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SOCIOECONOMIC ANALYSIS OF SOIL-LESS FARMING SYSTEM -AN COMPARATIVE EVIDENCE FROM JORDAN, THE MIDDLE EAST

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Abstract:

The soilless farming system is an exclusive technique of growing plants with the out use of soil in the large-scale farms owned by a few exporters in Jordan. The research offers an economic analysis of this soilless system for sustainable water and land use. It deals with the socio-economic compared to the conventional farming system. Two types of questionnaires were used to collect data from both systems; 32 and 68 farms, respectively. The socioeconomics was analyzed using cost-benefit Analysis. The results show the efficiency of the soilless system concerning irrigation, enhancing agricultural productivity and returns. The adopters receive a higher income, where 40% of them get more income compared to 20% in the conventional system. Furthermore, the cost-benefit analysis confirms its high profitability according to different indicators. The economic, and environmental benefits are sufficient and convincing reasons to make soilless agriculture the most agricultural practical method to accommodate growing trends in sustainability and development.
Keywords: *Soilless culture, conventional farming, cost-benefit analysis, Jordan.*
Jel Codes: *Q12, Q13, N55*

1. Introduction

Agriculture in the Middle East faces major developmental challenges of scarcity of water and land degradation. Jordan is ranked the second water-deficient country in the world, where water per capita is 88 m^3, therefore, it is below the international water poverty line of 1,000 m^3 (UNDP, 2015). In addition, the total population in Jordan dramatically increased from 6.698 million in 2010 to 9.559 million in 5 years later (DOS, 2015). Due to the recent crisis in the region, Jordan has received around 1.4 million Syrian refugees and hundreds of thousands of refugees from neighboring countries. Regarding these facts, the country should adopt sustainable agriculture to achieve food security and conserve the natural environment (Ministry of planning and international cooperation, 2015).

Agriculture consumes 65% of Jordan's water supply while contributing only 3.8% to the Gross Domestic Product (GDP) (Index Mundi, 2016). In addition to its key role in food security and trade balance development, the sector positively affects rural development and creates opportunities in the other economic sub-sectors like; the industrial and services sectors. Thus, sustainable agriculture is a critical step to achieving effective development which has led to a renewed interest in studying sufficient practices that mitigate the growing competition for scarce natural resources and alleviate the severe environmental impacts associated with the conventional farming system (CFS). Since the water scarcity is affecting all economic sectors, the adoption of a soilless farming system (SFS) is considered an efficient practice for irrigation water management and thus contributes to food security (Fernández-Cirelli, *et al.*, 2009) and improves crop productivity and reduces the pressure on water resources by promoting water use efficiency (USAID, 2014). The soilless farming system can be defined as "any method of growing plants without the use of soil as a rooting medium, in which the inorganic nutrients absorbed by the roots are supplied via the irrigation water" (Savvas, *et al.*, 2013). From the environmental perspective, soilless agriculture is a valuable solution to the shortage of soil fumigants and expensive steam sterilization as well. Furthermore, it is a sufficient farming technique for avoiding soil-borne diseases, salinization, and alteration of its physical-chemical properties which finally affect the farms' yield (Jensen, 1997). Moreover, Hussain, *et al.*, (2014) argue that modern farming systems appear to cope with the challenges of rapid growth rates of urbanization and industrialization, increasing food demand and thus decreasing arable land for food production.

Accordingly, the recent research was conducted to; assess the socio-economic aspects of SFS as an effective technique for sustainable agriculture and compare it with the CFS; determine the productivity and profitability in both farming systems; and finally discuss the incentives, challenges, and solutions of SFS.

2. Research Design and Methodology

2.1 Research Procedures

The research used quantitative and qualitative analytical descriptive design to assess the performance of SFS and CFS. The main source of the needed data is visit interviews using two questionnaires. The face-to-face interviews were used to collect data from the farmers for the year 2016/2017. The questionnaire is used to collect data on the demographic information about the SFS and CFS farmer; soilless production systems information in SFS only, financial assessment/support; irrigation water and agrochemicals application; production prices and variable costs; technology adoption in SFS and access for funds. After each section family heads in both farming systems have been asked about their perception of the existing problems and the most potential solutions that could overcome these problems and improve the profitability and productivity of their agricultural enterprises.

The sample of SFS participants applies different techniques of soilless agriculture, and different crops in eight governorates all over Jordan. However, the sample of CFS comprises 68 participants. The random selection of CFS participants was by the assistance of a local private agricultural institution. Those farmers implement protected and open field cultivation for different vegetable crops.

2.2 Sample Characteristics

Based to Israel (1992), the current research conducted for 100 farms producing vegetables, strawberries, and cut flowers adopted both production systems (SFS & CFS). The first sample contains 32 farms of 40 SFS farms in Jordan varying from large commercial farms and small rural households. The other comparative sample consists of 68 commercial CFS farms. Both production systems are scattered in eight Jordanian governorates which are located in four bio-geographical regions: Mediterranean, Irano-Turanian, Sahara-Arabian, and Sudan Penetration (ICARDA, 2012). The total area of both farming systems is 7,045,000 m^2 out of which SFS farms represent 63%. The targeting crops farms are major crops like; strawberry, tomato, cucumber, pepper, cantaloupe, lettuce, basil, coriander, parsley, thyme, mint, and cut-flowers. The irrigation water for both types of farming is supplied from the available water resources and treated wastewater (MWI, 2016).

2.3 Data Analysis

The study uses the cost-benefit analysis approach (CBA), which assesses all costs and benefits of investing in the SFS and CFS, thus reflecting the economic profitability and efficiency of both systems. The analysis focuses on direct costs and benefits and focused on water use efficiency (WUE). For economic analysis, the direct costs include the investment costs and the operational costs which compose of two parts, the first part is related to maintenance and replacement costs. The second is about the production cost of the planted crops. The direct benefits are referred to as the value of the crops based on the farm gate prices. In cost-benefit analysis, the total cost and benefits were estimated, followed by the economic evaluation which includes 1) Net Present Value (NPV), 2) Benefit-Cost Ratio (B/C) and 3) Internal Rate of Return (IRR).

2.4 Overview of the Soilless Farming System in Jordan

The United States Agency for International Development fund a project hydroponic green farming initiative (USAID, 2013). The project aimed to introduce an integrated model of hydroponic farming tied to renewable energy in commercial farms and rural households. Fandi, *et al*., (2010) conducted an experimental study on this project to estimate the benefit of using local tuff and sand substrates media in comparison with soil in tomato cultivation. The researchers found that tomato production in tuff has a higher yield. Thus, it could be evidence for the productivity of the soilless system on tuff as a substrate may be proper for tomato production without dramatic variations in yield or fruit quality and it saved about 65-70% of water consumed as well. However, the main disadvantage of adopting soilless systems is the high costs of importing compared to using local material such as black volcanic rock (tuff).

Wheat and other fodder crops such as alfalfa (Medicago sativa), barley, cowpea, and sorghum were used to estimate green fodder production and measure water use efficiency in hydroponic conditions. The study was conducted under soilless culture laboratory conditions, controlled by temperature and light. Results showed that production yields can be obtained after 8 days from planting. Cowpea and barley crops have the highest green dry yield and consume water more efficiently. They concluded that barley is the best choice to be cultivated of hydroponic for green forage with a minimum amount of water consumption (Al-Karaki and Al-Hashimi, 2011).

3. Results

3.1 Socio-economic Characteristics

The socioeconomics influences the adept new farming innovation significantly. Rogers (1995) stated that the adoption of innovation is related to the decision process through which individuals pass from first knowledge of an innovation to form an attitude towards the innovation, deciding to adopt or reject the innovation, implementing the new ideas, and confirming the adept decision. This implies that soilless farming can only be accepted by rural farmers when they have passed through the decision process and these farmers have picked an interest concerning. Feder (1985), stated that farmers adopt or practice new technologies when they expect a more profitable outcome than the existing technology. Furthermore, Adesope, *et al.* (2012) found that farming experience is negatively correlated with the adoption of new practices which means that those with less farming experience have higher adoption levels.

This section will give us an overview of the socioeconomic attributes of the SFS and CFS farmers. They include the farmer's age, educational level, agricultural experience, land ownership, and income levels.

3.1.1 Socio-economic Attributes for the SFS Farmers

Descriptive analyses illustrated the differences between the two groups of the production system. Based on the results of the descriptive analyses a set of variables were identified as hypothetical factors affecting farmers' decisions on the adoption SPSs or CPS.

The results show that all SFS farmers are Jordanian and 12.5% of them are females. However, the average age of respondents is 43 years (table 1). About 50% of the respondents have from 1 to 10 years of experience in agricultural activities, 41% from 11-20 years, and 9% more than 20 years. Regarding practicing soilless farming, ca. 19% of respondents have 4-5 years of experience, 62% have a maximum of 3 years, and 19% have between 6 to 10 years. Regarding the educational level, 81% of SFS farmers have bachelor's degrees and 19% have higher education. 53% of the respondents are originally farmers, 13% are agronomists- governmental employee, while the rest has other work in the private sector besides farm activities. 56% of the SFS farmers earn a monthly income of more than JD 1000, about 41% earn between JD 500 to1000, and the rest receives less than JD 500. It should be noted that the monthly income per family in Jordan is about 200 JD according to the survey by the Department of Statistics (DOS, 2018).

Table 1 shows that 46.9% of the respondents own the farms, 3.1% are partners, and the rest 50% rent the farms. It showed that 56.2% of the respondents had received technical support from the United States Agency for International Development (USAID), while the rest of the respondents received technical support from other foreign institutions.

3.1.2 Socio-economic Attributes for the CFS Farmers

The distribution of farms owner nationality is 66% Jordanian and 34% are non- Jordanian; Pakistani, Egyptian, and Syrian (see table 1). The average age of respondents is 47 years, and 100% are male. About 6% of the respondents have from 1 to 10 years of experience in agricultural activities, while 40% have from 11 to 20 years and 54% more than 20 years. However, about 29% of those farmers are illiterates, 24%, 41%, and 6% have secondary, bachelor's degrees, and high studies, respectively. About 90% of the respondents are farmers, 9% are agronomists- governmental employee, and the rest has a job in the private sector besides agriculture. However, 21% of the farmers have a monthly income of more than JD1000, 69% of the farmers have an income between JD 500 to 1000, and 10% earn less than JD 500.

Table 1. Socioeconomic characteristics of SFS and CFS farmers

		SFS (%)	CFS (%)
Nationality	Jordanian	100	66
	Non-Jordanian	0	34
Age	Less than< 40	46.9	41
	41-50	40.6	20.6
	More than >50	12.5	38.4
Education	Illiterate	0	29.4
	Secondary	0	23.5
	Bachelor degree	81.2	41.2
	High studies	18.8	5.9
Agricultural experience	1-10 years	50	5.9
	11-20 years	40.6	39.7
	>21 years	9.4	54.4
Soilless farming experience	> 3 years	62	
	4-5 years	19	
	6-10 years	19	
Main job	farmer	53.1	89.7
	Governmental employee	12.5	8.8
	Nonagricultural sector	34.4	1.5
Monthly income	Less than 500 JD	3.1	10.3
	500-1000 JD	40.6	69.1
	More than 1000 JD	56.3	20.6
Financial support	**No** financial support	**56**	**51.5**
	Local banks	6	5.9
	Local institutions	0	2.9
	Foreign institutions	38	39.7
Tenure system	Owner	46.9	32.4
	Partner	3.1	7.4
	Rent	50	60.3
Technical Support	No technical support	0	20.6
	USAID	56.2	4.4
	other foreign institutions	43.8	66.2
	Ministry of Agriculture	0	8.8

However, ca. 52% of the farmers don’t receive any financial support. Only 6% of them received a loan from the local bank, 3% from local institutions, while the rest received financial support from foreign institutions. In addition, 4% of the respondents have received technical support from the USAID and 66% from foreign companies and institutions. Only 9% have received support from the ministry of agriculture, while the rest hasn’t received any technical support.

The results show that 47% of the respondents own the land, while 3% are partners, and ca. 50% rent the land. About 56% of the respondents don’t receive any financial support and 6% of the respondents have a local bank’s loan, while the rest of the respondents (38%) receive support from foreign institutions. Considering land tenure, only 38% of the respondents have private land ownership, while 6% are partners, and the rest rents the land. However, 56% of them receive technical support from the USAID, while the rest receives technical support from other foreign institutions.

Regarding the willingness of the conventional farmers to learn and adopt the SFS, the interviews showed that two-thirds of respondents demonstrate genuine to medium willingness to learn and adopt this farming system. The rest of the respondents expressed a little degree of willingness to adapt the soilless farming.

3.2 Description of the Soilless Farming System in Jordan

This section describes the infrastructure of SF for crops, drainage, fertigation systems, and types of growing media. The SFS is quite a more complex system than the conventional system (soil agriculture). Figure 1 visualizes the main components of the applied SFS. It consists of several elements and each of them could have considerable influence on the productivity within the system (see figure 1).

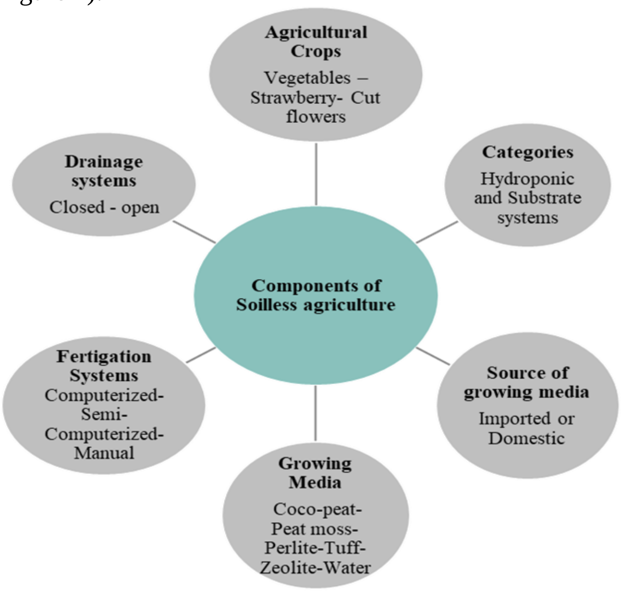

Figure 1. Main Components of the SFS in Jordan

Table 2. Areas and crops of SFS

Crops	No. of Farms	% from the Total	Area (dunum)	% from the Total Area
Tomato	3	9.4	47.8	3.16
Sweet pepper	1	3.10	7.00	0.46
Cucumber	3	9.40	4.66	0.31
Cantaloupe	1	3.10	14.00	0.92
Strawberry	8	25	1314	87
Lettuce	5	15.60	11.65	0.77
Basil	2	6.3	57.5	3,8
Thyme	2	6.30	0.41	0.03
Parsley	1	3.10	1.50	0.1
Coriander	1	3.10	1.50	0.1
Mint	1	3.10	0.16	0.01
Rosa spp.	3	9.4	49.8	3.3
Lillium	1	3.10	4	0.3
Total	32	100	1514	100

3.2.1 Crops and Area

The farms in SFS are planted with many different crops like; Tomato, Sweet pepper, Cucumber, Lettuce, Basil, Thyme, Parsley, Coriander, Mint, cantaloupe, strawberry, Rosa spp., and Lillium. About 87% of the area is planted with strawberries and 3.8%, 3.16%, 3.3% with Basil, Tomato, and Rosa spp., respectively. However, other crops were distributed on less than 1% per crop (see table 2).

3.2.2 Drainage, Fertigation Systems, and Production Conditions

The drainage system is a very important component of irrigated agriculture. Figure 2 shows about 81% of SFS farms adopt the closed drainage system on 88% of the area, while 19% of the farmers adopt an open drainage system in 12% of the planted area.

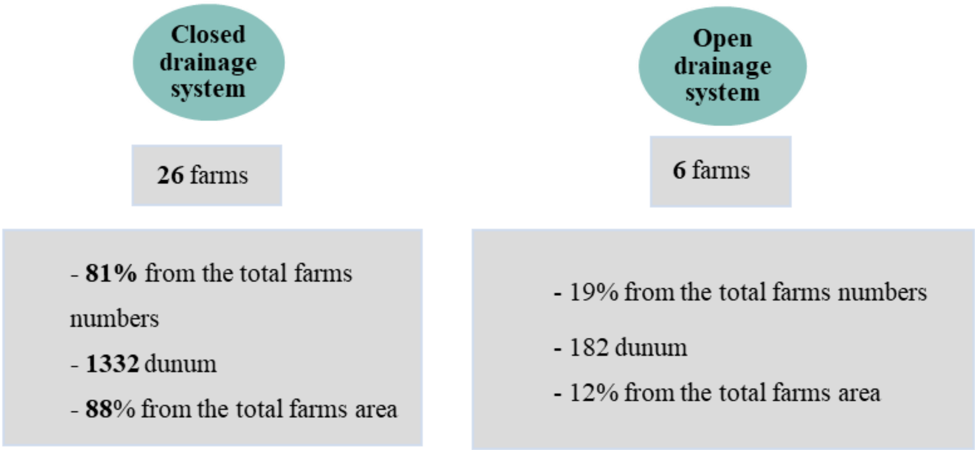

Figure 2. Areas and Drainage Systems in SFS

Table 3. Fertigation Systems and Production Conditions

Items	Computerized	Semi-Computerized	Manual	Total
Fertigation Systems				
No. of farms	15	10	7	32
A percentage of the total (%)	46.9	31.2	21.9	100
Areas (du.)	1417	91	5.78	1514
A percentage of the total (%)	93.6	6.06	0.38	100
Production Condition				
No. of farms	1	0.0	31	32
% from the total farms	3.1	0.0	96.9	100
Areas (du.)	56	0.0	1458	1514
% of the total farms' area	3.7	0.0	96.3	100

Source: Data survey.

There are three different types of fertigation systems in the SFS, namely full or semi-computerized, and manual systems. Table 3 shows that about 47% of the farms (94% of the total area) are managed by a full computerized fertigation system, while 31% of the farms (6% of the area) are managed by a semi-computerized fertigation system, and the rest 22% (0.38% of the area) managed manually. Regarding the production conditions, the production conditions for 97% of the SFS farms are manually controlled, which represented 96% of the total area. On the other hand, there is only one farm of 32 farms adopted a full computerized system for managing production conditions (see table 3).

3.2.3 Growing Media

The vital difference between SFS and CFS is the growing media. Whereas the soil is the main part of the CFS which has been replaced with other growing media in SFS. The growing materials are; Cocoa-peat, Peat moss, Perlite, Tuff, Zeolite, and water. The soil has been replaced aiming of increasing resource efficiency, productivity, and sustainability goals. Table 4 shows that 14 farms which represent 91% of the farm area used imported growing media. However, only 18 farms represent 9% of the farm area used domestic growing media (see table 4). The results display that the majority of the farms (35%) use the Coco-peat as growing media on 89% of the farm area. The second type of growing media is Tuff which is used by 22% of the farms on 7% of the area. About 19% of the 32 farms used water as plant growing media which is called the Hydroponic System (HS). Thus, the ratio of the hydroponic system in the farm area is 0.4%, while the rest ratio is the substrate-soilless system (99.6%).

Table 4. Areas, Source, and Types of Growing Media in SFS

Source of Growing Media	**Imported Growing Media**			**Domestic Growing Media**			**Total**
Kind of Growing Media	Coco-peat	Peat Moss	Perlite	Tuff	Zeolite	Water	
Farm Number % of Farms	11 (34.4%)	1 (3.12%)	2 (6.25%)	7 (21.9%)	5 (15.6%)	6 (18.75%)	32 (100%)
Total	14			18			32
Areas (du.)	1348	30	0.32	99.41	30.2	5.75	1514
% from the Total Area	89	2	0.021	6.6	2	0.38	100
Total	91%			9%			100%

Source: Data survey.

3.3 Efficiency Parameters of the Soilless and Conventional Farming Systems

This section will deal with the input use efficiency and productivity of both farming systems in Jordan. Whit regard to irrigation water, ca. 84% of the respondents in both farming systems are using groundwater for irrigation and 16% use treated wastewater.

Table 5 shows the quantities of water and fertilizers applied in CFS are three times more than in SFS, and even more. This fact reflects the efficiency of SFS according to resource use and sustainability. In addition, the productivity of SFS is three times more than that of CFS which confirms the effectiveness of this system (see table 5).

3.4 Cost-Benefit Analysis of Soilless Farming System

Cost-Benefit Analysis (CBA) is usually used to justify the investment needs and to analyze decisions of improvements in the context of the agricultural sector. It provides a clear methodology to compare the costs and benefits of different options for production systems and resource use. CBA deals with the benefits and costs of the activity over the project life span, thus discounting future values of benefits and costs into present values.

3.4.1 Costs

- *Investment Costs*

The investment costs consist of the costs of the buildings, protected houses structure, and the soilless system structure, which includes: basins, trays, pipes, fertigation unit, mulch, and the growing media. In addition, there are costs of other equipment like; pesticide sprayers motors, desalinization units, solar power systems, fixed labor, and transportation means (appendix 1).

- *Operational costs*

The operational costs include the costs of production inputs, wages of seasonal workers, electricity, fuel, and product packaging (appendix 2). CBA approach is applied in the study for Strawberry, Lettuce, and Roses production which are the most profitable products in SFS (table 5).

3.4.2 Return and Cash Flows

The farm returns are composed of the direct selling value of crop products at farm gate prices in 2015. The cash flows are calculated for the entire agricultural project life span (20 years), considering the investment costs only in the first year. Even though the very high investment cost in the first year of the project cycle, the cash flows are all positive, which reflects the profitability of the SFS project in the production of strawberries, Lettuce, and Roses. The Cash flows are the discounted returns minus total discounted costs. Table 6 shows that the capital recovery period is less than 1 year for Strawberry production, 3 for Lettuce, and 2 for Rosa spp. This means that the capital turnover period is relatively short. The recovery period is calculated by dividing the total investment costs by the cash flow. However, the rate of return on investment reflects the capital productivity which is the highest in Rosa spp. production followed by strawberry (see table 6).

3.4.3 Cost-benefit Analysis (CBA)

The analysis aims to apply fixed criteria to decide on the feasibility of the proposed projects. The most common standard criteria utilized in the cost-benefit analysis are the net present value (NPV), benefit-cost ratio (BCR) as well as the internal rate of return (IRR). NPV is the difference between the present value of cash inflows and the present value of cash outflows over some time. NPV is used in capital budgeting and investment planning to analyze the profitability of an investment. BCR is a cost-benefit analysis to summarize the overall relationship between the relative costs and benefits of a proposed project. IIR is a metric used in capital budgeting to estimate the profitability of potential investments and IIR is a discount rate that makes the net present value (NPV) of all cash flows from a particular project equal to zero (Alkaraan and Jabal, 2012).

Table 5. Annual Fertilizers and Water Consumption, Water Productivity, and Productivity in SFS and CFS

Crops	**Fertilizers Quantities (kg/du/y)**		**Water Consumption (m^3/du/y)**		**Water Productivity (kg/m^3)**		**Productivity (kg/du/y)**	
	SFS	CFS	SFS	CFS	SFS	CFS	SFS	CFS
Strawberry	191	2262	341	1000	25.98	3	8860	3000
Tomatoes	343	3350	300	1100	20.6	9.1	6180	10000
Cucumber	672.3	2390	1220	3000	25.20	10	30750	10000
Sweet pepper	330	2180	280	1100	17.85	3.63	5000	4000
Cantaloupe	330	1090	200	500	30	6	6000	3000
Lettuce (sub. media)	608	442	944	675	6.62	3.7	28220	2500
Lettuce (hydroponic)	693	442	944	675	56.33	3.7	53179	2500
Thyme	195.5	2118	1037	1000	2.06	4	2142	4000
Mint	247	N.A	988	N.A	5.06	---	5000	N.A
Parsley (hydroponic)	900	N.A	590	N.A	16.95	----	10000	N.A
Coriander (hydroponic)	900	N.A	590	N.A	16.95	----	10000	N.A
Basil (sub. media)	513	N.A	1047	N.A	20.69	----	21666	N.A
Basil (hydroponic)	1000	N.A	580	N.A	17.24	----	10000	N.A
Lillium	1500 (Kg/13000 bulb)	14040 (Kg/13000 bulb)	865 (m^3/13000 bulb)	260 (m^3/13000 bulb)	60.11 (flower/m^3)	50 (flower/m^3)	52000 Rose 13000 bulb	13000 flowers
Rosa spp.	467 (Kg/1866 seedlings)	2923 (Kg/1866 seedlings)	1233 (m^3/13000 bulb)	746.4 (m^3/1866 seedlings)	86.91 (flower/m^3)	60 (flower/m^3)	107166 flower and 1866 seedlings	44784 flowers

Source: Data survey.

Table 6. Returns and Cash Flows for some Selected Crops

Crop	Returns in JD	Cash Flow (1st year)	Cash Flow (2nd -20th year)	Capital Recovery in years	Rate of return on investment
Strawberry	1,173.69	625.58	254.50	0.8	0.47
Lettuce (substrate media)	500.48	405.69	435.06	2.17	0.46
Lettuce (hydroponic)	236.71	176.85	206.21	2.9	0.34
Rosa spp.	165.37	135.59	164.95	1.81	0.85

Source: Data survey.

Table 7. Final results of CBA indicators over 20 years at a Discount rate of 12% for SFS

Crop	NPV	B/C	IRR (%)
Strawberry	6,548,357	3.95	75
Lettuce (substrate media)	24,272,159	7.06	45
Lettuce (hydroponic)	15,085,506	6.8	33
Roses (Rosa spp.)	12,003,513	35.1	52

Source: Data survey.

CBA parameters in table 7 indicate the high profitability of SFS. Indeed, NPV is positive for all crops over 20 years included in the analysis. The B/C ratios are more than one for all crops at the 12% discount rate. The internal rate of return (IRR) is the highest for strawberry and Rosea spp. which are 75 and 52%, respectively. All of the CBA criteria indicate the high feasibility and profitability of the adoption investment of SFS (see table 7).

3.4.4 Motivation and Challenges for Adopted SFS

Considering the motivations for the adoption of SFS, about 44% of respondents asserted the desire to increase yield quantity and improve the quality. About 53% pointed out to objective of alleviating soil-borne diseases and decreasing pest infections and 41% of respondents adopted this technique to avoid the scarcity of natural resources. However, 53% of farmers pointed out that they adopt this farming system due to the encouragement and support from supporting institutions and companies (Figure 3). Therefore, 38% of the respondents said that the purpose of production is merely to meet the demands of the foreign market, while the rest which is 63% are producing crops for local markets, mainly.

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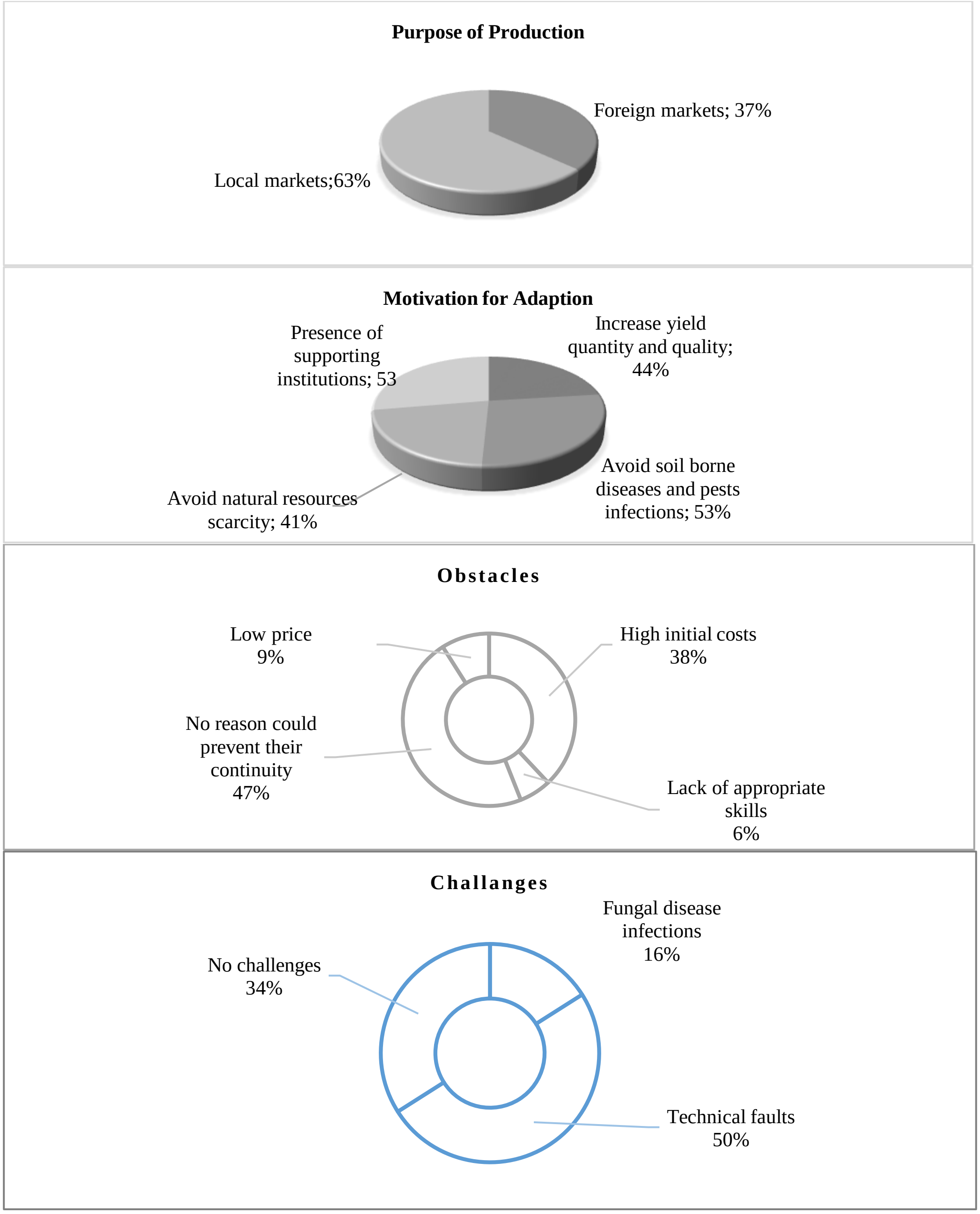

Figure 3. Motivations, obstacles, and challenges for SFS Adoption

3.4.5 SFS Adopters' Impression in Comparison to Previous Experience in CFS

Regarding the impression of the respondents about the adoption of SFS, about 97% of respondents have previously planted the same crop in the conventional system. After they turned to SFS, 53% of them noted an increase in production, ca. 41% asserted that no effect on crop production, and 6% noted that SFS adoption reduced crop production. Further impressions about the crop quality about 84% pointed out that turning to SFS enhanced crop quality and decreased loss in production which has affected positively the quantity for export. On the other hand, 6% said that the crop quality decreased, and the rest 9% see no effect on crop quality (see table 8).

However, by asking the adopters about the knowledge and skills of the soilless technique, 78% of them obtained it from foreign institutions, while 16% obtained skills from the media, and the rest which is 6% gained the knowledge by participation in foreign exhibitions and attended training courses.

Table 8. Farmers' Impressions for SFS Adoption

	Increase	Decrease	No effect	Total
Quantity				
Frequency	17	2	13	32
Percentage (%) of the SFS adopters	53	6	41	100
Quality				
Frequency	27	2	3	32
Percentage (%) of the SFS adopters	84	6	9	100

Source: Data survey.

3.4.6 Plan for the Next Five Years and the Farmers' Attitudes in CFS for the Adoption of Soilless Agriculture

The SFS adaptors declare the strong intention to expand the application of this technology over the next five years, to use new energy and fertilization sources, and to improve their experience and skills in the soilless techniques (see table 9). On the other hand, the attitudes and knowledge of CFS farmers, about the SFS had been collected. The result shows that about 96% of the CFS farmers have a good idea about SFS (table 10). An interesting fact is that 18% of the CFS farmers, which are 12 farmers have adopted the SFS, 33% of them pointed out that adoption of this system increased crop production quantity, and 33% asserted decreasing the production while 33% said that no effect for adoption on production quantity. In addition, about 59% noted that the adoption of SFS enhances product quality and 42% answered that the quality decreased. Another reason for SFS adoption discontinuity, is the high investment cost by 33% of CFS farmers, while about 67 % see the main reason for discontinuity as the lack of essential knowledge and skills for this technology (see table 10).

4. Discussion

This research focuses on two farming systems that scatter in different governorates in Jordan. The soilless farming system (SFS) is a total of 32 farms and they include two types of media: substrate media cultivations and the growing media include different types like; inorganic growing media; perlite, zeolite, tuff or organic growing media; peat moss, coco-peat; and hydroponic cultivation is applied in 6 farms in which water is the growing media. However, the soil is the growing media in 68 conventional farms.

In the line with the new technology adoption theory (Midgley, 2014), the average age of SFS farmers is 43 years. This finding confirms the youth orientation for adopting and new generation farmers able to learn and adopt new technology in agricultural practices. An interesting result is about 12% of the SFS adopters are women which ensures the gender equity attributes of this new technology and indicates the role of national and international efforts to empower women and strengthen their role in rural development and agricultural income. The education level of SFS farmers is higher than in the conventional farming system (CFS) which reflects the importance of education level in increasing the knowledge and skills of farmers which qualify them to adopt modern technologies. The high incomes have been obtained by SFS adopters in comparison to CFS farmers which reflects the economic benefits and profitability of SFS.

Table 9. Plans for the next five years of the SFS adopters

Frequency	Percentages (%)	Plans
15	47	Increase cultivated area using the SFS and increase the number of seedlings in cultivation unite
14	43	Establishing a solar panel system as a source of energy
12	38	Intend to stop using locally manufactured pesticides and turn to exported pesticides only
9	28	Turning from current fertigation system to full computerized fertigation system.
9	28	Growing medical herbal and leafy vegetables
9	28	Trying to adopt organic cultivation in a part of the farm's land area
6	19	Desalination station initiation
6	19	Building storage tanks for rainfall water harvesting
5	16	Intending to increase the number of women's labor
5	16	Shift from domestic markets to export.
5	16	Improve their experience and skills in the soilless techniques
4	13	Turning the drainage system from an open soilless system to a closed soilless system
3	9	Increases rose's cultivations area to meet the domestic market demands
2	6	Try to obtain a bank loan to establish small projects in home gardens to meet their family's vegetable requirements

Source: Data survey.

Regarding agricultural experiences, ca. 62% of the SFS adopter had less than 3 years which indicates a new orientation to this technique. However, only 38% of the adopters have between 4-10 years of farming experience. This result indicates the effort of the foreign institutions in involving these adopters in the hydroponic agricultural program which started in 2013 to 2016. Whereas, about 56% of the SFS adopters have received technical support from USAID which signposts the significant role of such institutions to enhance the adoption of modern agricultural techniques and thus the developmental benefits. About 40% of CPS farmers have also received financial support from foreign agricultural institutions which shows the effort of foreign institutions in developing agricultural areas in Jordan. We have noted here the complete absence of the role of the ministry of agriculture in supporting and developing this new technology to preserve the environment and agricultural resources. Despite this fact, one-third of CFS farmers demonstrated a growing willingness to learn and adopt the SFS which indicates their awareness of the increasing scarcity of resources.

All SFS adopters assert that working in this farming system provides decent work for laborers, safe working conditions, high returns, and provide them with advanced skills. According to the crops planted in SFS, Strawberry is the highest commercial value cash crop and it represents the largest ratio of the area about 87% which means the soilless system is a highly capable technique for strawberry production in the country. The vegetables come in second place with about 9% of the SFS cultivated area. The rest of the cultivated area was planted with cut-flowers production (4%). Furthermore, the production of cut flowers is important in Jordan as a high economic value cash crop.

Table 10. Farmer's Attitudes in CFS towards the SFS Adoption

Item	Frequency	Percentage (%)
CPS farmers' knowledge about SFS		
Did not hear about SFS before	3	4.4
Know SFS	65	95.6
Total	68	100
Previously adopted SFS		
Yes	12	17.6
No	56	82.4
Total	68	100
Adoption of SFS on yield quantity		
Increase yield	4	33.3
Decrease yield	4	33.3
No effect	4	33.3
Total	12	100
Adoption of SFS on yield quality		
Increased	7	58.3
Decreased	5	41.6
Total	12	100
Reasons for discontinuity		
High cost	4	33.3
Lack of knowledge and skills	8	66.6
Total	12	100

Source: Data survey.

The closed drainage system is applied by 88% in SFS. From the sustainability concept, this fact represents a developmental indicator of good production practice. This system is the most favorable for protected agriculture due to its simplicity, recyclability of most of its constituents, and water preservation efficiency, in addition, to mitigating the release and accumulation of agrochemicals into the environment.

The productivity of strawberry and cucumber growing in the SFS using two types of growing media, coco-peat and perlite is triple the quantities for the same crops in CFS. Moreover, the yield quantity of cantaloupe, sweet pepper, lettuce, and Rosa spp. is multiplied in comparison to the yield in CFS. These facts ensure the efficiency of the SFS in improving the crop quantity and point out the developmental aspect of this technique in food supplying, crops availability, and stability in sufficient quantity over the year and thus acceptable price which substantially contributes to food security and resource use efficiency in the country.

Tow qualities of irrigation water are used which are freshwater by 84% of SFS farms and wastewater by 16%. This result appears a good opportunity to mitigate the pressure on the freshwater which is extremely scarce in Jordan. This finding is consistent with Al-Karaki, *et al.*, (2011) who conclude that the use the treated wastewater efficiently improves the yields of green forage.

The average irrigation water quantity for strawberries is three times less than the irrigation water used in CFS. Furthermore, there is a huge increase in strawberry productivity of one m^3 water of 25 kg/m^3 in SFS in comparison to 3 kg/m^3 in CFS. Furthermore, the water consumption in the production of tomato and cucumber is 300 and 1220 m^3/du in SFS while it is for the same crops 1100 and 3000 m^3/du in CFS, respectively. For leafy vegetables like lettuce, the irrigation water consumption is 4263 m^3/du, while lettuce in CPS consumes 675 m^3/du. This hug water consumption in SFS due to the increase in growing seasons numbers for the lettuce which already reach seven seasons per year. On the other hand, the irrigation water productivity reaches 6.6 kg/m^3 in SFS in comparison to CFS which is 3.7 kg/m^3. In addition, the water productivity is 60 flower/m^3 in SFS in comparison to 50 flower/m^3 in CFS. Therefore, the irrigation water quantity and productivity prove that adopting SFS is a sustainable irrigation practice since it promotes water use efficiency and generates yield profitability at the same time while conserving the associated natural resources.

Regarding fertilization, the average fertilizer quantity for strawberries, Tomato, Cucumber, Sweet pepper, Cantaloupe, and Thyme in SFS lower than those in CFS by twelve-fold. The average fertilizer quantity for Lilium and Rosa spp. in SFS is 6 and 9-fold lower than quantities used in CFS. The findings are in agreement with the fact that CFS is characterized by extensive use of fertilizers and water (De Pascale and Maggio, 2004; Qaryouti, *et al.,* 2013). Such developmental benefit confirms the sustainability aspect of the SFS by reducing agrochemicals application and mitigates their residual impact on plants, soil, and groundwater. These findings of the study are consistent with all literature which proves the efficiency of the SFS in conserving production input by minimum consumption of water and fertilizers that lead to preventing soil degradation (De Pascale and Maggio, 2004; Polycarpou, *et al*., 2014; Wilfried, *et al*., 2013; Schnitzler, 2013; and Somerville, *et al*., 2014).

Furthermore, the research confirms the high profitability of SFS by applying cost-benefit analysis measures. Nevertheless, the high investment costs compose a great share of the total costs of SFS adoption, and they constitute a significant impediment to adoption.

Certainly, adopting the soilless techniques is addressing the food quantity (Engindeniz and Gül, 2009) and quality and it helps to create new opportunities for farmers and exporters into the local markets. Indeed, the soilless techniques have many direct developmental aspects and benefits; contribution to crop availability in adequate quantity, crop accessibility because of low prices, crops safety because of high-quality yield, and minimum amount of chemical residue. It has also indirect developmental benefits; it ensures sustainable use of water resources and thus reduces pressure on natural water resources and saves its quantity and quality. Additionally, it reduces soil degradation; salinity, and erosion, besides avoiding soil-borne diseases. These aspects will directly decrease the risks of production and improve profitability. However, the main challenges of SFS adoption from the adopters' perspectives are the technical fault since this system requires good skills and knowledge besides the export obstacles and fungal diseases and pests' infections. By discussing the next five years plan of SFS, the adopters show a great intention to increase cultivation area and modernize their farms and improve their experience and skills regarding the soilless techniques. These findings indicate the high acceptance degree for the technique and awareness of the Jordanian adopters.

5. Conclusion

The adoption decision of the soilless farming system is examined in the context of the economic analysis and the investigation of the socio-economic and efficiency determinants affecting the implementation of the system. The results are encouraging for enhancing and facilitating the adoption of this system in Jordan. It provides the decision-makers with the needed evidence of the feasibility and the efficiency of this system in the Jordanian environment.

Based on the vision of the Millennium Development Goals (Millennium Development Goal Fund, 2016), of ensuring environmental sustainability and eradicating extreme poverty and hunger, this study point toward SFS as a sustainable practice for food production technique that copes with natural resource scarcity. The social, economic, and environmental benefits of this system are the convincing reasons why it is the most practical method to accommodate growing global trends in sustainability and development.

Thus, Jordan has to pay undivided attention to the benefits of SFS and also, define a water use efficiency concept copying the country's water situation. Therefore, SFS is a sustainable food production approach, and it could be applied for a wide range of vegetable and cut-flowers production, which are: strawberry, tomato, cucumber, cantaloupe, sweet pepper, lettuce, basil, parsley, coriander, mint, thyme, Rosa spp., and Lilium. The domestic market orientation of SFS ensures providing optimal food production, quality, availability, and stability over the year with acceptable prices which contributes to food security at the country level.

From the economic point of view, SFS achieves high economic profitability; improves production yields with lower cost and production uncertainty. It could create high skills and employment opportunities and it opens new export markets which increase the income of small and rural farmers, the improve livelihoods of rural families, and generate profitability of the agricultural activities which could play a big role in reducing migration from the agricultural work.

The national and international agricultural institutions should work together with the environmental protection agencies, universities, and sustainable agricultural organizations to develop a long-term research and extension initiative aiming to understand the aggregate properties of soilless farming on land, water, environment, and national economy and to encourage the development of agricultural practices that could enhance environmental quality, simultaneously sustaining economic viability and community well-being. There is also a need to adopt mechanisms to increase local consumers' awareness and attitudes toward paying slightly higher prices for foods with lower or no agrochemicals residues Therefore, the increasing food demand deserves more research attention for practical solutions to food security in the context of social needs, water scarcity, and population.

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Conflict of interests

The authors have not declared any conflict of interest.

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Appendix 1. The Investment Cost for 47.313 m^2 of SPSs Farms in Jordan

Area (m^2)	**Soilless System Structure**						**Other Investments Costs**	**Total Investment Cost**
	Buildings*	**Protected Houses Structure**	**Fertigation**	**Fertigation Unit**	**Mulch**	**Growing Media**	**(JD)**	**(JD)**
Per 1000 m^2 (du.)	236	1853	654	499	654	322	1982	6200
For 47313m^2	11156	87686	30939	23626	30939	15252	93846	293444

Appendix 2. The Operational Costs for the Some Selected Crops

Farm No.	**Crop**	**Operational costs(JD)**	**Total Cost(JD)**
1	Strawberry (substrate media)	251.047	548.114
2.1	Lettuce (substrate media)	650.777	947.844
2.2	Lettuce (hydroponic)	301.558	598.625
3	Roses (Rosa spp.)	700.146	297.767