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Full Length Research Paper

Assessing the agricultural sustainability of conventional farming systems in Samsun province of Turkey

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The objective of this study was to evaluate the sustainability of the agricultural activities in Samsun province. Research data belongs to 2004-2005 production period and was gathered from randomly selected 93 farms by means of questionnaire. In this research, economical, social, bio-physical and environmental sustainability of agricultural activities were investigated. Total sustainability index, based on the selected 40 sustainability indicators was used to determine sustainability level. Research results revealed that some serious problems in the aspect of agricultural sustainability arise in the research area. The basic problem is that of economic viability of farms in first and second sub regions, while for third region, it is social sustainability. The most deficient social factors in the research area are insufficient sewerage systems, inadequate health service and problematic land ownership issues. The most important economic barrier is the low level of return on asset. Unconscious and excessive chemical input use, insufficient irrigation water and water erosion were the most important environmental and bio-physical barriers for agricultural sustainability. Increasing farm level productivity and controlling production costs and investment to the farm sector might enhance the sustainability of agricultural activities in the area. These farm level measures must be adopted by related government agencies and especially infrastructural and land ownership problems should be tackled as soon as possible.

Key words: Agricultural sustainability, sustainability index, indicators.

INTRODUCTION

Up to now, meeting the needs of human is one of the main problems for mankind. Population pressure led to rising of demand for agricultural products. For this reason, many societies have aimed to counterbalance the human needs and food production. This made the farmers use much more modern inputs such as inorganic fertilizers, pesticides and water in production activities. Farmers, especially in developing countries as well as developed ones have used excessive agrochemicals in order to increase their crop yields at the expense of endangering the future generation needs. Pretty (1995) suggested that overuse and inappropriate use of agrochemicals have led to environmental problems such as contamination of water, loss of genetic diversity and deterioration of soil quality. On the other hand, it has been familiar that the consumption of agrochemicals led to human health problems (Harwood, 1990; Marquez et al., 1992; Roll and Pingali, 1993). Tilman et al. (2002) pointed out that agriculture does not only significantly affect the environment, but is also impacted directly by changes in the environment. The social and economic impacts of environmental changes are also significant in many developing countries. Lynam and Herdt (1989) stressed that agricultural researchers should recognize the importance of the sustainability of agricultural systems, devise appropriate ways of measuring sustainability, empirically examine the sustainability of some well-defined cropping or farming systems, define the externalities present in such systems and develop methods to measure those externalities. Many previous researches therefore have concentrated on the assessment of agricultural sustainability all over the world and considerable efforts have been made to identify appropriate indicators for agricultural sustainability (Rigby et al., 2001; Van der Werf and Petit, 2002; Prada et al., 2003; Peschard et al., 2004; Bachev, 2005).

In Turkey, agriculture is still a relatively important sector. It contributed 12.9% of gross domestic product and accounted for 32.9% of total employment (TURKSTAT, 2007). Nowadays, a serious attention has come into existence about the sustainability of agriculture in Turkey due to the environmental problems facing it such as deterioration of land, contamination of water etc, bothforcing the economic factors surrounding the farmers and willingness of Turkish farmers to increase crop yield has caused intensive use of chemical inputs. This transition process has been enhanced by providing subsidies on inorganic fertilizers; pesticides and irrigation equipment to enable farmers adopt these technologies for increasing crop yields in Turkey (MARA, 2004). Synthetic fertilizer use has increased approximately 4 times during 1970-2002 (AERI, 2003). Fertilizer consumption is 76.8 kg per ha of arable land (World Bank, 2007).

Fertilizer intensity coefficient in Turkey (0.038 ton/ton biomass) is higher than the mean of the World (0.035 ton/ton biomass) and increased by 11% during last decade (Ceyhan et al., 2002). Similarly, using levels carbamates insecticide, carbamates herbicides, amides, rodenticides and triazine has increased by 61, 90, 100, 50 and 64% respectively in Turkey during the years 1994-2001 (FAO, 2008). Intensive use of fertilizers and pesticides have led to deterioration of land (Tanrıvermiş, 1996; Kızılkaya, 1998; Aşkın, 2000), contamination of ground water (Balkaya et al., 1996) and residue accumulation on some crops (Kumbur et al., 1996).

Nowadays, the environmental problems such as deterioration of land and contamination of water sourced by agrochemical use have become a current issue in Samsun. Ceyhan et al. (2002) reported that fertilizer intensity coefficient in Samsun was 0.031 ton/ton biomass and increased by 43% during the last decade. Also, ratio of chemical fertilizer applied to the area was 98% and only 7% of the farmers used the fertilizers through the soil analysis. Similarly, the ratio of pesticide used area was 73% and only 8% of the farmers applied the pesticide according to the guide on the box. It was clear from the upper evidence that there is a need of evaluation of agricultural sustainability in Samsun. However, little work has been done on assessing the agricultural sustainability at farm and aggregate level in Samsun.

Although lots of sustainability indicators have been developed all over the World, many of them do not cover ecological, economic and social aspects of sustainability. Rasul and Thapa (2003) stated that indicators used in one country are not necessarily applicable to other countries due to variation in biophysical and socio-economic conditions. Similarly, Dumanski and Pierri (1996) suggested that indicators should be location specific and constructed within the context of contemporary socio-economic situation. Therefore, the objectives of this study were (i) to identify appropriate location specific indicators for agricultural sustainability and (ii) to examine empirically the agricultural sustainability at both farm and provincial level in Samsun province of Turkey. This study is the first empirical analysis that covered economic, social, environmental and bio-physical aspect of agricultural sustainability in Turkey.

METHODOLOGY

The research area

The area of Samsun is 957,888 ha and approximately half of it is agricultural land, while the rest are forest, meadow and pasture. Samsun has a mild climate (TURKSTAT, 2007). In general, Samsun province can be divided into three sub regions in terms of agricultural and geographical characteristics. First sub region is coastline area, which involves eight different districts and covers 279 thousand hectares of land. Second is a transition region and it covers 27 thousand hectares of land. The third one is a highland plateau and involves five districts.

It covers 144 thousand hectares of land (MARA, 2005) (Figure 1). Forty seven percent of the total agricultural land in Samsun is first, second and third soil class, while the ratio of fourth, sixth and seventh soil class land is 44% (MARA, 1984; MARA, 2001). Only 18% of the total agricultural land has irrigation possibilities in Samsun (Demir ve ark., 2002). There are 103,752 farms in Samsun and approximately 90% of them involve in both crop and animal production (TURKSTAT, 2007).

Samsun ranks 14th order among 80 provinces of Turkey with the population of 1.2 million and approximately, 77, 19 and 4% of total population lives in the first, second and third sub regions, respectively. Agricultural population density is 3 people per hectare. The greatest majority of population lives in the first sub region. Gross national income per capita is around $2300 in Samsun (TURKSTAT, 2005).

Framework for the assessment of agricultural sustainability

A single sustainable index was used for assessing the agricultural sustainability in Samsun province of Turkey. Agricultural sustainability indices were developed for 3 sub regions. The aggregation of two or more indicators to form an index comprises interconnected four-part process; selection of variables, transformation of data, weighting of index and valuation of index (OECD, 2002).

Forty suitable indicators were characterized for agricultural sustainability assessment, which were subsequently divided into four groups: economic, social, environmental and bio-physical. Each group covers ten indicators. Final indicators were given in Table 1. Since the selected variables did not have the same dimension, transformation was performed in the study. Transformation methods include normalization, standardization and distance to policy target analysis of data (OECD, 2002). Methodologies suggested by Barrera-Roldan and Saldivar-Valdes (2002) were applied in this study when transforming the indicator variables. According to the procedures, all indicator values for 3 different agro-ecological sub regions were transformed into a relative score between 0 and 1. Score 1 means sustainability at satisfactory level, while the score 0 means sustainability at unsatisfactory level. Two transformation equations were used in the study. Equation1 was applied for indicator variables where high scores were classified as being more sustainable, while Equation 2 was used

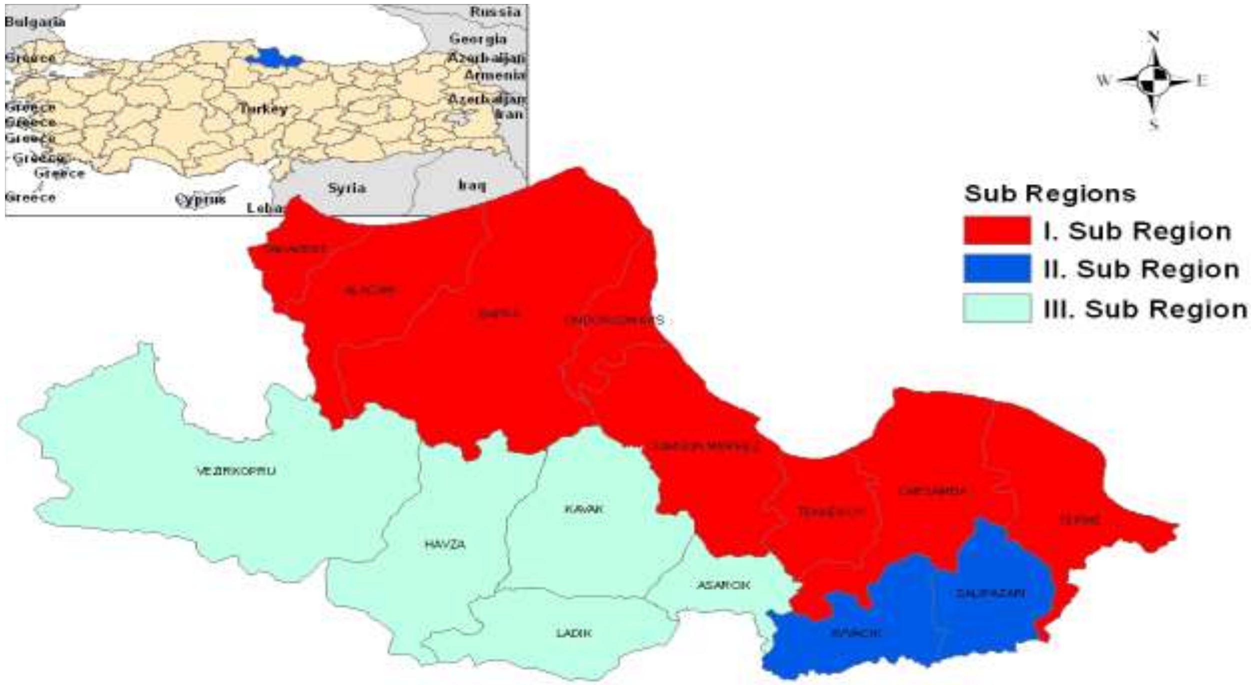

Figure 1. The map of the research area.

when the reverse was the case.

$$Index = 1 - \frac{[Maximumvalue] - [X]}{[Maximumvalue - Minimumvalue]} \quad 1$$

$$Index = 1 - \frac{[X] - [Maximumvalue]}{[Minimumvalue - Maximumvalue]} \quad 2$$

In index valuation, maximum and minimum values were determined from existing real figures rather than a theoretical maximum or theoretical minimum. So, maximum and minimum values were assigned for all indicators and used in equation 1 and 2.

Weighting of index constituent variables involves judging and assigning a value to the relative importance of various components of the index (OECD, 2002). When summarizing all the information in an overall judgment, the weighted sum ranking method was used. Since Andreoli and Tellarini (2000) stated that it is not possible to set a system of weights that could be generally applied due to the fact that different situation can result in different levels of importance given to biotic, social and cultural needs, we decided touse same weight for all groups in order to eliminate influences of weights on the results of the multi-criteria analysis. Indicators in each group were summed to give a final score out of 10. Economic, social, environment and bio-physical indices were developed for all sub regions. From these indices, a final index of agricultural sustainability was calculated by summing all four index scores and multiplying by 2.5 to give a final score out of 100.

Statistical analysis

One-way analysis of variance (ANOVA) was used to test the hypothesis and by that means, they were equal when comparing the 3 different sub regions in terms of non-categorical scale variables. Once it was determined that differences existed among the means, pair wise multiple comparisons were made using Duncan's Multiple Range Test.

Data

The farm level data used in this study were collected by using structured survey from randomly selected 93 farms in Samsun province of Turkey during the production year of 2004 - 2005. During the sampling process, following identification of the study population, sample frame was defined and subsequently sample size was determined by the simple random sampling method (Yamane, 1967). Survey would target the answers to its questions to be 90% accurate with a 10% margin error. Numbers generated randomly from a table of random numbers were used to select the farmers. According to the random numbers, optimum sample size covered 63 producers from 32 villages out of 637 in the first sub region, 23 producers from 23 villages out of 289 in the second sub region and 7 producers from 5 villages out of 69 in the third sub region. The questionnaire was pre-tested both internally and in a few sessions with producers and was refined over several stages based on the comments and suggestions so received. The secondary data was gathered from provincial agricultural statistics, research station records and agricultural institutions records for each sub region of Samsun.

The variables included in this study can be divided into four groups: economic, social, environmental and bio-physical.

Ten different farm level variables were included in economic group. The variable of return on assets (ROA) (%) is utilized as an indicator on how profitable a farm is, relative to its assets and was calculated by dividing a farm's annual income by its total assets. Second variable was economic efficiency. Farm level economic efficiencies were calculated by using Data Envelopment Analysis

Table 1. Final sustainability indicators used in the study.

Group	Indicators
Economic	Return on asset (%)
Economic	Economic efficiency
Economic	Total factor productivity
Economic	Risk (%)
Economic	Net farm income per capita ($/person)
Economic	Credit use ($/ha)
Economic	Ratio of farms having unoccupied farmland (%)
Economic	Ratio of farms planning operating investment (%)
Economic	Ratio of farms extend their farmlands (%)
Economic	Ratio of farms invest capital to off-farm (%)
Social	Ratio of village not to enjoy sewerage system (%)
Social	Distance from nearest health institution (km)
Social	The ratio of village having insufficient drinking water (%)
Social	The ratio of asphalted road (%)
Social	Population/government health official
Social	The number of student per teacher
Social	Ratio of farm having social security (%)
Social	Agricultural population density (person/ha)
Social	Ratio of farm that their title deed are belong to more than two person (%)
Social	Ratio of farm deciding to break away agriculture (%)
Environment	Technical efficiency
Environment	Size of cultivated area applied synthetic fertilizer / total cultivated area (%)
Environment	Size of cultivated area applied pesticide/ total cultivated area (%)
Environment	Ratio of farm used more synthetic fertilizer than suggested level (%)
Environment	Ratio of farm used more pesticide than suggested level (%)
Environment	The number of factory established in first class area
Environment	Ratio of farm operators who supported the idea of cutting woodland off to gain extra farmland (%)
Environment	Ratio of farm operators who supported the idea of establishing factory on agricultural land (%)
Environment	The size of organic farming area (ha)
Environment	Ratio of settlements founded on first and second class agricultural land (%)
Bio-physical	Ratio of land where organic matter is low (%)
Bio-physical	Crop diversity (Simpson index)
Bio-physical	Ratio of shallow land (< 20 cm) (%)
Bio-physical	The size of IV, VI and VII class land /total agricultural land (%)
Bio-physical	Ratio of farm faced with irrigation water shortage (%)
Bio-physical	Ratio of agricultural land faced with severe water erosion (%)
Bio-physical	The quality of irrigation water (salinity, C4 (%))
Bio-physical	Ratio of agricultural land that their pH is not between 6.8 and 7.3 (%)
Bio-physical	The size of land that their slope is more than 20%/total agricultural land (%)
Bio-physical	The size of soil that their saline amount is more than 0.15%

(DEA). DEA is one of several techniques that can be used to calculate a best practice production frontier (Coelli et al., 1998). The Farrell input oriented efficiency measure was used as a measure of efficiency, since farms tended to have greater control over their inputs. The Farrell measure equals 1 for efficient farms on the frontier and then decreases with inefficiency. The economic efficiency of the farms was modeled in a three inputs (land, labor and capital) and single output framework. Total factor productivity was the third economic variable. Fourth economic variable was downside risk faced by farms (%), which reflects the likelihood that gaining farm income is less than the variable expenses of farm. In order to reveal the effect of the off farm investment on sustainability, the variable of farms ratio invests capital outside the farm (%) was included in the analysis as an economic variable. The other economic variables were net farm income per capita ($/person), credit use ($/ha), ratio of farms having unoccupied farmland (%), ratio of farms planned operating investment (%) and ratio of farms planned to increase size of their farmland (%). Social variables group included ten different variables obtained from both farm and provincial levels. Provincial level social variables were;

Table 2. Socio-economic characteristics of sample farms in Samsun province of Turkey.

Variables	First sub region (n = 63)		Second sub region (n = 23)		Third sub region (n=7)	
	Mean	Std.	Mean	Std.	Mean	Std.
The age of farm operators (year)	50.25[ab]	10.52	54.13[b]	10.27	45.43[a]	4.46
Family size (person)	4.54[b]	2.45	5.04[c]	3.28	3.14[a]	1.44
Experience of operators (years)	36.83[b]	11.44	39.33[b]	10.89	28.00[a]	8.64
Total family consumption ($/year)	8646.54[b]	7949.43	6149.17[ab]	4822.92	3433.75[a]	1779.51
Farm size (ha)	5.26[b]	5.60	5.77[b]	5.29	4.44[a]	2.73
Un-irrigated area (ha)	3.12[a]	3.70	5.65[b]	3.15	4.15[a]	3.42
Irrigated area (ha)	2.14[a]	1.90	0.12[b]	0.21	0.29[b]	0.08
Number of plot (unit)	4.53[a]	3.43	8.05[b]	4.34	8.00[b]	4.20
Credit use ($/ha)	333.31[a]	433.23	239.23[a]	212.92	193.15[a]	233.77
Off farm income ($/year)	1660.63[b]	2412.33	775.25[ab]	706.77	439.56[a]	549.45
Return on asset (%)	5.85[a]	5.21	4.75[b]	4.37	5.55[a]	4.77

*The sub regions with different letter(s) are significantly different.

ratio of village not to enjoy sewerage system (%), distance from nearest health institution (km), ratio of village having insufficient drinking water (%), ratio of asphalted road (%), sufficiency of government health officials, number of students per teacher and agricultural population density (person/ha). The variables of ratio of farms having social security (%), ratio of farms that land ownership belong to more than two persons (%) and ratio of farms deciding to give up agriculture (%), constituted other farm level social variables.

Environmental variables were also gathered from both farm and provincial documents. Ratio of farm operators who supported the idea of cutting off woodland to gain extra farmland (%) and ratio of those who supported the idea of establishing a factory on agricultural land (%) were the proxy variables that reflects the consciousness of the farmers when using natural resources. Farm level technical efficiency, size of cultivated area applied chemical fertilizer/total cultivated area (%), size of cultivated area applied pesticide/total cultivated area (%) and ratio of farms that use more synthetic fertilizer than suggested level (%) were other farm level environmental variables. Provincial environmental variables group included the variables of the number of factories established in first class agricultural land, size of organic farming area (ha) and ratio of settlements founded on first and second class of agricultural land (%). Crop diversification index was the first bio-physical variable. It was calculated by using the following formulae:

$$CDI = 1/(P_a + P_b + P_c + ...P_n)/N_c$$

where CDI was the crop diversification index, P_a was the proportion of sown area under crop a, P_b was the proportion of sown area under crop b, P_c was the proportion of sown area under crop c, P_n was the proportion of sown area under crop n and N_c was the number of crops. The other bio-physical variables were: the ratio of land where organic matter is low (%), the ratio of shallow land (< 20 cm) (%), the amount of IV, VI and VII class land /total agricultural land (%), the ratio of farm faced with irrigation water shortage (%), the ratio of agricultural land faced with severe water erosion (%), the quality of irrigation water (salinity, C4%), the ratio of agricultural land with pH which is not between 6.8 and 7.3 (%), the size of land that slope is more than 20% / total agricultural land (%) and the size of soil with >0.15% saline (%).

RESULTS AND DISCUSSION

Research results showed that sample farms conducted their activities on 5.33 ha of farmland, in which only 39% of it had the irrigation facilities and consisted of 6 different plots, on average. Farm households compromised 4 people on average. Farm operators averaged 51 years old. Their farming experience was vast, while their education level was moderate. On average, they received $2,368 of net farm income per hectare from $41,637 of total assets per hectare. Their ROA was approximately 5.5%. In addition, they have $1,354 off farm income. They also used a few credit and preferred to use equity. Only 35% of the total sample of farmers used credit, averaging $300 per ha in a year. Annual family consumption was $7,657 on average (Table 2).

It was clear that farmers who conducted their activities in the first and second sub regions had more farmland than those that conducted their activities in the third sub region. Most farmland in the second and third sub regions was dry land, while more than half of the farmland was irrigated in the first sub region. Similarly, land consolidation need was more in the second and third sub region compared to the first sub region. Farm operators in the third sub region were younger and less experienced than that of other sub region.

On the other hand, farms in the first sub region gained more ROA than the second sub-region and more off farm income when compared to the third sub regions (Table 2). In general, cash crops such as hazelnut, maize, rice, tobacco and vegetables were dominant in the first sub region, while wheat, sugar beet and barley were the main field crops in the second sub region. Farmers tended to raise animal and fodder crops in the third sub region of Samsun.

Table 3. Economic sustainability of the farms in Samsun province of Turkey.

Indicators	1st sub region		Second sub region		Third sub region	
	Value	Index	Value	Index	Value	Index
Return on asset (%)	5.85	0.14	4.75	0.06	5.55	0.12
Economic efficiency	0.83	0.83	0.69	0.69	0.78	0.78
Total factor productivity	1.3	0.53	0.5	0.30	1.11	0.41
Downside risk (%)	33.36	0.66	47.21	0.53	40.02	0.60
Net farm income per capita ($/person)	4437.4	0.60	1630.2	0.02	2353.5	0.17
Ratio of farms having unoccupied farmland (%)	33	0.67	53	0.47	33	0.67
Ratio of farms planning operating investment (%)	37	0.37	23	0.23	86	0.86
Credit use ($/ha)	333.31	0.42	239.23	0.35	193.15	0.23
Ratio of farms extend their farmlands (%)	35	0.35	46	0.46	86	0.86
Ratio of farms invest capital outside farm (%)	18	0.82	22	0.78	29	0.71

Table 4. Social sustainability of the farms in Samsun province of Turkey.

Indicators	First sub region		Second sub region		Third sub region	
	Value	Index	Value	Index	Value	Index
Ratio of village not to enjoy sewerage system (%)	91.26	0.09	78.15	0.22	100.00	0
Distance from nearest health institution (km)	5.32	0.23	5.89	0.21	6.07	0.20
Ratio of village suffering drinking water (%)	16.79	0.83	8.23	0.92	18.09	0.82
Ratio of asphalted road (%)	58.53	0.59	48.69	0.49	13.57	0.14
Population/government health official	218.44	0.76	286.19	0.63	572.40	0.05
The number of student per teacher	19.23	0.72	23.06	0.46	28.34	0.11
Ratio of farm having social security (%)	49	0.49	74	0.74	43	0.43
Agricultural population density (person/ha)	3.33	0.42	1.57	0.86	1.80	0.80
Ratio of farm that their title deed are belong to more than two person (%)	63	0.37	52	0.48	29	0.71
Ratio of farm deciding to give up agricultural activities (%)	16	0.84	55	0.45	72	0.28

Evaluation of agricultural sustainability

Sustainability indices revealed that economic viability of farms were at unsatisfactory level in the research area. In terms of economic sustainability, the second sub region was the worst, while the third sub region was the best. Farmers who conducted their activities in the first sub region had higher return on asset and lower production cost compared to other sub regions. Moreover, their total investment was higher and investment outside the farm was lower than that of the rest. However, they are not eager on more investment to extend their farming operations. Since the farms in third sub region were more desirous on future investment to extend their farmland than farms in first sub region, they appeared economically more sustainable. Although farms in the first and third sub regions were economically sustainable, their sustainability level was unsatisfactory. Their economic sustainability was approximately 50% far from the ideal level. Main barriers decreasing the economic sustainability differed for the three sub regions. Low level of return on asset and low level of aspiration for future investment were the main economic problems in the first sub region. Off farm investment was the main threat in the third sub region. In the second sub region, the main economic threats were downside risk and having more unoccupied farmland (Table 3). Considering social sustainability, infrastructure problem had a priority. The most sustainable sub region was the second, while the third sub region was the worst. Problems sourced by sewerage system, insufficient health service and asphalt road were the basic barriers in the third sub region. Absence of sewerage system and distance to health institution were social threats for the first and second sub regions (Table 4).

Environmental sustainability was also at unsatisfactory level in the research area. Tendency of excessive use of synthetic fertilizer was the main problem for all sub regions. Synthetic fertilizer and chemical usage was more in the first sub region compared to others. Presence of organic production was the main advantage for the first sub region (Table 5). The first sub region was the best in

Table 5. Environmental sustainability of the farms in Samsun province of Turkey.

Indicators	First sub region		Second sub region		Third sub region	
	Value	Index	Value	Index	Value	Index
Technical efficiency	0.78	0.78	0.73	0.73	0.83	0.83
Size of cultivated area applied synthetic fertilizer / total cultivated area (%)	68	0.32	44	0.56	56	0.44
Size of cultivated area applied pesticide/ total cultivated area (%)	63	0.37	51	0.49	60	0.40
Ratio of farm used more synthetic fertilizer than suggested level (%)	31	0.69	26	0.74	29	0.71
Ratio of farm used more pesticide than suggested level (%)	39	0.61	32	0.68	42	0.58
The number of factory established in first class area	4	0.40	1	0.90	0	1
Ratio of farm operators who supported the idea of cutting woodland off to gain extra farmland (%)	3.72	0.96	5.00	0.95	7.25	0.93
Ratio of farm operators who supported the idea of establishing factory on agricultural land (%)	23	0.77	28	0.72	12	0.88
The size of organic farming area (ha)	801.30	0.17	0	0	0	0
Ratio of settlements founded on first and second class agricultural land (%)	1.57	0.98	2.48	0.97	1.35	0.99

Table 6. Bio-physical sustainability of the farms in Samsun province of Turkey.

Indicators	First sub region		Second sub region		Third sub region	
	Value	Index	Value	Index	Value	Index
Ratio of land where organic matter is low (%)	14.78	0.85	24.00	0.76	38.45	0.62
Crop diversity (Simpson index)	0.60	0.60	0.55	0.55	0.54	0.54
Ratio of shallow land (< 20 cm) (%)	20.06	0.80	33.72	0.66	26.93	0.73
The size of IV, VI and VII class land /total agricultural land (%)	38.26	0.61	17.62	0.82	39.62	0.60
Ratio of farm faced with irrigation water shortage (%)	47.00	0.53	85.00	0.15	71.00	0.29
Ratio of agricultural land faced with severe water erosion (%)	53.34	0.47	53.99	0.46	34.80	0.65
The quality of irrigation water (salinity, C4 (%))	10.35	0.90	40.00	0.60	19.00	0.81
Ratio of agricultural land that their pH is not between 6.8 and 7.3 (%)	40.39	0.40	39.16	0.39	47.70	0.48
The size of land that their slope is more than 20%/total agricultural land (%)	53.48	0.47	54.43	0.46	65.45	0.35
The size of soil that their saline amount is more than 0.15%	2.49	0.97	1.86	0.98	0.20	0.99

terms of bio-physical characteristics, while that of the second sub region was the worst. Vital bio-physical problem was water erosion in the first sub region. In the second sub region, limitation of irrigation water and unsatisfactory level of soil pH were the main bio-physical problems, while existence of sloped farmland was the main problem in the third sub region (Table 6). When focusing on the strong and weak points of the sub regions, it was clear that the first sub region was better than the others in terms of economic variables. It had high level of ROA, satisfactory level of total factor productivity and sound investment. In contrast, low level of ROA and net farm income per capita, investment outside the farm and low level of operating investment were the weak points for the second and third sub regions (Table 7). Regarding the social variables, the first and second sub regions were better compared to the third region in general. They had good condition of asphalt road for transportation and good health and education services. Willingness to continue agricultural activities and presence of organic farming activities were other positive aspects.

However, the second and third sub regions were in better position than the first one in terms of population density and social security (Table 8). In the aspect of environmental variables, the second and third sub regions were healthier compared to the first sub region. Pesticide use was closer to optimum level in the second and third sub regions, while that of the first sub region was excessive. Similarly, there was high level of

Table 7. Strong and weak points of the sub-regions in terms of economic variables

Strong points			Weak points		
First sub-region	**Second sub region**	**Third sub-region**	**First sub-region**	**Second sub-region**	**Third sub-region**
- Good ROA -Satisfactory level of total factor productivity. - Fully use their farmland. -Enough investment	- Satisfactory level of fixed investment.	- Good ROA. - Satisfactory level of total factor productivity. - Fully use their farmland. -Having enough operating investment -Willingness to extend farmland.	-Unwillingness to extent farmland -Unwillingness for future investment. -Investment outside the farm such as real estate etc.	- Low ROA and net farm income per capita. - Unsatisfactory level of total factor productivity and economic efficiency. - Presence of unoccupied farmland. - Investment outside the farm such as real estate etc. - Low level of operating investment -High level of downside risk	-Low level of net farm income per capita - Large family size - Investment outside the farm such as real estate etc.

Table 8. Strong and weak points of the sub-regions in terms of social variables.

Strong points			Weak points		
First sub-region	**Second sub-region**	**Third sub-region**	**First sub-region**	**Second sub-region**	**Third sub-region**
- Good condition of asphalt road for transportation. -Willingness to continue agricultural activities. - Satisfactory level of health and education services.	- Satisfactory level of sewerage system. - Good condition of asphalt road for transportation. - Low agricultural population density. - Satisfactory level of health service. -Strong social security.	- Satisfactory level of Agricultural population density. -There is no ownership problem.	- Unsatisfactory level of sewerage system. - Unsatisfactory level of social security. - High agricultural population density. - Ownership problem	- Unsatisfactory level of Infrastructure for education. - Ownership problem. -Unwillingness to continue agricultural activities.	- Unsatisfactory level of sewerage system. -Insufficient health, transportation and education infrastructure. - Social security problem. - Unwillingness to continue agricultural activities

consciousness on natural resources use in the second and third sub regions. The only better position in the first sub region was the presence of organic farming activities (Table 9).

Regarding bio-physical variables, the most disadvantageous point for all sub regions was irrigation water shortage. The first sub region was stronger than others in terms of soil and irrigation water related problems. Soil related problems were weak points for the second and third sub regions (Table 10).

In overall, the first sub region was in better position in terms of agricultural sustainability compared to the others. Total sustainability scores revealed that there were serious problems for agricultural sustainability. Economic problems were the basic barriers in the first and second sub regions. For the third sub region, social problems had the highest priority. The second sub region was environmentally more sustainable compared to others (Table 11 and Figure 2).

Table 9. Strong and weak points of the sub-regions in terms of environmental variables.

Strong points			Weak points		
First sub-region	**Second sub region**	**Third sub-region**	**First sub-region**	**Second sub-region**	**Third sub-region**
-Presence of organic farming activities	-Low level synthetic fertilizer usage. -Agricultural areas use for agricultural activity solely. -High level of consciousness on natural resources use.	-Low level of pesticide usage. -Agricultural areas use for agricultural activity solely. -High level of consciousness on natural resources use.	-Excessive pesticide and synthetic fertilizer usage. -There are agricultural areas for purposes of non-farming activities. -Low level of consciousness on natural resources use.	-Environmentally friendly production system is not common. -Excessive synthetic fertilizer usage.	Environmentally friendly production system is not common. --Excessive synthetic fertilizer usage.

Table 10. Strong and weak points of the sub-regions in terms of bio-physical variables

Strong points			Weak points		
First sub-region	**Second sub-region**	**Third sub-region**	**First sub-region**	**Second sub-region**	**Third sub-region**
-High level of organic matter in soil. - Low level of shallow land. - No salinity problem in irrigation water. -Low level of slope problem	-Low proportion of IV, V and VII class land	-Low level of water erosion risk. - No salinity problem in irrigation water	-Irrigation water shortage. -High level of water erosion risk -pH problem -High proportion of IV, V and VII class land	-Irrigation water shortage. -Salinity problem in irrigation water. -High level of water erosion risk -pH problem -There are lots of shallow land	-Irrigation water shortage. -pH problem -Slope problem -High proportion of IV, V and VII class land -Low level of organic matter

Table 11. Overall agricultural sustainability indices in Samsun province of Turkey.

Group	First sub region	Second sub region	Third sub region
Economic	4.75	3.89	5.41
Social	5.34	5.46	3.54
Environmental	6.05	6.74	6.76
Bio-physical	6.60	5.83	6.06
Overall sustainability	56.85	54.80	54.43

Conclusion

Research results clearly revealed that low level of return on asset insufficient investment and insufficient desire for future investment were the main economic factors hindering the sustainability. Infrastructure and ownership problems were the vital social problems for sustainability. Excessive synthetic fertilizer and chemical use, sparing high quality farmland for non-agricultural purpose, insufficient irrigation water and slope and water erosion were the other barriers for sustainability.

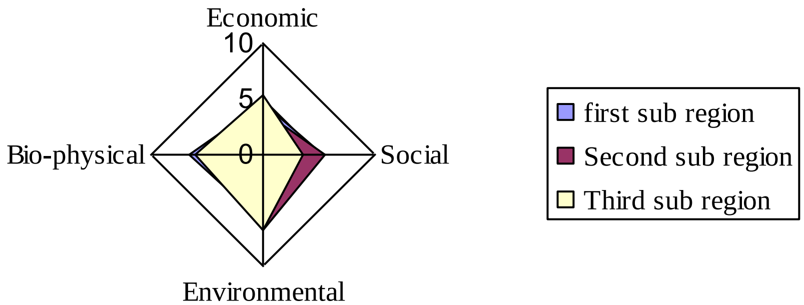

Figure 2. Cobweb diagram comparing sustainability index scores for three sub regions.

Table 12a. Solution suggestions table for the problems in the research area (1).

Issue	Solutions
Economic viability of farms	- Increasing the farm level productivity and efficiency by applying the best production methods. - Controlling production cost. - Redirecting the off farm investment to the farms. - Developing education and extension programs for farmers to increase their managerial skills. - Encouraging the cooperation among farmers. - Providing farmers with greater access to credit. - Reducing population pressure by educating the rural people via education and certificate programs.
Insufficient infrastructure	- Infrastructure investment for improving road and sewerage system by using national and international funds. - Increasing number of the teacher and improving conditions of the schools in rural areas. - Government support for improving health services. - Building irrigation canals - Building the processing, storage and package units for agricultural crops.
Social security	- Extending social security umbrella for including all farmers. - Providing education and extension programs to inform the farmers on benefits of security - Supporting the farmers by partly paying the insurance premium.
Ownership problem	- Designing and applying the law for avoiding the farmland reduction sourced by shareholders. - Completing the activities for title deed.
Thinking of leaving agriculture	- Reducing the population pressure on farm performance by creating new job opportunities. - Developing measures to increase the farm level productivity and efficiency. - Supporting the cooperation among farmers to enhance their market power. - Structural measures such as land consolidation, regulation for ownership structure, infrastructure investment and supporting policy oriented to increase farm income.

Possible solution suggestions for the research area were presented in Table 12.

Farmers should control their production costs, increase their productivity and efficiency by applying better production methods, developing education and extension programs for farmers to increase their managerial skills, providing farmers with greater access to credit, redirecting off farm investment to their farms, reducing population pressure by educating the rural people via education and certificate programs and encouraging the cooperation among farmers for being economically viable. In addition, Government should support the farm level efforts via structural measures such as land consolidation, regulation for ownership structure and

Table 12b. Solution suggestions table for the problems in the research area (2).

Issue	Solutions
-Excessive chemical input usage.	- Providing education and extension programs focusing on optimum use of chemical input. - Developing the supervisor system in agriculture. - Encouraging the soil and plant analysis for determining the optimum input use. - Encouraging the crop rotations.
-Using agricultural areas for non-farming activities	- Designing the law to hinder the farmland use for non-farming activities. - Coordinating the government institutions to provide good control.
-Low level of consciousness on natural resources use	- Providing education and extension programs focusing on natural resource use to the farmers. - Developing and applying the effective legislations.
-Irrigation water related problems	- Building the dam to reduce the insufficient irrigation water problem. - Providing the better access to laboratory service for farmers to explore the quality of irrigation water. - Organizing the course about irrigation water covering the problems and solution suggestions.
- Problems related soil	- Encouraging the benefit from farmland according to the soil class. - Accelerating the soil mapping activities. - Choosing the most suitable crops to reduce the negative effect of soil problems. - Developing the site specific measures to remove soil problems such as low level of organic matter, slope etc.

infrastructure investment. Government should also draw oriented policy measures to increase the productivity level and input use efficiency in the research area for enhancing economic viability.

Economic and political stability, which may accelerate the infrastructure investment, was the key factor to social sustainability. Infrastructure investment for improving road and sewerage system should be increased by utilization of national and international funds. Establishing the processing, storage and package units for agricultural crops may also facilitate easing infrastructure problems. On the other hand, transferring the surplus population from agriculture to other sectors for ease of hidden unemployment and ownership problems and extending the social security umbrella by providing education and extension programs to inform the farmers on benefits of security, may contribute positively to social sustainability. Increasing irrigation investment, choosing the most suitable crop varieties associated with slope and using the most appropriate farming and irrigation methods may be beneficial for decreasing the effects of bio-physical problems. Developing the site specific measures to remove soil problems and accelerating the soil mapping activities, may also contribute in solving of soil related problems.

Considering environmental sustainability, farmers should adopt t he environmentally friendly production methods such as organic and precision farming. Simultaneously, Government should organize extension programs focused on reducing synthetic chemical use and develop policy instruments controlling farm pollution via designing legislation for pollution. Encouraging the soil and plant analysis for determining the optimum input use and encouraging crop rotations may be beneficial. Drawing policy measures to protect and promote the availability of land for farming purposes may also be useful for environmental sustainability.

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