression analysis of grape farms

Using the method described in the section above, technical, cost-allocative and scale efficiency scores of the grape farms were related to factors that describe other farm characteristics. Finding out factors that could explain the differences in efficiency scores among farms is of major interest to farmers and other stakeholders as by improving these factors opportunities to improve farm performance will be better. In the truncated regression model (equation 22) technical, cost-allocative and scale efficiency scores were related to: 1. farmer's age (in years); 2. farmer's education (in years); 3. household size (number of the family members living regularly at farm house); 4. employment (number of the family members working regularly at farm); 5.experience in agriculture (number of years active in farming); 6. farm size (in ha); 7. number of parcels; and 8. number of cultivated crops. A coefficient diagnostics test was performed and redundant variables were omitted from the initial model. Regression coefficients of the best fitted model are presented in the table 60.

Table 60: Regression results of the TE, CAE and SE scores and other grape farm characteristics

Independent variables	Coefficient TE_{VRS}	Coefficient CAE_{VRS}	SE
Household size	0.011860*	-	-
	(0.005279)		
Farmer's age	-	0.004970	-0.003567
		(0.004299)	*(0.002718)*
Education	0.018711*	-0.023694*	0.020392**
	(0.007377)	*(0.011241)*	*(0.007205)*
Number of parcels	-	-	-
Number of cultivated crops	-0.018068	-0.018099	0.024886*
	(0.012677)	*(0.016113)*	*(0.010045)*
Employment	-0.024317	0.016954	-
	(0.015315)	*(0.017785)*	
Farm size	0.013459	-	-
	(0.007503)		
Experience	-	-0.002471	0.004941
		(0.004193)	*(0.002659)*
Constant	0.643859	0.886039	0.606183
	(0.113482)	*(0.207073)*	*(0.127409)*
Σ	0.127892	0.176793	0.111353
Log-likelihood	25.59841	14.58928	29.68857

Note: TE, technical efficiency; CAE, allocative efficiency; SE, Scale efficiency; VRS, variable returns to scale. Asterisks *, represent statistical significance at the 5% and ** 1% level. Number in parenthesis and italics are standard errors. None of the independent variables included in the censored regression model were statistically significant in explaining the variation of the CE scores.

The level at which grape farmers were educated was positively correlated and significantly determined the variation of technical and scale efficiency scores. Farmer's education has significant impact on cost-allocative efficiency scores but it was shown to be negatively correlated. This could be explained by the education profile of the grape producers. Most of those who are considered to be better educated (high school or university) graduated in agronomy, meaning that they know much more about cultivation of grapes and production techniques but a majority does not keep records of their expenses and revenues. As a result, they are not able to conduct more specialized duties like calculation of the production costs or their profit margins, which is essential for farm performance improvement and making better investments decisions. Household size was positively correlated and appears to have significant impact on technical efficiency suggesting that bigger families are more efficient in the use of resources. The number of cultivated crops in a farm was shown to have a positive and significant effect on farm scale efficiency, indicating that farmers who diversify their crop portfolio more do perform on a more optimal scale.

5.3.3 Regression analysis of apple farms

The technical, cost, and cost-allocative efficiency scores were regressed to the same variables as in the previous regression models with tomato and grape producers. Initial regression model was simplified through backward elimination of the redundant variables and the best fitted models and estimated coefficients for three types of the estimated efficiency (TE, CE and CAE) are presented in the following table.

Finding out factors that could explain the differences in efficiency scores among farms are of major interest to farmers and other stakeholders as by improving these factors, opportunities to improve farm performance will be better. In the censored regression model (see equation 13) technical, cost-allocative and scale efficiency scores were related to: 1. farmer's age (in years); 2. farmer's education (in years); 3. household size (number of the family members living regularly at farm house); 4. employment (number of the family members working regularly at farm); 5. experience in agriculture (number of years active in farming); 6. farm size (in ha); 7. number of parcels; and 8. number of cultivated crops. Coefficient diagnostics test was performed and redundant variables were omitted from the initial model. Regression coefficients of the best fitted model are presented in the table 61.

Table 61: Regression results of the efficiency scores and other apple farm characteristics

Independent variables	Coefficient TE_{VRS}	Coefficient CE_{VRS}	Coefficient CAE_{VRS}	SE
Household size	-	-0.053454*	-0.075507**	
		(0.024244)	*(0.029062)*	
Number of income sources	-0.024978	-	-0.025301	
	(0.014193)		*(0.027925)*	
Number of parcels	0.026955**	0.038842*	0.023150	
	(0.009671)	*(0.019385)*	(0.018086)	
Farmer's age	-	-	-	
Number of cultivated crops	-	-0.027855	-0.038543	
		(0.026429)	*(0.022887)*	
Employment	-0.024865	0.057117	0.073413	
	(0.019116)	*(0.046063)*	*(0.042375)*	
Farm size	-	-	0.008280	
			(0.010812)	
Experience	-	-0.004170	-	
	0.007057***	*(0.002949)*		
	(0.001464)			
Constant	1.026450	0.766120	1.032739	
	(0.100894)	*(0.161379)*	*(0.222600)*	
Σ	0.130946	0.255395	0.239896	
Log-likelihood	17.59888	2.911149	5.113338	

Note: TE, technical efficiency; CE, cost efficiency; CAE, allocative efficiency; SE, Scale efficiency; VRS, variable returns to scale. Asterisks *, represent statistical significance at the 5% level. Number in parenthesis and italics are standard errors.

6. ENVIRONMENTAL EFFICIENY ANALYSIS

This chapter presents the results of the extended efficiency measure and analysis for tomato, grape and apple producers. The extension considered involves environmental variables (soil quality and number of cultivated varieties given the cultivated crop) that could influence the efficiency of a farm.

6.1 Environmental efficiency estimation

In addition to the traditional inputs and output data, we introduced environmental data into the environmental efficiency analysis that could affect the efficiency level of a farm. The model of TE estimation was extended by adjusting two other variables that describe the environment, such as soil quality and the number of cultivated varieties within a given crop (tomato, grape or apple).

The soil quality index (SQI) was used as an indicator of the quality of land where a particular crop was cultivated. The two stage method was performed to determine the direction of influence of the SQI into TE scores. In the *first stage*, an output oriented TE model under VRS assumption (as in equation 24) was performed, and after, in the *second stage* the obtained TE scores from the first stage method has been regressed upon the SQI, using the truncated regression method as in equation 23. The positive sign of the coefficient of the SQI indicated the direction of influence into TE scores. Moreover, on average the estimated SQI of cultivated land was higher than the SQI of uncultivated land (SQI 6% higher in cultivated land). Taking these results into an account, we considered the SQI of cultivated land as a positive or desirable output which is jointly produced in addition to the traditional output (tomato, grape and apple). The Shannon's diversity index (SHDI) was considered as measure of biodiversity, calculated based on the number of cultivated varieties within given crop. In several studies SHDI is considered as positive output in addition to the traditional outputs in agriculture e.g. (Sipiläinen T., 2008) and (Solovyeva I. and Nuppenau A. E., 2013). At the farm level, cultivation of the different varieties of a specific crop on given area is related to conservation of biological variation, which is a good that the society values. Following the Coelli (2005) model, both environmental variables SQI and SHDI were introduced in the LP as positive outputs. The output-oriented TE_{VRS} LP changes as following in the LP (Coelli T. P., 2005):

(23)

$$Max_{\theta,\lambda}\,\theta,$$

$$Subject\ to \quad -\theta q_i + Q_\lambda \geq 0,$$

$$x_i - X\lambda \geq 0,$$

$$z_i - Z\lambda \geq 0,$$

$$N1'\lambda = 1,$$

$$\lambda \geq 0,$$

where "positive effect" environmental variables were denoted by the *Lx1* vector z_i for the *i*-th farm and by the *LxN* matrix Z for the full sample. The sign on the dual variable associated with the Z-variable has indicated whether the variable has a desirable on non-desirable effect upon the efficiency of a farm. The *i*-th farm is compared with a theoretical frontier farm that has an environment that is no better than the one of the *i*-th farm.

6.1.1 Environmental efficiency results of tomato farms

In the environmental efficiency analysis, the method seeking to identify inefficiency of the tomato farms as equi-proportional increase in outputs produced by holding the quantities of the inputs used fixed. The environmental variables were directly introduced into the LP formulation as ordinary variables. The purpose of this analysis was to evaluate the effect of the inclusion of environmental variables into the farm performance assessment. Descriptive statistics of the variables included in the environmental efficiency measure are shown in the table below.

Table 62: Descriptive statistics of the environmental variables included in efficiency measure of tomato farms

Variable	Mean	SD	Minimum	Maximum
Input				
SQIO	0.56	0.121	0.33	0.75
Output				
SQII	0.63	0.117	0.33	0.92
SHDI	1.73	0.398	0.85	2.50

Note: SQIO-soil quality index for uncultivated land; SQII-soil quality index for cultivated land; SHDI-Shannon's diversity index.

The results of ETE_{VRS} and ETE_{CRS} reflect high technical efficiency with regard to maximization of the outputs, indicating that on average tomato farms could increase the output level only by 2% given the quantity of inputs used.

Table 63: Descriptive statistics of the output-oriented ETE score of tomato farms

Efficiency	Mean	SD	Minimum	Maximum
ETE_{CRS}	0.964	0.065	0.756	1
ETE_{VRS}	0.981	0.048	0.797	1

Note: ETE-environmental technical efficiency; VRS-variable returns to scale; CRS-constant returns to scale; SD-standard deviation.

Table 64: Bias-corrected ETE scores for tomato farms under VRS assumption

Orientation	Bias-corrected efficiency score	Bias-corrected 95% CI†	SD of bias-corrected efficiency score
$Output_{VRS}$	0.979	0.974-0.980	0.497

Table 65: Distribution of the output-oriented efficiency scores of tomato farms

Efficiency range	TE_{VRS} no. of farms	%	ETE_{VRS} no. of farms	%
1	25	65.78	30	78.94
>0.9 < 1.0	3	7.89	5	13.15
>0.8 < 0.9	1	2.63	2	5.26
>0.7 < 0.8	6	15.78	1	2.63
>0.6 < 0.7	3	7.89	0	0
>0.5 < 0.6	0	0	0	0
<0.5	0	0	0	0
Total	38	100	38	100

In general, the inclusion of additional variables into the DEA analysis leads to an increase of the efficiency scores. Therefore, the mean of efficiency scores with additional desirable outputs was in general greater compared to the one estimated with the traditional output. From the distribution of the efficiency scores (Table 65) we can also see the tendency of farms from lower to higher efficiency ranges between TE and ETE. As TE and ETE are considered to be two different production systems, we were not able to directly compare the means of efficiency scores between TE and ETE. A non-parametric Wilcoxon test was firstly performed using the SPSS software. The mean rank and sum of ranks for ETE was relatively higher compared to the TE, but this difference has not been proven to be statistically significant (exact sig. 2-tailed 0.085, 1-tailed 0.042). Later, a comparison of two models was done based on the rank of each farm in TE and ETE as for e.g. Areal et al. (2012) and Solovyeva I., and Nuppenau A. E., (2013).

Further possible explanations for the ranking differences between the two models were sought. The differences in ranking were observed for each farm and three different groups in terms of positioning within in ranking were found:

Group 1: Farms which showed an increase in ranking at ETE when compared to TE;

Group 2: Farms with no differences in ranking;

Group 3: Farms showing a decrease in ranking at ETE when compared to TE.

Group 1: The total number of farms showing an increase in ranking at ETE was 7. On average, this group of farms was having lower yields (131,984.12 kg/ha) compared to the overall sample mean (144,462.41). In regard to the environmental variables, SHDI was higher (1.852) when compared to the overall sample mean (1.733). Farms in this group, mostly maintained a good level of soil quality. The mean of the SQII (0.61) and the SQIO (0.595) were slightly smaller than the means of the overall sample (SQI = 0.63, SQIO = 0.56).

Table 66: The group of tomato farms increased in ranking at ETE

Farm increased in ranking	Yield ka/ha	SQII	SQIO	SHDI
H05	138,888.89	0.58	0.75	2.24
H25	130,000.00	0.42	0.50	0.85
H28	180,000.00	0.75	0.58	1.73
H34	100,000.00	0.67	0.42	2.14
H12	125,000.00	0.58	0.58	2.07
H19	130,000.00	0.67	0.67	1.86
H29	120,000.00	0.67	0.67	2.08
Mean of the group	131,984.13	0.62	0.60	1.85
Mean of total sample	144,462.41	0.63	0.56	1.73

Group 2: This group of farms showed no differences in ranking as they were fully efficient in the TE model and due to this we cannot clearly observe the environmental effect as they were performing fully technically and environmentally efficient. The total number of total farms belonging to this group was 26. The average yield in this group was significantly higher (152,865.40 kg/ha) than the overall sample mean. The mean of the SQII (0.64) was also greater than the overall sample mean. However the SQIO (0.56) and the SHDI (1.73) were almost equal to the overall sample means.

Table 67: The group of tomato farms with no difference in ranking at ETE

Farms with no difference in ranking	Yield ka/ha	SQII	SQIO	SHDI
H01	85,937.50	0.75	0.33	2.00
H02	212,765.96	0.75	0.67	1.88
H04	112,500.00	0.67	0.67	1.69
H06	200,000.00	0.58	0.50	1.96
H07	133,333.33	0.58	0.58	1.91
H08	166,666.67	0.58	0.67	1.95
H09	150,000.00	0.67	0.67	1.56
H10	150,000.00	0.33	0.33	1.74
H11	162,500.00	0.75	0.67	1.53
H15	146,666.67	0.67	0.58	1.86
H16	192,307.69	0.75	0.67	2.50
H17	153,333.33	0.67	0.50	1.51
H18	245,000.00	0.92	0.58	0.85
H38	140,000.00	0.67	0.67	1.73
H35	100,000.00	0.58	0.50	1.98
H30	153,846.15	0.33	0.42	2.05
H31	140,000.00	0.67	0.67	1.03
H32	144,000.00	0.50	0.42	2.19
H33	166,666.67	0.67	0.42	1.80
H13	133,333.33	0.58	0.42	2.41
H20	200,000.00	0.58	0.33	0.95
H21	200,000.00	0.58	0.75	1.59
H22	77,777.78	0.67	0.75	1.78
H24	125,000.00	0.67	0.58	1.62
H27	130,000.00	0.75	0.58	1.10

Mean of the group	152,865.40	0.64	0.56	1.73
Mean of total sample	144,462.41	0.63	0.56	1.73

Group 3: The total number of farms showing a decrease in ranking at ETE model compared to TE was 5. This group of farms was performing weakly in both TE and ETE models. The average yield was much lower (132,142.86) compared to the overall mean. Smaller averages were also observed for the SQII (0.58), SQIO (0.52) and the SHDI (1.64) when compared to the means of these indicators for the entire sample.

Table 68: The group of tomato farms which decreased in ranking at ETE

Farms decreased in ranking	Yield ka/ha	SQII	SQIO	SHDI
H26	119,047.62	0.50	0.50	1.51
H23	125,000.00	0.67	0.50	1.61
H03	166,666.67	0.67	0.50	1.98
H37	150,000.00	0.42	0.42	1.73
H36	100,000.00	0.67	0.67	1.38
Mean of the group	132,142.86	0.58	0.52	1.64
Mean of total sample	144,462.41	0.63	0.56	1.73

6.1.2 Environmental efficiency results of grape farms

Similar to the tomato producers, environmental variables were implemented into output-oriented DEA analysis and the frontier line for ETE was calculated under VRS assumption. The descriptive statistics of environmental variables included in ETE efficiency analysis at grape farms are presented below (Table 69).

Table 69: Descriptive statistics of the environmental variables included in efficiency measure at grape farms

Variable	Mean	SD	Minimum	Maximum
Input				
SQIO	0.41	0.15	0.08	1.0
Output				
SQII	0.49	0.15	0.17	1.0
SHDI	1.12	0.44	0.30	2.05

Note: SQIO-soil quality index outside; SQII-soil quality index inside; SHDI-Shannon's diversity index.

The mean of the ETE score under VRS assumption across grape farms was estimated to be 0.958 (SD = 0.079) with arrange of 0.662-1.000. This result indicates that most of the grape producers were able to achieve high technical efficiency when three outputs were considered. Nevertheless, on average there is still a possibility to improve the level of outputs obtained given the quantity of inputs used. The difference in ETE under the two different assumptions shows the presence of the scale inefficiency (mean of the ETE_{CRS} was 0.908 with SD = 0.133). The average ESE was 0.947 (SD = 0.106) with a range of 0.562-1.000. Out of 34 grape farms included in the sample, 14 were not performing at fully optimal scale. The estimated efficiency scores under NIRS showed that most of the farms operating at inefficient scale were too big.

Table 70: Bias-corrected ETE scores of grape farms under VRS assumption

Orientation	Bias-corrected efficiency score	Bias-corrected 95% CI†	SD of bias-corrected efficiency score
$Output_{VRS}$	0.954	0.940-0.958	0.0837

Note: CI-confidence interval; † 2000 replications were used for bootstrapping.

Table 71: Distribution of the output-oriented efficiency scores of grape farms

Efficiency range	TE_{VRS} no. of farms	%	ETE_{VRS} no. of farms	%
=1	20	58.82	23	67
>0.9 < 1.0	3	8.82	4	11
>0.8 < 0.9	3	8.82	5	14
>0.7 < 0.8	4	11.76	1	2
>0.6 < 0.7	2	5.88	1	2
>0.5 < 0.6	2	5.88	0	0
<0.5	0	0.00	0	0
	34	100	34	100

The distribution of efficiency scores (Table 71) shows an upward shift of the farms from lower to higher efficiency ranges at ETE, when compared to the TE. The differences in farm ranking between TE and ETE were observed and according to the Wilcoxon test, the sum of ranks at ETE under VRS assumption is greater than the sum of ranks at TE but, the difference was not shown to be statistically significance at 5% level ($p = 0.232$). Similar to the tomato farms, explanations for the efficiency differences between the two models were investigated. According to the observed results, we had a group of farms that had significantly improved in ranking at ETE compared to the TE model, a group of farms that decreased in ranking and another group of farms that had almost no differences in ranking.

Group 1: The number farms ranked higher in ETE model compared to the TE was almost the same as for tomato producers (6 farms). On average, this group of farms was smaller than the average farm size of the overall sample in terms of size (in ha). The average yield in this group was considerably lower (11,907.15 kg/ha) when compared to the average yield of the entire sample (13,014.95 kg/ha). The SHDI was greater (1.186) than the one in total sample (1.116). This group of farms had larger differences between the SQII and SQIO, in favor of the first one and also higher mean of SQII (0.661) and SQIO (0.472) when compared to the means of the entire sample (SQII = 0.487, SQIO = 0.414).

This result shows that a greater difference (meaning improvement) in SQI and higher values of the SHDI were shown to be significant determinant factors for the higher rank of a farm. Technical and environmental performance of a farm is often interrelated and should not be treated in isolation, but on the basis of this result it can be illustrated that farms performing weaker in technical aspects (lower yields), showed better performance in terms of environment.

Table 72: The group of grape farms increased in ranking at ETE

Number of farms decreased in ranking	Yield ka/ha	SQII	SQIO	SHDI
H16	15,000.00	0.67	0.67	1.75
H27	14,725.00	0.50	0.33	1.27
H29	9,333.33	0.83	0.58	1.07
H19	13,625.00	0.67	0.50	1.35
H08	7,659.57	0.58	0.50	0.58
H32	11,100.00	0.42	0.25	1.11
Mean of the group	11,907.15	0.61	0.47	1.19
Mean of total sample	13,014.95	0.49	0.41	1.12

Group 2: The second group of farms that show almost no differences in ranking at ETE, were farms being fully efficient in TE model. The average yield in this group was slightly higher (13,403.18 kg/ha) when compared to the overall mean. The averages for other indicators were almost the same (SQII = 0.487, SQIO = 0.387, SHDI = 1.153) as in the overall mean. The total number of farms belonging to this group is 20. When comparing the differences of SQII with the

SQIO, we observed improvement of the SQII in almost all farms, but the improvement effect was not shown in the ranking as this group was performing technically efficient.

Table 73: The group of grape farms with no difference in ranking at ETE

Farms with almost no difference in ranking	Yield ka/ha	SQII	SQIO	SHDI
H04	9,250.00	0.83	0.67	1.57
H05	16,000.00	0.67	0.42	0.92
H06	14,625.00	0.58	0.33	0.94
H07	8,714.29	0.67	0.58	1.15
H10	6,774.19	0.50	0.42	0.30
H11	13,720.93	0.33	0.17	0.62
H12	9,166.67	0.50	0.33	1.53
H14	16,000.00	0.25	0.08	0.30
H15	16,666.67	0.50	0.50	1.24
H30	19,750.00	0.25	0.50	1.24
H31	11,965.22	0.42	0.33	2.05
H33	19,680.00	0.42	0.17	1.34
H34	19,500.00	0.50	0.42	1.55
H17	11,484.38	0.25	0.42	0.58
H18	16,160.00	0.50	0.67	1.14
H20	12,181.82	0.58	0.42	1.22
H23	13,028.57	0.50	0.33	1.44
H24	7,733.33	0.58	0.42	1.70
H26	11,500.00	0.58	0.42	0.45
H28	14,162.50	0.33	0.17	1.79
Mean of the group	13,403.18	0.49	0.39	1.15
Mean of total sample	13,014.95	0.49	0.41	1.12

Group 3: The third group of farms that show a decrease in ranking, consisted mostly fo farms that had a lower average yield (12,875 kg/ha). The average SQII (0.395) has shown a decrease when compared to the SQIO (0.437) and the SQII of the total sample. Contrary to this, the SQIO of this group was higher than the average SQIO of the entire sample. In addition, the mean SHDI was much lower (0.971). In summary, this group of farms had lower averages in all indicators which is reflected in weaker performance sat TE and ETE and also a decrease in the ranking scores.

Table 74: The group of grape farms decreased in ranking at ETE

Farms decreased in ranking	Yield ka/ha	SQII	SQIO	SHDI
H21	12,500.00	0.50	0.58	0.97
H02	17,142.86	0.42	0.50	0.60
H13	11,323.53	0.50	0.50	0.96
H25	16,500.00	0.42	0.25	1.19
H03	12,526.32	0.25	0.25	1.29
H01	14,042.55	0.17	0.33	1.31
H09	8,966.67	0.50	0.67	1.16
H22	10,000.00	0.42	0.42	0.30
Mean of the group	12,875.24	0.40	0.44	0.97
Mean of total sample	13,014.95	0.49	0.41	1.12

6.1.3 Environmental efficiency results of apple farms

As for tomato and grape producers, environmental variables were directly introduced as ordinary variables into the LP formulation. Descriptive statistics of the variables included in the environmental efficiency measure are shown in the table below.

Table 75: Descriptive statistics of the environmental variables included in the efficiency measure of apple farms

Variable	Mean	SD	Minimum	Maximum
Input				
SQIO	0.63	0.14	0.33	0.91
Output				
SQII	0.63	0.11	0.33	0.83
SHDI	1.40	0.35	0.69	2.08

Note: SQIO-soil quality index for uncultivated land; SQII-soil quality index for cultivated land; SHDI-Shannon's diversity index.

The mean of ETE score under VRS assumption across apple farms was estimated to be 0.978 (SD = 0.044) with a range of 0.863-1.000. This result indicates that most of the apple producers were able to achieve high technical efficiency when three outputs were considered. However on average there is still a possibility to improve the level of outputs obtained given the quantity of inputs used.

Table 76: Bias-corrected ETE scores of apple farms under VRS assumption

Orientation	Bias-corrected efficiency score	Bias-corrected 95% CI†	SD of bias-corrected efficiency score
$Output_{VRS}$	0.977	0.970-0.978	0.046

Note: CI-confidence interval; † 2000 replications were used for bootstrapping.

Table 77: Distribution of the output-oriented efficiency scores of apple farms

Efficiency range	TE_{VRS} no. of farms	%	ETE_{VRS} no. of farms	%
=1	14	45.16	23	74.19
>0.9 < 1.0	3	9.67	4	12.90
>0.8 < 0.9	4	12.9	4	12.90
>0.7 < 0.8	3	9.67	0	0
>0.6 < 0.7	3	9.67	0	0
>0.5 < 0.6	2	6.45	0	0
<0.5	2	6.45	0	0
	31	100	31	100

The distribution of efficiency scores (Table 77) shows a significant upward shift of the apple farms from lower to higher efficiency ranges at ETE. Similar to the two other production systems we had a group of farms that had significantly improved in ranking at ETE, a group of farms that decreased in ranking and another group of farms that had almost no differences in ranking.

Group 1: The number farms ranked higher in ETE model was 9. The SHDI was greater (1.60) than the one in total sample (1.41). On average the difference between SQII and SQIO was very small (SQII = 0.61, SQIO = 0.60) and the averages were close to the ones obtained for the total sample (SQII = 0.63, SQIO = 0.63). The average yield in this group was considerably higher (59,156.80 kg/ha) when compared to the average yield of the total sample (54.339.35 kg/ha). These higher values of the SHDI were shown to be significant determinant factors for the higher rank of a farm.

Table 78: The group of apple farms increased in ranking at ETE

Farms improved in ranking	Yield ka/ha	SQII	SQIO	SHDI
H03	62,500.00	0.75	0.75	1.73
H04	55,000.00	0.50	0.67	2.09
H07	93,000.00	0.58	0.67	1.28
H12	119,615.38	0.33	0.33	1.59
H15	79,333.33	0.67	0.50	1.33
H21	45,500.00	0.75	0.58	1.84
H24	15,000.00	0.67	0.50	1.24
H06	35,062.50	0.58	0.58	1.81
H10	27,400.00	0.67	0.83	1.50
Mean of the group	59,156.80	0.61	0.60	1.60
Mean of total sample	54,339.35	0.63	0.63	1.41

Group 2: The second group of farms that show almost no differences in ranking at ETE, were farms being fully efficient in TE model. The averages for SQI and SHDI were almost the same (SQII = 0.64, SQIO = 0.66, SHDI = 1.39) as in the overall mean. The average yield in this group was lower (46,748.41 kg/ha) when compared to the overall mean. The total number of farms belonging to this group was 15.

Table 79: The group of apple farms with no difference in ranking at ETE

Farms with no difference in ranking	Yield ka/ha	SQII	SQIO	SHDI
H05	60,416.67	0.58	0.83	0.69
H09	170,000.00	0.67	0.92	1.79
H11	83,000.00	0.58	0.42	1.60
H13	42,857.14	0.75	0.75	1.35
H14	15,000.00	0.75	0.58	1.74
H16	45,000.00	0.75	0.58	1.63
H17	45,000.00	0.42	0.75	1.28
H19	26,550.00	0.58	0.58	1.75
H20	10,920.00	0.50	0.50	1.92
H22	98,750.00	0.83	0.83	1.39
H23	35,000.00	0.42	0.42	1.04
H26	11,000.00	0.58	0.67	1.72
H29	10,000.00	0.75	0.58	1.34
H31	11,040.00	0.67	0.58	0.94
H01	36,692.31	0.75	0.83	0.75
Mean of the group	46,748.41	0.64	0.66	1.39
Mean of total sample	54,339.351	0.634409	0.63172	1.407404

Group 3: Third group of farms that show decrease in ranking, were mostly farms that had significantly higher average yield (64,411.79 kg/ha). The average SQII (0.65) showed a small increase when compared to the SQIO (0.62). The mean of SHDI was much lower (1.16) compared to the overall mean.

Table 80: The group of apple farms decreased in ranking at ETE

Farms decreased in ranking	Yield ka/ha	SQII	SQIO	SHDI
H27	78,666.00	0.75	0.58	1.33
H28	79,000.00	0.67	0.50	1.32
H08	123,461.54	0.67	0.83	1.38
H30	78,789.00	0.67	0.67	1.28
H34	15,900.00	0.67	0.67	0.89
H02	48,500.00	0.58	0.50	0.82
H32	26,566.00	0.58	0.58	1.08
Mean of the group	64,411.79	0.65	0.62	1.16
Mean of total sample	54,339.35	0.63	0.63	1.41

7 CONCLUSIONS

Efficiency analysis serves as bedrock for better resource utilization and policy making. The standard efficiency measurement does not take into consideration the environmental goods and services in the production function. Environmental externalities which are non-marketable outputs are usually disregarded by producers in their decision making process, reflecting only private costs and benefits. Externalities can be either negative or positive and take place when economic entity through the production process influences the welfare of others and yet does not pay or receive any compensation for the given effect. Positive externalities are usually undersupplied in the market as the marginal private benefit is lower than the marginal social benefit. Therefore, whenever positive externalities are generated policy intervention is needed to encourage production of more positive externalities.

Agriculture plays a multifunctional role related to economic, environmental and social dimension but it also affects other ecosystem functions such as biodiversity and soil quality. The provision of these ecosystem functions highly depends on farmer production practices e.g. extensive agriculture that uses less inputs (labor, fertilizers and capital) to the utilized agricultural area can contribute to the increase of biodiversity and improve the soil quality. Rich biodiversity in agricultural production systems contributes to the protection of ecological structure and also is in benefit of soil conservation. Maintenance of healthy soil is not only important for production of healthy food but it is also important for stabilization of the natural ecosystems and for better air and water quality. Many of the conducted studies considered negative externalities generated from agriculture into efficiency estimation. However, fewer studies were focused on positive externalities produced by agriculture and they did not appear until the 1980s.

The overall farm household size is relatively large and it was proved to be significantly larger for the farms oriented in tomato production when compared to apple and grape farmers. Almost all farms included in the study were male-headed. On average farmers producing tomato were significantly younger and considerably less educated than apple and grape farmers. The likelihood of having additional profession aside from a farmer was proven to be dependent on farmer's education. Agriculture plays an important role in the welfare of the family farms producing tomato and it was considered to be one of the main sources of income. Family farms producing grape choose to diversify more income sources in order to support living standards. Whereas, different situation stands for apple producers where family farm wellbeing was mainly based on off-farm activities. Farmer's education and the experience in terms of years active in farming were shown to be important factors on income source determination. The household size, number of family members working actively in farm and farm size were significantly positively correlated with farm income.

Most of the farms are considered to be well established farms, as on average they were active in farming for more than two decades. The average size of the farms included in the study was considerably higher when compared to the average farm size at national level. Farm size of apple producers was bigger followed then by grape and tomato producers. For the farmers with primary education, the main reason of being involved in agriculture is that there was no other opportunity for them. While, those with secondary and tertiary education 'tradition' was the most affirmed reason. Farmers producing tomato tend to lease more land from other landowners when compared to apple and grape producers. This is considered to be the easiest way to expand their agriculture business without high capital investment costs. The farm land was very fragmented for three production systems in the study and scattered over a wide area.

The soil quality index was calculated for cultivated and uncultivated farm land. Based on the obtained results, the soil quality index of tomato farms was higher than the two other group of farms, indicating better quality of soil for tomato producers. In general, the soil quality index at cultivated farm land was greater when compared to the uncultivated farm land. This difference in soil quality can be due to the effect of farm practices. The Shannon's diversity index of tomato farms was the highest among the three groups. This shows that production systems under perennial trees offer less possibilities to quickly change the compound and the distribution of varieties within a given species.

Almost half of the total tomato farms were operating fully technically efficient under the two different assumptions (constant and variable returns to scale) of the input oriented model. The average technical efficiency score of tomato farms was high and there was small extent to further reduce the level of inputs used and still obtain the same level of output produced. Choosing the output oriented model of technical efficiency estimation, results showed that tomato producers can further increase their output level of production by improving the resource use efficiency given agricultural technology. Less than fifty percent of the tomato farms were operating close to the optimal scale. The scale inefficiency of the tomato farms was mainly due to the small scale farm.

On average grape producers used more inputs than it was needed to produce the same amount of the output. The share of grape farms being fully efficient (under variable returns to scale assumption at input oriented model) was over fifty percent. At the output oriented model (variable returns to scale assumption), grape producers on average could have increased the level of output by ten percent and still keep the same level of inputs used. Most of the grape farms were operating at relatively high optimal scale. The estimated results under non-increasing returns to scale showed that scale inefficiency was mainly present of small holder farms.

The share of apple farms being fully technical efficient under variable returns to scale assumption was less than fifty percent. This result indicates that apple producers on average could have reduced the amount of inputs used given the level of output produced. When output oriented model under variable returns to scale assumption was performed, the results showed that on average apple farms could produce fifteen percent more of the output, using the same quantity of inputs. The level of fully scale efficient farms producing apple was considerably smaller when compared to the two other groups of farms. Similar to tomato and grape producers, for majority of the apple producers the inefficiency scale was present due to being too small farms.

At the estimation of environmental efficiency, the output oriented model under the variable returns to scale assumption was extended by adding up two additional variables that signified soil quality of the farm land and agro-biodiversity provision by each production system considered in the study. In DEA the efficiency score increases when additional inputs or outputs are introduced into the model. Therefore, at the environmental efficiency estimation farm efficiency scores were in general higher when were directly compared to the technical efficiency scores of the output oriented model.

As the environmental efficiency and technical efficiency models were not constituting similar production function, a direct comparison between environmental and technical efficiency scores for each farm was not appropriate. As a result, the differences in ranking between the two models were observed. Three different groups in terms of positioning in ranking were found. The first group consisted of farms which showed an increase in ranking at environmental efficiency when compared to the technical one. In the second group, were farms that did not show differences in ranking and in the third group were farms that decreased in ranking at environmental efficiency when compared to the technical efficiency estimation.

Farms which showed increase in ranking at environmental efficiency estimation, were mostly those that improved or maintained good level of soil quality and had a high value of Shanno's diversity index. The second group of farms that did not show difference in ranking, were fully efficient in environmental and technical efficiency estimation. That is why it was not possible to distinguish the inclusion effect of environmental factors into the efficiency estimation. The third group of farms were performing weakly in both, technical and environmental efficiency estimation. In general, for this group of farms, smaller averages were observed for the soil quality index and the Shannon's diversity index when compared to the averages of total sample.

Based on the study results smaller farms in terms of UAA seemed to stand better at estimated environmental efficiency. However, further research is needed in order to bring more evidence and knowledge associated to environmental performance of farms by size. The inclusion of more indicators from agro-ecological and socio-territorial scale will provide broader picture for more sustainable farming systems.

Environmental efficiency estimation is completely new approach in Kosovo and it can serve as a good base for further research towards environmental and sustainability performance of farms. It will be particularly important for smaller farms as they were usually excluded from the policy support and by considering other dimensions into efficiency estimation the support given to them might be justified. The results of the efficiency analysis in the study can serve as model for the development of evidence based policies.

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Annex 1: Scheme of classification of the habitat types

Habitat-Type	Annual	Perennial	Grasses	Herbs	Open soil	Herbicide
Ruderal Herbs open	< 50 %	>50 %	<50 %	>50 %	<50 %	Yes
Ruderal Herbs open	< 50 %	>50 %	<50 %	>50 %	<50 %	No
Ruderal Herbs dense	< 50 %	>50 %	<50 %	>50 %	>50 %	Yes
Ruderal Herbs dense	< 50 %	>50 %	<50 %	>50 %	>50 %	No
Ruderal Grasses open	< 50 %	>50 %	>50%	<50%	<50 %	Yes
Ruderal Grasses open	< 50 %	>50 %	>50%	<50%	<50 %	No
Ruderal Grasses dense	< 50 %	>50 %	>50%	<50%	<50 %	Yes
Ruderal Grasses dense	< 50 %	>50 %	>50%	<50%	<50 %	No
Weed Herbs open	> 50 %	<50 %	<50 %	>50 %	<50 %	Yes
Weed Herbs open	> 50 %	<50 %	<50 %	>50 %	<50 %	No
Weed Herbs dense	> 50 %	<50 %	<50 %	>50 %	>50 %	Yes
Weed Herbs dense	> 50 %	<50 %	<50 %	>50 %	>50 %	No
Weed Grasses open	> 50 %	<50 %	>50%	<50%	<50 %	Yes
Weed Grasses open	> 50 %	<50 %	>50%	<50%	<50 %	No
Weed Grasses dense	> 50 %	<50 %	>50%	<50%	<50 %	Yes
Weed Grasses dense	> 50 %	<50 %	>50%	<50%	<50 %	No






Different habitat types between and within the rows of the apple and grape orchards.

Annex 2: Questionnaire of the tomato, grape and apple farms

Questionnaire

Contents

I. Basic information

Number of questionnaire: [_______]
Date (Day/Month/Year): [_______][_______][_______]
Time: [_______][_______]
Farmer's name: [_________________________]
Phone number: [_________________________]
E-mail: [_________________________]
Village: [_________________________]
Municipality: [_________________________]
Region: [_________________________]

II. Demographics data on composition of the farmhouse

Q 1) Farmer's age: [_______]

Q 2) Formal education (in years): [_______]

Q 3) Form of the education: [_____________________]

Q 4) Do you have another profession besides farmer?

[0] [ ] Yes [1] [ ] No

If yes, please indicate your additional profession: [_____________________]

Q 5) Since when do you live in this village?

[ ] Since I was born.

[ ] Since [_______] Please indicate the year you came to this village.

Q 6) Including yourself, how many people live here regularly as members of this household?

Write down number: [_______]

Q 7) With whom you (household head) are living presently? Please indicate your relationship and the family members.

No.	Family member	Age	Education in years	Profession
1	Mother			
2	Father			
3	Wife			
4	Husband			
5	Sister			
6	Brother			
7	Daughter			
8	Son			
9	Sister in law			
10	Brother in law			
11				
12				
13				
14				

III. Employment status, sources and composition of income

Q 8)How many persons of your household are currently employed (in and out of your farmstead)?

Write down number: [_______]

Q 9) How many persons of your household work in your farmstead?

[_______] persons

Q 10) How many persons of your household are in paid work outside of your farmstead?

[_______] persons

Q 11) Do you have a family member who works outside the country?

[0] [ ] Yes [1] [ ] No

If the answer is yes, please indicate the number of family members working outside the country?

[_______] persons

Q 12) What is the current employment status of the household head and the family members respectively?

Please check all that apply	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Self employed in agriculture										
Self employed in tourism										
Self employed (neither agriculture nor tourism)										
Wage employee in agriculture										
Wage employee in tourism										
Wage employee (neither agriculture nor tourism)										
Housewife/houseman										
Pensioner										
Veteran										
Disabled										
Unemployed										
In school (student)										
Other (please indicate): _______________										

Q 13) Please consider the income of all household members and any income which may be received by the household as a whole. What is the main source of income in your household?

Wage income from the agricultural sector	[____]
Wage income from the touristic sector	[____]
Wage income (excluding agricultural and touristic sector)	[____]
Self employment income from the agricultural sector	[____]
Self employment income from the touristic sector	[____]
Self employment income (excluding agricultural and touristic sector)	[____]
Pensions	[____]
Unemployment/redundancy benefit	[____]
Any other social benefits or grants	[____]
Income from investment, savings, insurance or property	[____]
Private transfers (e.g. remittances)	[____]
Public transfers (e.g. pensions, social payments)	[____]
Other (please indicate)___________________________________	[____]
Refused	[____]
Don't know	[____]

Q 14) Do you receive a financial support from the family members who are working outside the country?

[0] [ ] Yes [1] [ ] No

If yes, please indicate the average monthly amount you receive (indicate the amount in Euro): [_______]

Q 15) If you add up the income from all sources, what is the average family income per month (year)?

Please indicate the amount in Euro: [_______]

Q 16) What is your family income composed of? Please indicate the amount of euro you gained in the last 12 months from the activities listed below:

Agricultural activities	[_______]

Tourism activities [_______]
Non-agricultural activities [_______]
Private transfers (e.g. remittances) [_______]
Public transfers (e.g. pensions, social benefits) [_______]
Leasing out land [_______]
Subsidy
Other (please indicate): ____________________________ [_______]

IV. Information at farmlevel

Q 17) For how many years have you been active in farming?

[_______] years

Q 18) What is the main reason you are engaged in agricultural activities? Please give one of the main reasons listed below.

Because of income generation [_______]
Because of tradition [_______]
Hobby [_______]
There is no other opportunity [_______]
Other (please indicate):______________________ [_______]

Q 19) How satisfied are you with your farming activities?

Please indicate on the scale to what extend you are satisfied.

Very satisfied	5	4	3	2	1	Not satisfied at all

Q 20) Will one of your children take over your farmstead when you retire?

[0] [ ] Yes [1] [ ] No

V. Information on land use

Q 21) How much land do you cultivate presently (in total)?

Please indicate in hectares: [_______] hectares

Q 22) Of the total land you cultivate today, how much land is on your ownership?

Please indicate in hectares.

[_______] hectares

Q 23) Do you lease land from someone else?

[0] [ ] Yes [1] [ ] No

If the answer is yes, how much land do you lease? Please indicate in hectares.

[_______] hectares

Q 24) What is the price you pay per hectare for the land you lease? Please indicate the amount in Euro: [_______]

Q 25) In how many land parcels it is divided (owned and leased)? Please indicate the number of parcels.

[_______] parcels

	Q 26) How large is the parcel?	Q 27) What type of land is the parcel?	Q 28) What is your ownership status of the parcel?	Q 29) How is the distance from your house to the parcel?
	Indicate in hectares.	1 = Land below the house	1 = Owned by household members	Indicate in meters.
		2 = Land around the house, garden	2 = Owned by other family members	
		3 = Arable land	3 = Leased from the state/local government	

		4 = Perennials	4 = Leased from large private persons	
		5 = Orchards	5 = Leased from large agricultural enterprises	
		6 = Hay meadows	6 = Use rights (communal ownership)	
		7 = Pasture	7 = Other, please indicate	
		8 = Other, please indicate		
1	ha			m
2	ha			m
3	ha			m
4	ha			m
5	ha			m
6	ha			m
7	ha			m
8	ha			m
9	ha			m
10	ha			m

Q 30) Would you like to cultivate more land than you do at the moment?

[0] [ ] Yes   [1] [ ] No

VI. Information on crop production and market

Q 31) Of the total land you cultivate: what are the crops you produce?

Please list all kind of crops you grow below.

1. [__________________]
5. [__________________]
2. [__________________]
6. [__________________]
3. [__________________]
7. [__________________]
4. [__________________]
8. [__________________]
9. [__________________]
10. [__________________]

Number of crops [_______]

Q 32) Of the crops you cultivate: how many hectares is being used for each kind of crop?

Please indicate the number of hectares.

1. [__________________]
5. [__________________]
2. [__________________]
6. [__________________]
3. [__________________]
7. [__________________]
4. [__________________]
8. [__________________]
9. [__________________]
10. [__________________]

Q 33) How do you usually sale crops you produce? Please check all that you apply.

1	Directly from the farm	[_______]
2	In the streets in the village I live in	[_______]
3	In a store in the village I live in	[_______]
4	On a farmer's market in the village I live in	[_______]
5	In a store in the surrounding village	[_______]
6	On a farmer's market in the surrounding villages	[_______]
7	In bigger cities	[_______]
8	Wholesale market	[_______]
9	Supermarket	[_______]
10	Store (bigger cities)	[_______]
11	Restaurants	[_______]
12	Other (please indicate):	[_______]

Q 34) Do you face difficulties in sealing crops you produce?

[0] [ ] Yes [1] [ ] No

If the answer is yes,

Q 35) Please indicate what the main difficulties are you facing in the sale of crops you produce? State on the scale of 1 for the difficulty less frequently pronounced to 6 for the difficulty most frequently pronounced.

Market access	[_______]
Unfair competition	[_______]
Price	[_______]
Packaging	[_______]
Product quality	[_______]
Promotion	[_______]
Inefficient policy	[_______]
Late crops outcome in the market	[_______]
Other (please indicate):	[_______]

Q 36) Which of the product features is most important for your buyers? Please indicate on the scale of 1 for the feature less important to 4 for the feature most important.

Price	[_______]
Product quality	[_______]
Packaging	[_______]
Other (please indicate)	[_______]

Q 37) How do you manage to keepyour buyers nearby?

By maintaining product quality	[_______]
By offering products with lower prices	[_______]
Fair cooperation	[_______]
Other (please indicate) _______________	[_______]

Q 38) What are the most common objections of your buyers?Please indicate on the scale of 1 for the objection less frequently stressed to 4 for the objection most frequently stressed.

Price [_______]

Product quality [_______]

Packaging [_______]

Other (please indicate) [_______]

Q 39) How do you usually manage selling of your products?

Selling everything to one place	[_______]
Selling directly to costumers	[_______]
U-pick field	[_______]
Community supported agriculture	[_______]
Other (please indicate)	[_______]

Q 40) Could you please mention the names of major trading companies that you supply?

[_________________________] [________________________]
[_________________________] [_______________________]
[_________________________] [_______________________]
[_________________________] [_______________________]

Q 41) Do you organize selling jointly with other producers?

[0] [ ] Yes [1] [ ] No

VII. Information on production system

Q 42) For how many years have you been active in applying IPM production system? Please indicate the number of years.

[_______] years

Q 43) Why did you start applying IPM production system? Please state one of the main reasons listed below.

It produces food with higher quality (healthier for costumers)	[_______]
It creates higher income for the farm	[_______]
It reduces human and environmental exposure to hazardous chemicals	[_______]
	[_______]
It reduces overall costs of pesticide application material and labor	[_______]
It reduces farmers exposure to hazardous chemicals	[_______]
Other (please indicate): ___________________________________	

Q 44) How large is the area you apply IPM production system?

Please indicate in m^2.

[_______] m^2

Q 45) What are the crops you cultivate employing IPM production system? Please list the crops you cultivate below.

[______________] [______________]

[______________] [______________]

[______________] [______________]

Number of crops [_______]

VIII. Information on construction of the greenhouse

Q 46) Construction of the greenhouse(s) applying integrated production system (tomato):

Types of Greenhouses	Year of establishment	Area (please indicate in m^2)			
		Initially	2009	2010	2011
Simple tunnels					
Mid-level Greenhouse					
Block system					

Q 47) Type of the greenhouse(s) construction material:

Types of Greenhouses	Wood	Non-galvanized Metal	Galvanized Metal	Wood & metal combination
Simple tunnels				
Mid-level Greenhouse				
Block system				

Q 48) Origin of the greenhouse(s):

Types of Greenhouses	Simple tunnels	Mid-level Greenhouse	Block system
Who has built the greenhouse? *(the owner =* ***O****; a recognized company =* ***C****)*			
Where was the greenhouse manufactured? ***(name of the company*** *and* ***the country****)*			
Is it installed heating system: Yes = 0, No = 1			

Q 49) Present condition of the greenhouse(s):

Types of Greenhouses	Simple tunnels	Mid-level Greenhouse	Block system
What is the height of the greenhouse(s)? *(indicate in* ***meters)***			
Type of cover used: *(plastic =* ***P + durability in years****;glass =* ***G + durability in years****)*			
What kind of ventilation system does the greenhouse(s) have? *(front& back =* ***F&B****; lateral =* ***L****; roof =* ***R****; lateral + roof =* ***L&R****.)*			
What kind of irrigation system is used in the greenhouse(s)? *(drip irrigation =* ***DI****; sprinkler =* ***S****; both =* ***DI&S****; none =* ***N*** *)*			
What is the source of the water supply? *(a well =* ***W****; a river =* ***R - state name****; water pipes =* ***P - state company****; or another source =* ***state it****)*			
What heating system is used? *(none =* ***N****; diesel =* ***D****; gas =* ***G****; wood =* ***W****; coal =* ***C****; another fuel =* ***state it****)*			
During what period of the year are the greenhouses used? *(from* ***month X to month Y)***			
What vegetables do you cultivate in			

GH? *(tomatoes = **T**; cucumbers = **C**; peppers = **P**; lettuce = **L**; other = **state which**).*			

Q 50) Waste Management:

What do you do with the old or damaged plastic?

I use it for other purposes [_______]
I burn it [_______]
I throw it away [_______]
I sell it to recycling companies [_______]
Other (please indicate): [_______]

Q 51) Future investment plan:

Do you have a plan to expand your agricultural activities applying IPM production system?

[0] [ ] Yes [1] [ ] No

If the answer is yes, what will be the source of the investment?

A bank loan	[_______]
Own savings	[_______]
Other sources (please indicate) ___________	[_______]

Q 52) How much money did you spend on building the greenhouses you apply Integrated Production System?

Building material	**Capacity**	**Price in€**	**Total value€**
Construction material			
Covering			
Heating system			
Irrigating system			
Ventilation system			
Well			

Q 53) What kind of mechanization do you have? Please indicate the type of mechanization, year and money you spent buying it.

Type of mechanization	**Year**	**Price in €**
Total		

Q 54) What are other equipment you use in farming activities? Please indicate the type of equipment, year, and money you spent buying it.

Type of equipment	**Year**	**Price in €**
Pump for irrigation		
Pump for spraying		
Other (please indicate):		
______________________		
______________________		
______________________		
______________________		
______________________		
______________________		
Total		

IX. Information ongross revenue and production costs

Q 55)

Area in m^2				
Typical yield & price	*Quantity*	*Unit*	*€/unit*	*Gross revenue*
Tomato		kg		
Production costs (by activity)	*Quantity*	*Unit*	*€/unit*	*Cost*
1.Land preparation				
Fertilizer				
Manure				
Plastic mulch				
Labor to prepare land				
Total land preparation cost =				
2.Planting				
Tomato seeds				
Seedling trays				
Labor to raise & plant seedlings				
Total planting cost =				
3.Fertilization				
Fertilizer				
Fertilizer foliar				
Labor to apply fertilizers				
Total fertilization cost =				
4.Pest control				

Labor to apply pesticides				
Total pest control cost =				
5.Irrigation				
Water				
Labor to apply water				
Total irrigation cost =				
6.Warming				
Fuel				
Labor to apply warming				
Total warming cost =				
7.Harvesitng				
Taking care, pruning, etc.				
Labor to harvest				
Boxes				
Total harvesting cost =				
8.Marketing				
Labor to transport to market				
Total marketing cost =				
9.Mechanized operations				
Fuel, oil & lube				
Total machinery cost =				
10.Operating overhead				
Operating interest				
Excise tax				
Commissions				
Management				
Office overhead				
Total operating overhead =				

11.Other variable costs				
Total variable costs of production =				
GROSS MARGIN (gross revenue minus variable costs) =				

X. Information on grape/ apple grave

Cultivars	Year of establishment	Area (please indicate in ha)			
		Initially	2000	2005	2010

Q 42) When did you establish an apple grove?
Please indicate in years: [_______]
Q 43) How large is the area
Please indicate in hectares [_______] ha
Q 44) What are cultivars you cultivate? Please list all cultivars you cultivate below.
[______________] [______________]
[______________] [______________]
[______________] [______________]

Number of cultivars [_______]
Q 45) What are the apple cultivars most in demand on the market? (list in order)
[______________] [______________]

XI. Information on gross revenue and production costs

Total cultivated area in ha [_______]

Q 46) Costs of producing apple:

Production costs (by activity)	*Quantity*	*Unit*	*€/unit*	*Cost*
Variable costs				
Pruning				
Training				
Fertilization				
Manure				
Fertilizer				
Foliar fertilizer				
Labor to apply fertilizers				
Total fertilization cost =				
Beehives				
Pest control				
Labor to apply pesticides				
Total pest control cost =				
Irrigation				
Water				
Electricity/Fuel				
Labor to apply water				
Total irrigation cost =				
Harvesting				
Picking labor				
Other labor (checkers, tractor drivers)				
Boxes				
Hauling apples				
Total harvesting cost =				
Marketing				
Labor to transport to market				
Transport costs				
Total marketing cost =				
Mechanized operations				
Fuel, oil & lube				
Maintenance and repairs				

Fixed costs				
Interest				
Depreciation				
Taxes (land)				
Other expenses				

Cultivars	Number of trees	Yield	Price in euro per kg
Total			

Q 47) Future investment plan
Do you have a plan to expand cultivated area with apple?
[0] [ ] Yes [1] [ ] No

If the answer is yes, what will be the source of the investment?

A bank loan	[________]
Own savings	[________]
Other sources (please indicate) ____________	[________]

Q 48) What were the main diseases appeared last year:

____
____
____
____
____

Q 49) What kind of mechanization do you have? Please indicate the type of mechanization, year and money you spent buying it.

Type of mechanization	Year	Price in euro[2]	Actual price in euro	Number of total hours used within a year	Number of total hours used in apple production
Total					

Q 50) What are other equipment you use in farming activities? Please indicate the type of equipment, year, and money you spent buying it.

Type of equipment	Year	Price in €[3]	Actual price in market	Number of total hours used within a year	Number of total hours used in apple production
Pump for irrigation					
Pump for spraying					
Other (please indicate):					
______________________					
______________________					
______________________					
______________________					
______________________					
______________________					
Total					

2 (when the equipment was bought)
3 (when the equipment was bought)

I. Information on fertilizer and pesticide application

56) Fertilizer application record

MAKE A RECORD OF EACH APPLICATION OF EACH FERTILIZER					
	App. 1	App. 2	App 3	App. 4	App. 5
Field or Site Location (give name or number of the field treated)					
Date (Day, Month Year):					
Size of Area Treated (in m^2):					
Fertilizer Used (Brand Name) and total amount applied ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________					
Crop/Commodity or Site					
Formulation					
Additives					

Method of Application					
Stage of Crop Growth					
Purpose of Application					
Temperature					
Time of Day					
Wind					
Cloud Cover					
Effectiveness					

Q57) Pesticide application record

MAKE A RECORD OF EACH APPLICATION OF EACH PESTICIDE					
	App. 1	App. 2	App 3	App. 4	App. 5
Field or Site Location (give name or number of the field treated)					
Date (Day, Month Year):					
Size of Area Treated (in m^2):					
Pesticide Used (Brand Name) and total amount applied InsecticideFungicideHerbicide					

Crop/Commodity or Site					
Formulation					
Additives					
Method of Application					
Stage of Crop Growth					
Purpose of Application					
Stage of Development of Pest					
Soil Conditions					
Temperature					
Time of Day					
Wind					
Cloud Cover					
Effectiveness					

Annex 3. Gross margins of tomato producers

A	INCOME	Unit	Quantity	Price/Unit	Value	Quantity (ha)	Value (EUR/ha)
1.1	Total tomato yield	Kg/ha	137,500	0.26	35,750.00	85937.50	22343.75
	Total income				**35,750.00**		**22343.75**
2	**VARIABLE COSTS**						
2.1	**Inputs**						
	Seeds-Sapling	Sapling	33000	0.13	4,158.00	20625.00	2681.25
	Artificial fertilizer (NPK)	kg/ha	925	0.60	555.00	578.13	346.88
	Manure	kg/ha	55500	0.03	1,480.00	34687.50	1040.63
	Crystaline Fertilizer	kg/ha	990	0.68	668.92	618.75	420.75
	Foliar feeding	l/ha	0.00	0.00	0.00	0.00	0.00
	Total pesticides	kg/l/ha	0.00	0.00	119.00	0.00	74.38
	Plastic mulch	m2	0.00	0.00	0.00	0.00	0.00
	Packing (boxes)	piece	27500	0.28	7,700.00	17187.50	4812.50
	Irrigation		0.00	0.00	0.00	0.00	150.00
	Total inputs				**14,680.92**		**9526.38**
2.2	**Mechanized operations**						
	Plugging	l/diesel	60	1.2	72.00	37.50	45.00
	Harrowing	l/diesel	60	1.2	72.00	37.50	45.00
	Planting	l/diesel	10	1.20	12.00	6.25	7.50
	Fertilization	l/diesel	0.00	0.00	0.00	0.00	0.00
	Spraying	l/diesel	0.00	0.00	0.00	0.00	0.00
	Diesel fuel for irrigation	l/ha	345	1.20	414.00	215.63	258.75
	Transport to market	Lump sum	375	1.20	450.00	234.38	281.25
	Maintenance	Lump sum					25.00
	Total working machinery costs				**1,020.00**		**662.50**
B	**Total variable costs**				**15,700.92**		**10188.88**
3	**CONTRIBUTION MARGIN (A-B)**				**20,049.08**		**12154.88**
4	**FAMILY LABOUR FORCE**						
	Labor to prepare land	p/d	2.0	15.00	30.00	1.25	18.75
	Planting	p/d	70.0	15.00	1,050.00	43.75	656.25
	Fertilization	p/d	10.0	15.00	150.00	6.25	93.75
	Spraying	p/d	24.0	15.00	360.00	15.00	225.00
	Seedlings connection	p/d	70.0	15.00	1,050.00	43.75	656.25
	Removal of buds	p/d	120	15.00	1,800.00	75.00	1125.00

	Harvesting	p/d	450.0	15.00	6,750.00	281.25	4218.75
	Transport to market	p/d	15.0	15.00	225.00	9.38	140.63
	Total work		**761.00**		**11,415.00**	475.63	**7134.38**
5	**GROSS MARGIN BEFORE DEPRECIATION**				**8,634.08**		**5020.50**
	Depreciation	Lump sum			1,241.32		1241.32
6	**NET MARGIN WHEN 100% OF WORKS CARRIED OUT BY FAMILY MEMBERS**				**20,049.08**		**10913.55**
	Works carried out by family members				**11,415.00**		**7134.38**
	NET REVENUE				**8,634.08**		**3779.18**

Annex 4. Gross margins of grape producers

	Unit	Quantity	Price per unit	Value in EUR	%	Quantity (ha)	Valu in EUR (ha)
REVENUE							
Grapes	kg/ha	27,520	0.25	6742.4		11,965.22	2,931.48
Subsidy	EUR/ha					0	0
Total income				**6742.4**	**100%**	0	**2,931.48**
VARIABLE COST						0	0
Inputs						0	0
Strings	kg/ha	4.6	3.00	13.80		2	6
NPK	kg/ha	900	0.46	410.0		391.30	178.26
NAG	kg/ha	0	0.00	0.0		0	0
Leaf fertilizer	kg/ha	0	0.00	0.0		0	0
Pesticides	kg/ha	11	23.09	254.0		4.78	110.43
Other consumables	Lump sum			0.0		0	-
Total inputs				**677.80**	**10%**	0	**294.70**
Machinery services						0	0
Spring plowing (2 times)	l/diessel	268	1.20	321.60		116.52	139.83
Autum plowing (2 times)	l/diessel	268	1.20	321.60		116.52	139.83
Cultivation (2 times)	l/diessel	268	1.20	321.60		116.52	139.83
Fertilization NPK	l/diessel	20	1.20	24.00		8.70	10.43
Additional fertilization NAG	l/diessel		0.00	0.00		0	0
Spraying (3 times)	l/diessel	75	1.20	90.00		32.61	39.13
Other works	l/diessel	0	0.00	0.00		0	0
Total cost of machinery services				**1,078.80**	16%	0	**469.04**
Marketing costs		0.00	0	0.00		0	0
Transport	Operations	37.5	4.00	150.00		16.30	65.2173913
Total cost of marketing				**150.00**	2%	0	**65.22**
Total variable costs				**1906.60**	**28%**	**0**	**828.96**
CONTRIBUTION MARGIN (A-B)				**4835.80**		0	**2,102.52**

Labour						0	0
Pruning	p/d	29	0.00	0.00		12.61	-
Cleaning vines	p/d	0	0.00	0.00		0	0
Maintenance	p/d	0	0.00	0.00		0	0
Binding vines	p/d	10	0.00	0.00		4.35	-
Digging, cleaning soil	p/d	0	0.00	0.00		0	0
Removing weeds (2 times)	p/d	16	0.00	0.00		6.96	-
Binding branches	p/d	0	0.00	0.00		0	0
Spraying (3 times)	p/d	3	15.00	45.00		1.30	19.57
Harvesting	p/d	20	0.00	0.00		8.70	-
Total labour costs		**78.00**		**45.00**	**0.67%**	**33.91**	**19.57**
GROSS MARGIN BEFORE DEPRECIATION				**4790.80**		0	**2,082.96**
Depreciation	**Lump sum**			**300.00**	**4.45%**	0	**130.43**
NET MARGIN WHEN 100% OF WORKS CARRIED OUT BY FAMILY MEMBERS				**4490.80**	**66.61%**	0	**1,952.52**

Annex 5: Gross margins of apple producers

	Unit	**Quantity/ ha**	**Unit price Euro**	**Total cost Euro/ha**
Apples	kg/ha	32000	0.36	11520
Total income				11520
VARIABLE COST				
Inputs				
Manure	Mt/ha	60	5	300
Fertilizer	kg/ha	825	0.7	577.5
PPP	kg/ha	14	60	840
Total inputs				1767.5
Works				
Cultivation between rows	service/day	3	30	90
Spraying (6 times)	service/day	6	30	180
Other works	Lump sum			100
Total works				370
Marketing costs				
Boxes	Pieces	4000	0	0
Transport	Operations	14	50	700
Total marketing				700
Total variable costs				2837.5
GROSS MARGIN				8682.5
Labour				
Pruning	Price per tree	1600	1	1600
Manuring	p/d	8	15	120
Fertilizing	p/d	2	15	30
Irrigating	p/d	2	15	30
Spraying	p/d	14	15	210
Fruit thinning	p/d	8	15	120
Harvesting	p/d	80	15	1200
Other labor	p/d	2	15	30
Total labour		128.00		3,340.00
				300.00
NET MARGIN				5342.5

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