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Study on sustainability of Saffron (*Crocus sativus* L) agro ecosystem in Qaen and Torbate heydariyeh (in east region of Iran)

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ABSTRACT: In order to study Saffron agro ecosystem sustainability, an investigate was conducted in year 2013 in Qaen and Torbate heydariyeh To do this study several main and sub indicators were defined The main indicators of sustainability index include, socio economic, yield, chemical and organic fertilizer, weed control, water and irrigation, tillage and machinery The data on these indicators collected through questionnaire The results of step wise regression showed that the important factor that affected on sustainability index include, gross production of Saffron, availability of agricultural facilities, availability of agriculture extensions service, insurance availability, bank loan, tillage, Saffron farm size, irrigation and water consumption The results also showed that the studied region was not in a stable condition Only 10% of farmers obtained score equal or more than 50 from 100 The highest score among agro ecosystems was 52 The total score of Qaen and Torbate heydariyeh that obtained of 100 in order were 4046 and 3415 The sustainability index in studied region was 3730 from 100 that indicated vulnerability of Saffron agro ecosystems in this region socio economic, yield , chemical and organic fertilizer, weed control, water and irrigation, tillage and machinery main indicators obtained the 4023%, 264%,329%, 4333%, 42% and 3116% of sustainability index score

***Keywords*:** indicator, sustainability index, Saffron

INTRODUCTION

Saffron (*Crocus sativus* L) is one of important crops that has a serious effect on farmers income and provide acceptable foreign exchange for country (Tajiani & Koopahi, 2005; Ghorbani,2006) Iran, Greece, Morocco, Cashmere, Spain, Italy are the world important country of Saffron production Among these country Iran as a origin of this crop with 47208 hectares and 160 ton production is the most important country of Saffron production (Kafi, 2002) According to evidence in year 2005, Saffron production in Iran was 230 ton that was 937% of world production (Ghorbani, 2006**)** Therefore having sustainable Saffron production in Iran is very important to bring foreign exchange and provide job for labor that are deal with Saffron

Scientists defined Sustainability in different ways (Vn Ittersum, 1997 ; Webster, 1999) Finding a precision define for sustainability is difficult (Afrazz, 1997) Beus and Dunlop (1994) explained that some agricultural operations such as, pesticide, chemical fertilizer and diversity are important to achieve in sustainable agriculture as well Sustainable land and water resources management are important need of sustainable agriculture (Rasul and Thapa, 2003) Smyth and Dumanski (1993) reported that, conserving or increasing of productivity, decreasing of risk, conserving of natural resources, Socio-economic acceptability are needed for land sustainability management Agricultural

sustainability is a answer to question of anxiety of destructive side effect of conventional agriculture (Hanson, 1996) There are different idea among scientists about sustainable agriculture operation (Rigby and Caceres, 2001) The results of some study (Tisdell, 1996) indicated that using lower external energy is an important factor of sustainable agriculture Hansen (1996) believed in using some external energy to keep acceptable equivalent of soil nutrient and productivity Despite of different understanding of sustainable agriculture there are agreement on crops and livestock sustainable production, conserving environment quality and Socio-economic acceptability Several studies have done by scientists on qualitative of sustainability One of these studies carried out by Mahdavi Damghani (2005) in Iran He studied on Wheat- Cotton agro ecosystem and defined 82 sub indicators The sub indicators located in several main indicators include, Socio-economic, Agricultural and livestock production, Chemical material and fertilizer, residue management, water and irrigation, tillage an mechanization, agricultural diversity, and weeds management He used weighting sum method to obtained sustainability index According to this method each sub indicator devoted with a special score The score of each sub indicator varied from 0 to 2 The highest score belonged to best condition of sub indicator and the lowest score to worst condition After the scoring of each sub indicator, total score of sub indicator indicated the final score of each main indicator After calculation of sustainability index backward step wise analysis used to determine the important sub indicator among 82 sub indicator According to this method sustainability index considered as dependent variable and sub indicator as independent variable and the sub indicator that did not show significant effect on sustainability index were deleted and coefficient of sustainability index equation calculated by Multiple linear regression Tellarini & Caporali (2000) compared sustainability index of two high input and low input field based on energy in Italy Gowda & Jayaramaiah (1998) used 9 indicators including, integrated nutrient management, land productivity, integrated water management, integrated pest management, input self sustainability, yield stability, input productivity potential, availability of data and family food availability to evaluate sustainability in rice field in India Sands and Podmore (2000) proposed bioenvironmental indexes as a agricultural sustainability This study also carried out to understand Saffron agro ecosystem stability in Qaen and Torbate heydariyeh

MATERIALS AND METHODS

In order to study the stability of Saffron agro ecosystems, an study carried out in year 2013, in Qaen and Torbate heydariyeh In this study different aspects of sustainability was in consider To asses sustainability of Saffron agro ecosystems a sustainability index including of 90 sub indicators were designed The main indicators in this study were socio economic, weed control, tillage and machinery, water and irrigation, chemical and organic manure and yield Each main indicator include of several sub indicators The questionnaire was used to collect the data

Table 1. Classification of main indicators and values from 100 scores

Indicator	Score
Socio-economic	30
Yield	19
Chemical and organic fertilizers	14
Weed control	45
Water and irrigation	20
Tillage and machinery	125
Total	100

Sustainability index obtained through Weighting sum method (Andreoli & Tellarini, 2000; cited in Mahda vi Damghani, 2005) To do this method, a minimum and maximum score devoted to each sub indicator (0 to 4) The maximum score belonged to best condition and minimum score belonged to worst condition of sub indicator The main indicator score obtained of relevant sub indicator After scoring of each sub and main indicators the sum of score indicated the sustainability index In table 1 the score of each main indicators are shown This score are based on main indicators priority in region After designing of indicators number of 100 questionnaire prepared that 50 questionnaire belonged to Qaen and 50 of them belonged to Torbate heydariyeh province The farmer selection was independently Questionnaire filled in presence of farmer After calculating of sustainability score, step wise analyses were done to determine the most important indicators that affect on sustainability more than others According to this method sustainability index considered as dependent variable and indicators as independent variable The equation number 1 and 2, used to calculate sustainability index

Equation 1: $y= f(x_{1,} x_{2.....}x_{n)}$

Equation 2: $y= b_0+ b_1x_1+ b_2x_2+\dots b_nx_n$

b_1 to b_n, are independent variable coefficient
b_0, is the constant of equation
y, is dependent variable

According to more factors that affected on sustainability, in order to accessibility of correct results we can not evaluate simultaneously effect of all variable on sustainability index Therefore in this study only some of them according to their importance, assessed on Saffron farm sustainability index Unnecessary variables deleting was done by using step wise analysis Excel and Spss software used to analyze the data

RESULTS AND DISCUSSION

The sustainability index in Qaen and Torbate heydariyeh were 4046 and 3415 respectively and the sustainability index in studied region was 376 (table 2) The score of sustainability index in two Qaen and Torbate heydariyeh province and the average score of each main indicators are shown in table 2 The results indicated that studied agro ecosystems are not in stable condition Only 10 of farmers achieved to score of 50 or more than 50 The highest score among studied agro ecosystems was 52

Table 2. The average score of main indicators and sustainability index of Saffron agro ecosystems in east part of Iran

Indicator	Score		(%) Score	
	Qaen	Torbate heydariyeh	Qaen	Torbate heydariyeh
Socio-economic	129	1124	43	3746
Yield	746	45	2915	2368
Chemical and organic fertilizers	425	499	3035	3546
Weed control	216	147	48	3866
Water and irrigation	846	818	431	409
Tillage and machinery	429	35	3432	28
Sustainability Index	4046	3415	3798	3402

In Qaen the socio economic main indicator obtained score of 129 from 30 that was 43% of defined score (30) The yield main indicator and chemical and organic fertilizers in order obtained 74 from 19 and 425 from 14 that were equal with 2915% and 3035% The score of weed control, Water and irrigation and Tillage and machinery main indicators were 216, 846 and 429 that obtained 48%, 431% and 3432% of defined score respectively As mentioned the lowest score devoted to yield and chemical and organic fertilizers that received the 2915% and 3035% of defined score No usage organic manure and no usage of machine by farmer are the reason for lower score of these man indicators

In Torbate heydariyeh, socio economic, yield, chemical and organic fertilizers, weed control, Water and irrigation and Tillage and machinery main indicators in order obtained 3746%, 2368%, 3546%, 3866%, 409% and 28% of defined score (table 2 and 1) of these main indicators According to table 2 the weed control, yield and tillage and machinery in order obtained, 3866%, 2368% and 28% of defined score that are lower than 50% of defined score Lower sub indicator score of these main indicators such as lower yield, no controlling of weeds and lower machinery caused the lower score in these main indicators and indicated lower stability in studied regions Qaen obtained 396% score more than Torbate heydariyeh The same methods of sustainability index applied by other scientists

Mahdavi Damghani (2005), studied on wheat – cotton system in Razvi Khorasan and reported score of 436 as sustainability index of this system Iravani & Darban Astaneh (2004) reported that 467% of wheat producers in Tehran province are in the ranking of more unstable and unstable and 436% in the ranking of to some extend stable and 97% in the ranking of stable and more stable The results of Hasan Shahi (2009) indicated that 267% of wheat producers in Fars province are unstable, 431% semi stable, 302% are in stable condition

The average percent of score of sustainability index in two region shown in amoeba graph in fig1 If amoeba side is near to polygonal side, the stability is high and if the amoeba side is near to polygonal center the stability is low As shown in fig 1, the calculated score of socio-economic main indicator was more than other (4023%) Tillage and machinery main indicator score was lower than other main indicator and equal with 3116% score of sustainability index The reason for lower score of this main indicator in studied region is that, the only 39% of farmers applied disk and 43% leveler in their field Furrower and cultivator were used only in 25 and 152% of farmers field respectively They never used planter, sprayer and fertilizer broadcasting machine.

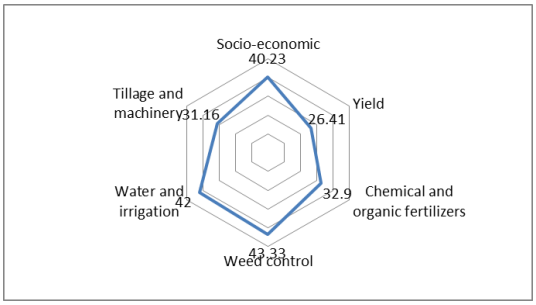

Figure 1. Amoeba graph of the sustainability indicators in Saffron field (%)

One of another effective agricultural operation on this main indicator is the kind of corm planting of Saffron Farmers did not use Saffron planter and all of them planted the Saffron corm by hand as heap planting that caused the zero score of this indicator Behnia (2008) in a 4 years study on planting method and corm density of Saffron, reported that in older Saffron field, planting method are more important than corm density on yield of Saffron He explained that Saffron yield in row planting was more than heap planting Beside machinery main indicator, the score of chemical and organic fertilizer was also lower than other main indicator (329) Nitrogen application in studied field in Qaen and Torbate heydariyeh were, 80 and 110 kg/h respectively that received 20 and 31% score of chemical and organic fertilizer main indicator The distribution of nitrogen in studied field showed in fig 2.

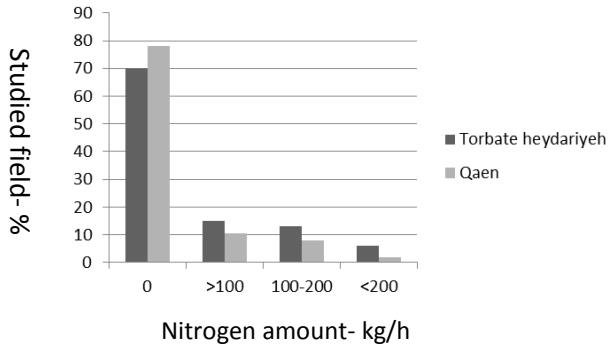

Figure 2. Nitrogen fertilizer (kg/h) consumption in studied field

Saffron is a low input crop and optimum nitrogen for suitable production is 50 kg/h net nitrogen that almost equal with 100 kg/h Urea fertilizer (Kafi, 2002) Using more than this amount of nitrogen not only produced more yield but also is a reason for more water contamination Increasing usage of nitrogen more than plant need, decreased the score of this indicator Therefore to approach to sustainable agriculture, is needed to use organic manure and biofertilizer beside suitable amount of nitrogen chemical fertilizer Omidi, (2009) reported higher qualitative and quantitative characteristics of Saffron in mixed usage of chemical with biofertilizer.

The yield main indicator obtained 2641% score of defined score (fig 1) The main reason for lower score of this main indicator, to more extended can attributed to small field size that make difficult machinery.

The relationship between Saffron yield and sustainability index in studied field in both Qaen and Torbate heydariyeh province were significant (P≤1%) (fig 3) The higher yield of Saffron is accompanied with higher stability index.

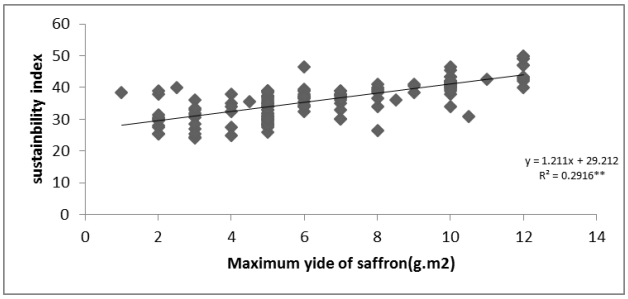

Figure 3. Relation between Saffron yield (g/m^{-2}) and sustainability index in the studied field

The results of Iravani & Darban Astaneh(2004) also showed a positive and significant relationship between wheat seed yield and agro ecosystem sustainability in Tehran province They explained that ecosystem production can attributed to economical and ecological aspect of agro ecosystem that indicated the higher potential and production and stable environmental condition of ecosystem that followed the farmer encouragement for more and better field operation Amani & Chizari (2006) reported that there were a positive and significant relationship between wheat seed yield and acceptance of low input farming, that is the farmers that gained higher yield they had a better understanding of sustainable agriculture Hayati & Karami (1999) showed a positive and significant relationship between wheat yield and knowledge of farmers The effective factor dealing with lower score of yield main indicator belonged to size of studied field that were very small Distribution of field size sub indicator shown in table 3.

Table 3. Size distribution (percent) of Saffron studied field

Area(m2)	Qaen	Torbate heydariyeh	mean
<1000	1425	20	1725
1000- 5000	29	3133	3016
5000- 10000	26	29	275
>10000	1933	23	2116

Field size is one of effective factor on Saffron yield Big size field, make possible using mechanization to do better sustainability management in field The best field size is the rate that the average of expense is in minimum rate (Hoseinzade, 2009)

No mechanical control of weed, burning the residue of weed in field and no biological control are the reason for lower score in weed control main indicator (4333).

The score of water and irrigation main indicator was also low (42%) Lower efficiency of irrigation system and more water usage are the reason for lower score of water and irrigation indicator In all studied field the irrigation system were traditional and therefore no one of field could get the 3 score of this sub indicator The results of this method of irrigation caused a plenty of water usage in Saffron field with lower water use efficiency The average of water usage in Saffron field in Qaen and Torbate heydariyeh were 3800 and 4150 m^3/h/year that is higher than Saffron water needed According to arid and semi arid regions of Iran we have to use the modern methods of irrigation with higher efficiency Karimzade Moghadam (2006) reported higher water use efficiency in Sugar beet field under the sprinkling irrigation

In order to select the effective indicator on sustainability index and deleting the unnecessary variable, step wise analyses was used and sustainability index obtained by below equation

Sustainability index=2921+ (0/0049*A) + (1/23*B) + (2/9*C) + (1/46 *D) + (0/0031*E) + (0/00041*F) + (0/0005*G) + (0/00000039*H)

S I= Sustainability index, A= Saffron gross production, B= Availability of agricultural inputs, C= Availability of agriculture extension service, D= Availability insurance and loan, E= Once plowing, F= Saffron farm size, G= Water consumption, H= other incomes The amount of estimated coefficient with T student and significant levels are shown in table 4.

Table 4. Estimated coefficients of sustainability index via stepwise regression

	b	t-student	Significant level
Constant	29/21	2301	000
Gross income from Saffron yield	00049	1617	000
Availability of agricultural inputs	123	2411	001
Availability of agriculture extension service	29	3912	000
Availability insurance and loan	146	3011	000
Once plowing	00031	1925	003
Saffron farm size	000041	6833	000
Water consumption	-00005	-1922	001
Other incomes	00000039	3362	000
R2 = 0/79	DW=1/59		

Among the affected main indicator on sustainability index, the coefficient of water consumption was negative but the coefficient of other indicators were positive According to table 4, the R^2 value is equal with 79% that indicated 79% of variability of sustainability index, exert by explained variable in table 4 In order to avoiding violation of classic hypothesis of linear regression, the necessary test was done The results indicated no self correlation, and no convergence of independent variables.

Generally, all of main indicators obtained lower than 50% of defined score that indicated lower stability in Saffron field in studied region Among main indicators the socio-economic compared with other main indicators obtained higher score After the Socio-economic other main indicators including water and irrigation, chemical and organic fertilizer, tillage and machinery, yield and weed control in order obtained lower score The average score of Qaen and Torbate heydariyeh were 4046 and 3415 respectively and the sustainability index of studied region was 3730 that indicated a vulnerable agro ecosystem of Saffron in east part of Iran Using organic manure, avoiding of planting Saffron in small size field to applied machine for land preparation and row planting, using efficient irrigation system, weed control, preventing residue burning and availability of agriculture extensions service are more important factors that can improve sustainability index in Saffron field.

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