The Future of Agriculture in Egypt

Version 2

Comparative Full Cost Accounting Study of Organic and Conventional Crop Production Systems in Egypt

Version 2 – May 2020

The Future of Agriculture in Egypt:
Comparative Study of Organic and Conventional Crop Production Systems in Egypt

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This study is endorsed by

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Abstract

This version is subsequent to the previous version “The future of Agriculture”, which was written by the Carbon Footprint Center in 2016 (version 1, 2016). Due to our vision to face many challenges in regards to climate change, food insecurity, water scarcity, and desertification we decided to rewrite and update the original study after the new economic development in Egypt. In November 2016, Egypt floated the Egyptian Pound, against all foreign currencies, in a move that has reduced its value by almost 50% against the US dollar as one step on the long way to improved economic performance. Considering these developments, this study was initiated to update the cost analysis in different approaches in the agriculture sector with the same objective to analyze the economic costs for five of the strategic crops growing in both old and new land in Egypt in 2019 and comparing these results with the published data of 2015. Thus, getting an overview whether the organic or the conventional growing system is ecologically and economically more sustainable for the long-term future.

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Acronyms

CFC	Carbon Footprint Center
EBDA	Egyptian BioDynamic Association
FAO	Food and Agriculture Organization of the United Nations
Fd	Feddan (1 Fd = 0.42Hectare)
GHG	Greenhouse Gas
HU	Heliopolis University
MALR	Ministry of Agriculture and Land Reclamation
N	Nitrate
P	Phosphorus
WTP	Willingness to Pay

Introduction

It is important to realize that agriculture and forestry have been the largest contributors to climate damage over the past 200 years. According to a report by the Intergovernmental Panel on Climate Change (IPCC, 2019), direct agriculture and forestry and other land use (AFOLU) are responsible for nearly 23 percent of global anthropogenic greenhouse gas emissions. "Direct" in this context means that energy and transportation used in agriculture have not been taken into account, but only factors such as soil nitrogen, biomass burning, fertilizer production, animal husbandry, and irrigation. Conversely, this also means that sustainable agriculture, especially the “Biodynamic” approach, offers solutions.

Nevertheless, there is a need for global major changes in agriculture, in order to provide enough food to feed the growing population, while minimizing its environmental impacts. For more sustainable farming practices, organic farming is often proposed as a solution. Research on our own fields has conclusively shown that biological, organically cultivated crops can be competitive to the conventionally cultivated ones in expenses and benefits since organic produce contains fewer pesticides, since chemicals such as fungicides, herbicides, and insecticides are widely used in conventional agriculture and residues remain in the planted crops. Organic farming is better for the environment since it reduces pollution, conserves water, reduces soil erosion, increases soil fertility, and uses less energy.

The presented version is subsequent to the previous version: “The future of agriculture” which was written by Carbon Footprint Center (version 1, 2016). The objective of the study was to analyze the economic costs for five of the strategic crops: 1) cotton 2) maize, 3) potatoes, 4) rice, and 5) wheat, that are growing in both old and new land in Egypt in 2019, and comparing these results with the results of 2015, thus, getting an overview whether the organic or the conventional growing system is ecologically and economically more sustainable for the long-term future. These crops have been selected due to their strategic importance in terms of the cultivated area, food insecurity, economy, and employment in Egypt (Allen, 2007), according to a study funded by the industrial modernization center IMC and prepared by Booz Allen Hamilton consulting.

2. Background

2.1 Global Challenges

Global climate change is considered one of the most urgent environmental problems. The main negative impact on climate change is the emission of greenhouse gases (GHGs; CO_2, CH_4, N_2O), which is, directly or indirectly, due to the burning of non-renewable resources (carbon bound in mineral oil or coal). Tropical rainforests hold the biggest living biomass on very delicate soils that may lose their fertility completely when clear-cutting is performed as in recent decades (Alföldi et al. 2002).

Agriculture contributes to over 20 percent of global anthropogenic GHGs emissions (OECD, 2001). Moreover, agricultural intensification has had major detrimental impacts on terrestrial and aquatic ecosystems of the world. The doubling of production during the last 35 years was associated with a 6.9 fold increase in nitrogen fertilization, 3.5 fold increase in phosphorus fertilization, and a 1.7 fold increase in irrigated land (Tilman, 1999), which consequently had resulted in negative impacts on soil health and environmental contamination.

Agriculture, however, is not only contributing to global warming but is also affected by it to a major extent. According to Burdick (1994), increasing global warming will shift cultivation zones polewards, plant growth and production will be jeopardized by changes in the distribution of rainfall, UV-B radiation will increase, and the chemical composition of the atmosphere will change. In regions with a continental climate, soils are subject to desiccation. Meaning, climate change will aggravate problems of salinity, erosion, and desertification. Extreme climatic events will occur more frequently. Pests and diseases favored by a warmer climate will continue to proliferate. All these factors will have negative impacts on agricultural yields (Reilly *et al.,* 1996)

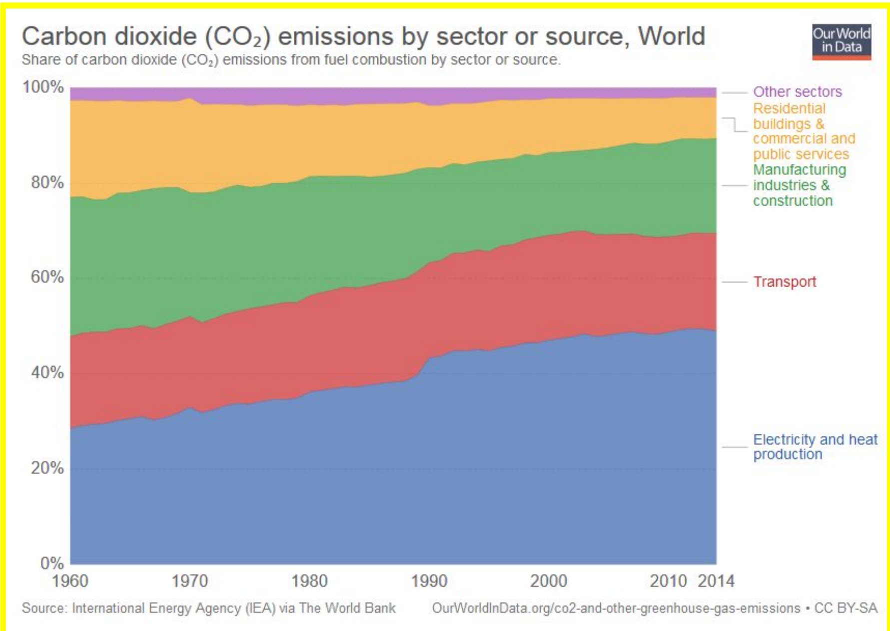


Figure 1

Globally, the primary sources of GHGs emissions are electricity and heat (31%), agriculture (11%), transportation (15%), forestry (6%), and manufacturing (12%). Energy production of all types account for 72% of all emissions (Climate Analysis Indicators Tool; World Resources Institute, 2017)

2.2 Challenges Facing Egypt

Egypt is facing many challenges related to demographics, economy, and public health, which have the potential to become exacerbated unintentionally by new problems related to the environment. For example, water scarcity continues to be a major issue for Egypt, which depends almost entirely on the Nile River for the country's water resources. According to some analysts, Egypt is on track to reach a threshold of "absolute water scarcity" by 2030. Climate changes, particularly higher temperatures are expected to shorten growing seasons and reduce agricultural yields in Egypt. Large amounts of water are also lost through evaporation every year, something that climate change will worsen. Not to mention the pollution damage to the Nile, which is widespread (Yale Environment 360, 2010).

A. Poverty

The percentage of Egyptians, who live in extreme poverty, rose to 32.5 in 2018 from 27.8 percent in 2015, with an increase of 4.7 percent, said State-owned Central Agency for Public Mobilization and Statistics (Ahram Online, 2019). According to CAPMAS's latest survey on income, expenditure, and consumption for 2017/2018, Egypt announced that individuals earning less than EGP 8,282 (US$ 501.03) annually and US$1.3 daily, live under the poverty line. The highest percentage of poverty among 99 million Egyptians was recorded in Upper Egypt, mainly in Assiut and Sohag, with 66.7 percent and 59.6 percent respectively. Poverty rates ranged from 80 to 100 percent in about 46 villages in these two governorates (Ahram Online, 2019).

B. Water Scarcity

Egypt has been suffering from severe water scarcity in recent years. Uneven water distribution, misuse of water resources, and inefficient irrigation techniques are some of the major factors playing havoc with water security in the country. Egypt has only 20 cubic meters per person of internal renewable freshwater resources, and as a result, the country relies heavily on the Nile River for its main source of water. The River Nile is the backbone of Egypt's industrial and agricultural sectors and is the primary source of drinking water for the population. Rising populations and rapid economic development in the countries of the Nile Basin, pollution, and environmental degradation are decreasing water availability in the country. Egypt is facing an annual water deficit of around 7 billion cubic meters. In fact, the United Nations is already warning that Egypt could run out of water by 2025 (EcoMENA 2020).

C. Agriculture

"Egypt is an agricultural-based country, where its development primarily depends upon rural resources. Agriculture contributes approximately 14% of the GDP and absorbs about 31% of the workforce. About 53% of the population lives in rural areas where, directly or indirectly, their livelihood depends upon the agricultural sector. Despite its positive and significant contributions to food security/supply, economy, employment, export earnings, and ecological balance, the agriculture sector in Egypt faces many threats and challenges which, in turn, impact rural development initiatives. The prominent challenges include land and water issues, old cultivation techniques, lack of information on marketing, poverty, degradation of natural resources and environmental issues, population growth, inadequate support services, framework and institutional constraints, and lack of agricultural and rural development policies" (Shalaby et al., 2011).

D. Soil characteristics

In the desert areas, soil types and their properties are very much influenced by geomorphic and pedogenic factors. Generally, soils in the new lands are short of nutrients (especially micronutrients), are very low in organic matter, alkaline (high pH), and have poor physical properties and moisture characteristics. In many areas, other adverse features include a high percentage of calcium carbonate ($CaCO_3$), high salinity content, and, in some cases, high gypsum content. In the main, the physical constraints are hardpans, which are formed at varying depths in the soil profile under the influence of many cementing agents. The characteristics of these resources vary considerably from one location to another because of their mode of formation. (ICARDA, 2011).

D.1. Old land

The old lands represent the largest irrigated area in Egypt and are found in the Nile Valley and Delta. These include lands which were reclaimed from the desert many generations ago and are intensively cultivated, mostly using water from the Nile. These lands, characterized by alluvial soils and spreading over 5.36 million feddan, are irrigated by traditional surface irrigation systems, which, compared to modern and improved irrigation systems, have a very low field water application efficiency of around 50%. Two problems, at most, occur on this land; continued encroachment by non-agricultural uses at a rate of 20,000 feddan/year and continued degradation of soil fertility (Amer et al., 2017).

D.2. New land

New lands include lands that have been reclaimed relatively recently, particularly since the construction of the Aswan High Dam, or areas that are currently in the process of being reclaimed. They are located mainly on the east and west sides of the Nile Delta and are scattered over various areas of the country. New lands cover 2.5 million feddan and cover old-new lands as well as new-new lands. The Nile is the main source of irrigation water, but in some desert areas also underground water is used. Sprinkler and drip irrigation regimes are common as well. The reclamation of these lands started in the early 1950s and is continuing. The government reclaimed approximately 1.92 million feddan of desert land between 1952 and 1987 and an additional 627,000 feddan between 1987 and 1991. During the fifth 5-year plan (1993-1997), the reclamation of 572,700 feddan (ca. 240534 ha) was proposed, of which about 469,900 feddan were reclaimed. (ICARDA, 2011). From the year 2011 till 2018, 235,600 feddans were reclaimed (CAPMAS, 2020)

E. Soil erosion

Soil erosion is regarded as one of the most serious environmental problems associated with land use (Morgan 1996). In many cases, erosion causes an almost irreversible decline in soil productivity and other soil functions (Biot & Lu 1995; Bruce et al. 1995) and leads to environmental damage. Egypt is located in the severely dry region extended from North Africa to West Asia. Wind erosion is considered one of the mainland desertification processes in areas exceeding 90% of the state area in the western desert, eastern desert and particularly Sinai. These areas are characterized by a fragile ecosystem, scarcity of vegetation cover, and severe drought (Wassif, 2002). Organic agriculture is a production system that is in closer alignment with natural cycles and processes. Hence, organic agriculture should also be less conducive to erosion than conventional agriculture, although this is yet to be proven.

2.3 Full Cost Accounting

One of the main objectives of this study is to raise awareness of the external effects of agriculture on the environment and society. The external effects are described as all unintended effects on the life of one person occurring during an action done by another person, which can be any action in daily life as well as any economic activity. Examples for human actions like this could include even one person spewing smoke into the air or dumping litter on the highway (Buchanan and Stubblebine, 1962).

Throughout this study, the most important examples for external costs are soil erosion, atmosphere damage through GHGs, and water damage, which are described in more detail in section 3 “Methodology”. In this study the term “Damage Costs” is used as an equivalent for the more commonly used term of ”External Costs” and they include particularly “Environmental Damage Costs”. Right now these damage costs are being paid by the society and future generations. An internalization by, for example, an environmental tax would represent a cost shift from the common responsibility to the responsibility of the polluter.

The Method of “Full Cost Accounting” is, as described in section 3 “Methodology” in more detail, highlighting the fact of further hidden costs besides the direct costs of raw material, labor, etc. This term of “Environmental Full Cost Accounting” (EFCA) can be seen as equal to the term of “True Cost Accounting” (TCA). True Costs are described as the sum of internal and external costs, which can be understood for this study as “Direct Costs” and “Damage Costs” (FAO, 2001).

3. Methodology

The study “Food Full Cost Accounting” is an economic and financial comparison of organic and conventional food production systems in Egypt for five of its strategic crops: rice, cotton, wheat, potatoes, and maize in old lands and in new lands.

The comparison structure and the calculation for the direct cost parameters are based on the methodology of the FAO Study “Economic & Financial Comparison of Organic and Conventional Citrus-growing systems” prepared by the University of Valencia in Spain in 2001, except for the financial investment calculation. This is because the presented study aims to focus on the explanation of the specific damage costs, which would be distorted by integrating financial multipliers. The calculation methodology for the damage cost parameter Water Quality, Atmosphere Damage, Greenhouse Gas (GHG) emissions, and Soil erosion is based on the FAO report “Food wastage footprint Full-cost accounting - Final Report 2014”.

3.1 Data Collection

The data collection and calculations are conducted by the Cool Farm Tool (CFC) team, led by Engineer Thoraya Seada and Dr. Ramy Mohamed. Primary and secondary data were collected from a total of four different parties, as follows:

A. Primary Data Collection:

1. Site visits: During several site visits in various Egyptian governorates such as Fayoum, Beheira, Kafr Elsheikh and Shakira, in-depth interviews with farmers were conducted to collect more data about the agri-culture process, costs, expenses and income. Each governorate was represented with at least 5 farmers.

B. Secondary Data Collection:

2. Data for the direct costs of conventional agriculture such as: raw material costs, costs for fertilizer, insecticides, fungicides, and herbicides, other costs, seed costs and labor and machinery costs was taken from the annual bulletins prepared by CAPMAS for the agriculture sector originated from the Egyptian Ministry of Agriculture (MALR)

3. The Egyptian Biodynamic Association (EBDA), provided data for the direct costs of organic agriculture.

4. The FAO Report “Food Wastage Footprint (FWF) Final Report” was used for the calculation of external damage cost: water quality (water pollution caused by pesticides and nitrate and phosphate), atmosphere damage regarding GHGs emissions, soil erosion, and pesticide poisoning.

3.2 Calculation and Evaluation

3.2.1 Carbon Footprint Calculation

The Carbon Footprint assessment is conducted by the Cool Farm Tool (CFT) which is an online greenhouse gas, water, and biodiversity calculator for farmers on this link https://coolfarmtool.org/. The CFT was originally developed by Unilever and researchers at the University of Aberdeen and the Sustainable Food Lab to help growers measure and understand on-farm GHG emissions. The Cool Farm Tool requires general information about farms, such as crop area, yield, soil type, fertilizer, and inputs, as well as some detailed information on electricity and fuel use (for field operations and primary processing). The CFT includes calculations of soil carbon sequestration, which is a key feature of agriculture that has both mitigation and adaptation benefits.

In organic farming, the calculation for the carbon footprint assessment includes the carbon sequestration through the use of compost. Carbon sequestration is defined as a long-term storage for carbon dioxide or other forms of carbon. The sequestration amount from compost may offset carbon dioxide emitted by other farm operations such as diesel consumption. Through calculations using the CFTool, the results for total GHG emission in organic farming in Egypt are calculated to be negative or zero. Subsequently, in conventional farming, the calculation for the carbon footprint assessment was done by the previously described methodology of the Cool Farm Tool.

3.2.2 Water Footprint Calculation

The concept of water footprint emerged in 2002, and it has been created in analogy to the ecological footprint. While an ecological footprint measures how much land a human population requires to produce the resources it consumes, and to absorb its waste, a water footprint measures human demand on freshwater. In November 2009, the first manual of the methodology “Water Footprint Manual” was published by the Water Footprint Network (WFN).

The Water Footprint methodology distinguishes three types of water usage:
1. Consumptive use of rainwater (greenwater)
2. Consumptive use of water withdrawn from groundwater or surface water (bluewater)
3. Pollution of water (greywater)

In organic farming, the water calculation was conducted with the previously described methodology “Water Footprint Assessment”, to determine the amount of water required per feddan (green & bluewater). The water quality costs (greywater) for organic farming equates to zero, as these costs are related to the usage of pesticides and to the number of nitrates in sources of drinking water.

In conventional farming, the calculation was conducted by using the Water Footprint Assessment to determine the amount of water required per feddan (green & bluewater). These costs are dependent on the usage of pesticides and the number of nitrates in sources of drinking water, therefore integrating greywater data as well.

3.2.3 Soil Erosion

Wind erosion ratio in Egypt is about 5.5 ton/hectare (2.33 ton/feddan) a year in the oasis areas in the western desert and 71–100 ton/hectare a year in areas of rainfed agriculture on the northwest coast, showing wind erosion risks in these areas wavering between moderate and severe (Wassif, 2002). This information was used to calculate the amount of soil erosion from wind for conventional farming and the cost is calculated according to the FAO Report.
In organic farming, the soil loss from erosion is 15% less for organic agriculture than for conventional agriculture according to Auerswald, Kainz, and Fiener (2003).

Soil erosion is treated differently for old land and new land in this study. Since the erosion of old land areas are reduced to a minimum in comparison to the new land because of the much more stable clay soil in the old land area. These circumstances are similar for conventional agriculture as well as organic agriculture

3.3 Parameters

This section demonstrates the explanation of all the used parameters in this study. In the following table, you will find a first outline of the main comparison parameters (Direct Cost, Damage Cost, and the Total Income as well as Total Expenses). After this short overview, each parameter listed in the cost tables will be explained in more detail.

Table 1: Parameters

A. Direct cost

A.1 Raw Materials Inputs
A.1.1 Irrigation Water
A.1.2 Fertilizers
A.1.3 Insecticides, Fungicides, and Herbicides
A.1.4 Seed Cost
A.1.5 Other Costs
A.2 Labor & Machinery
A.3 Certification

B. Damage cost

B.1 Water Quality
B.1.1 Pesticides in Sources of Drinking Water
B.1.2 Nitrate and Phosphate in Sources of Drinking Water
B.2 Atmosphere Damage
B.2.1 GHGs Emissions
B.3 Soil Erosion

C. Total

C.1 Total Income
C.2 Total Expenses
C.3 Net Benefit

A. Direct Cost: This represents all variable factors of production. For the sake of greater clarity, it has been broken down into different subcategories.

A.1 Raw Materials Inputs: This category represents the costs generated by inputs – that is the value of all inputs immobilized during the production process.

A.1.1 Irrigation Water: The irrigation cost includes the energy cost such as diesel and electricity used for the irrigation and calculated per feddan. As water is freely available to Egyptian farmers, the cost of irrigation is only related to the energy cost.
Cost of irrigation water regarding electricity and diesel cost calculated according to MERE prices in 2019 as follows:

- Irrigation using electricity costs 0.75 LE/KWh
- Irrigation using Diesel costs 6.75 LE/liter

A.1.2 Fertilizers: This includes the cost of compost for organic farming and the cost of fertilizer for conventional farming. The price is calculated using data from MALR for conventional farming and data from the EBDA for organic farming. The amount of fertilizer usage varies according to the type of crop.

A.1.3 Insecticides, Fungicides, and Herbicides: Conventional systems rely on pesticides (herbicides, insecticides, and fungicides), many of which are toxic to humans and animals. The data for the cost of pesticides for organic farming is assumed to be zero since no harmful synthetic pesticides are used. The emphasis in organic agriculture is on using the inputs (including knowledge) in a way that encourages the biological processes of available nutrients and defense against pests. Most pesticides are prohibited in organic farming as they can hinder these processes. In organic agriculture, management is directed towards preventing problems, while stimulating processes that assist in nutrition and pest management (IFOAM). Organic agriculture uses bio-control methods instead of synthetic pesticides.

A.1.4 Seed Costs: The cost of seeds is similar in conventional and organic farming. Prices were taken from the MALR and EBDA.

A.1.5 Other Costs: Costs that are not directly related to the manufacturing of a product or delivery of a service such as Maintenance or Emergency (annual bulletins prepared by CAPMAS with MALR data and discussions with EBDA organic farmers).

A.2. Labor & Machinery: Includes the total cost of labor required during the production cycle to perform farming tasks. Also, it includes the cost of renting machinery, since this is common in Egypt.

A.3. Certification: Cost incurred by the farmer to have his or her land certified as organic by the Organic Farming Board, which is the agency responsible for inspecting land and verifying the nature of the used growing method.

B. Damage Cost: In reference to the chapter of “2.3 Full Cost Accounting”, this cost determines the amount of damage on the environment and society caused by agriculture through the unsustainable use of water, atmosphere, and soil. The environmental impacts of food wastage have been monetized. These costs are estimated via the wastage quantities and unit costs of the related environmental and social impacts. This also applies to the categories that are assessed on the basis of per-area cost data, as the area numbers related to food wastage are at the end linked to the food wastage quantities.

B.1 Water Quality: Describes the effect on water resources, occurring through the use of pesticides and fertilizer in agriculture.

B.1.1 Pesticides in Drinking Water Sources: These estimates are based on the removal costs of pesticides from drinking water for the UK.

B.1.2 Nitrate and Phosphate in Sources of Drinking Water: These estimates are based on the removal costs of nitrate from drinking water for the UK – as no other data was available.

Table 2: Water quality cost (FWF, FAO, 2014)

Impact Category	Evaluation Method	Unit Value used (USD 2012)
Water quality (Nitrate and pesticide contamination of drinking water, N/P eutrophication)	Defensive expenditures (costs of pesticide, nitrate, phosphate removal from drinking water), damage costs, WTP to avoid.	Eutrophication (based on 0.286$/kg N leached in UK, correction for N input and output levels and agricul- cultural areas in each country, and benefit transfer) P eutrophication (based on 12.32$/kg P leached, correction for P input and output levels and agricultural areas in each country and benefits transfer) 0.78$/ha (Thailand) for pesticide contamination (total 264 million in the UK, 14.6 million Thailand, corrected for toxicity levels, area, and benefits transfer).

Benefit transfer is done as region-wide as possible. Where values for the UK and Thailand are given, UK numbers are used for developed country benefit transfer and Thailand numbers are used for developing country benefit transfer (FWF, FAO, 2014).

B.2. Atmosphere Damage: Removal of the main GHGs emissions from the atmosphere.

B.2.1 GHGs Emissions: Damage cost of GHG emissions (including deforestation and managed organic soils), based on a range of approaches, damage costs, and defensive expenditure.

Table 3: GHG Emission Cost (FWF, FAO, 2014).

Impact Category	Evaluation Method	Unit Value used (USD 2012)
GHGs emissions (including deforestation and managed organic soils)	The social cost of carbon (based on a range of approaches, damage costs, and defensive expenditure)	113 $/tCO_2e$ (globally, no benefit transfer needed)

B.3 Soil Erosion: The cost of soil loss through wind erosion caused by food production.

Table 4: Soil Erosion Cost (FWF, FAO, 2014).

Impact Category	Evaluation Method	Unit Value used (USD 2012)
Soil erosion (due to wind)	Damage costs (on-site and off-site)	27.38$/t for wind erosion (US values plus benefit transfer, plus per ha soil erosion levels from 48 countries and regional averages; corrected for soil erosion potential of different cultures)

C. Total

C.1 Total Income: The total income is calculated regarding the crop's revenue per feddan and it depends on the market price per each crop.The average premium price between organic and conventional crops was 14.49% in 2019.

Table 5: The Market price LE/Ton in 2019

Crops/Price	Rice	Maize	Potatoes	Wheat	Cotton
Conventional	6,000 LE	2,714 LE	6,000 LE	4,567 LE	16,680 LE
Organic	7,200 LE	3,250 LE	6,700 LE	5,200 LE	20,016 E

* *The mentioned table of prices is regarding the Egyptian market prices in 2019 for organic and conventional mentioned crops per tons.*

C.2 Total Expenses: The total expenses are the sum of the total direct cost which represents all variable factors of production and the total damage cost which determines the amount of damage on the environment and society caused by agriculture through the unsustainable use of water, atmosphere, and soil.

C.3 Net Benefit: The net benefit is the result of deducting the total expenses which included the direct cost and the damage cost from the total income.

4 Data Analysis: This chapter presents the calculated production costs of the five strategic crops covered by this study. It compares the cost trends of producing these crops under conventional farming and organic farming systems in old land as well as in new land in Egypt during the past four years.

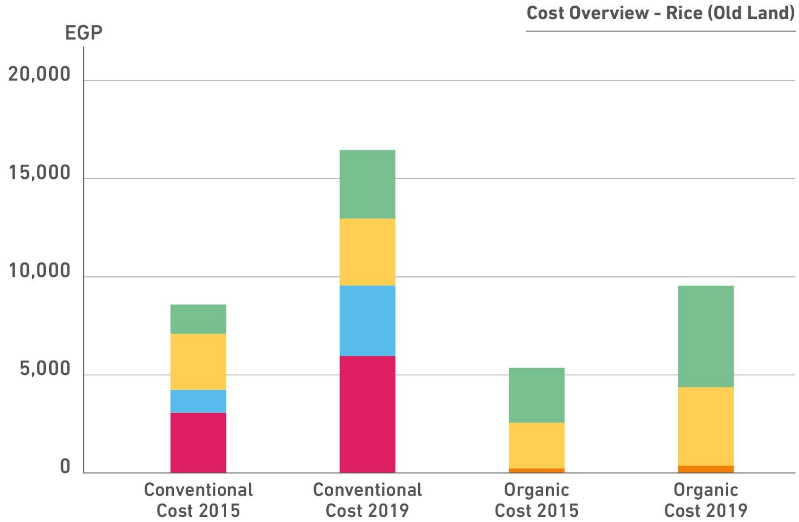
The results are presented using the previously described parameters, they include two main components of the production cost: "Direct Cost", which are costs commonly paid by the farmer during production, and "Damage Cost", which are not included in the individual cost calculation.

4.1 Rice Cost per Feddan

4.1.1 Rice Old Land Cost per Feddan

The higher direct cost for rice production under the organic farming system was calculated in 2015 at EGP 5,788, in contrast to EGP 3,933 under the conventional farming system. However, the damage costs in conventional systems were around EGP 4,444 compared with EGP 0.0 for organic farming, while in 2019, the direct cost for rice production under the organic farming system was calculated at EGP 9,367, in contrast to EGP 6,795 under the conventional farming system. However, the damage costs in conventional systems were around EGP 9,714 compared with EGP 0.0 for organic farming.

Cost Overview - Rice (Old Land)

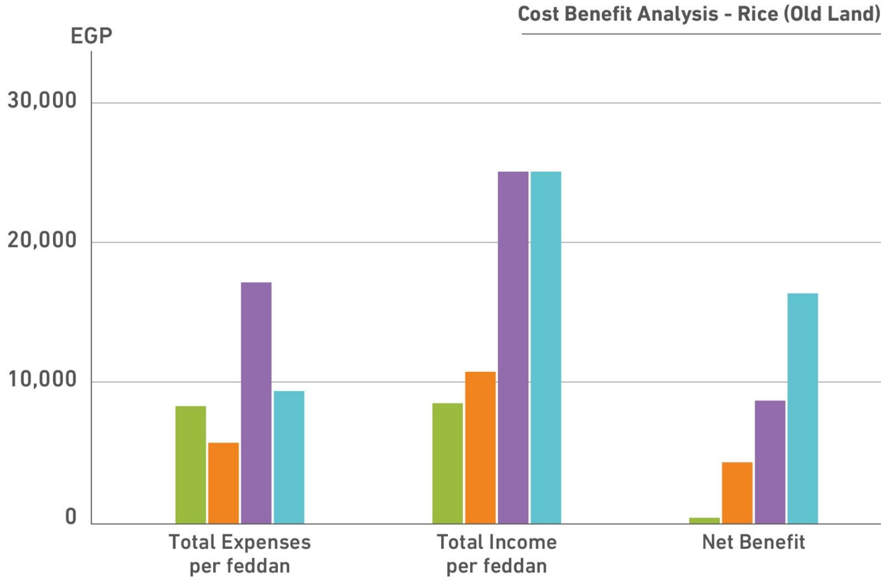


	Conventional Cost 2015	Conventional Cost 2019	Organic Cost 2015	Organic Cost 2019
Soil Erosion	0	0	0	0
Atmosphere Damage	2,868	6,341	0	0
Water Damage	1,575	3,373	0	0
Damage Costs	4,444	9,714	0	0
Certification	0	0	100	150
Labour & Machinary	2,228	3,650	2,680	4,200
Raw Materials	1,705	3,145	3,008	5,017
Direct Costs	3,933	6,795	5,788	9,367

As shown in Figure 4 total expenses per feddan for conventional farming in 2015 are calculated to be 8,377 EGP and the total income was 8,583 EGP. Therefore, the net benefit was 207 EGP. While in organic farming the total expenses were 5,788 EGP and the total income was 10,928 EGP. Therefore, a net benefit was calculated to be 5,140 EGP. These results clearly emphasize the remarkable advantage of organic farming.

In 2019, the total expenses per feddan for conventional farming are calculated to be 16,508 EGP, and the total income was 25,200 EGP. Therefore, the net benefit was 8692 EGP, while in organic farming the total expenses were 9,367 EGP and the total income was 25,200 EGP. A net benefit was calculated to be 15,833 EGP. These results clearly emphasize the remarkable advantage of organic farming.

Cost Benefit Analysis - Rice (Old Land)



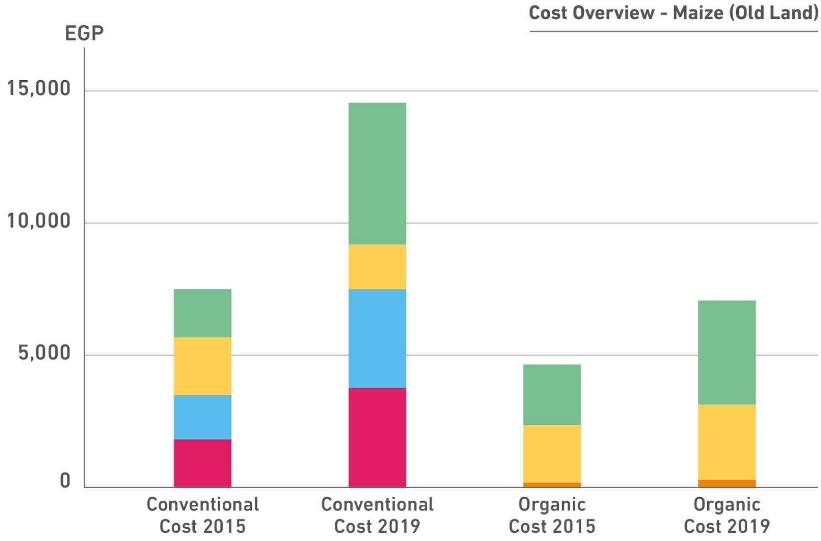
	Total Expenses per feddan	Total Income per feddan	Net Benefit
Conventional 2015	8377	8583	207
Organic 2015	5788	10928	5140
Conventional 2019	16508	25200	8692
Organic 2019	9367	25200	15833

4.2 Maize Cost per Feddan

4.2.1 Maize Old Land

In 2015, the direct production costs for maize, growing in the old lands were higher under the organic farming regime, calculated around 4,713 EGP. However, in conventional farming, the direct cost was around EGP 3,761. In contrast, the damage cost in conventional systems was calculated to EGP 3,470, while in 2019, the direct production costs for maize, growing in the old lands are higher under the organic farming regime, calculated at around 7,037 EGP. However, in conventional farming the direct cost is around EGP 7,241. In contrast, the damage cost in the conventional system was calculated at EGP 7,328

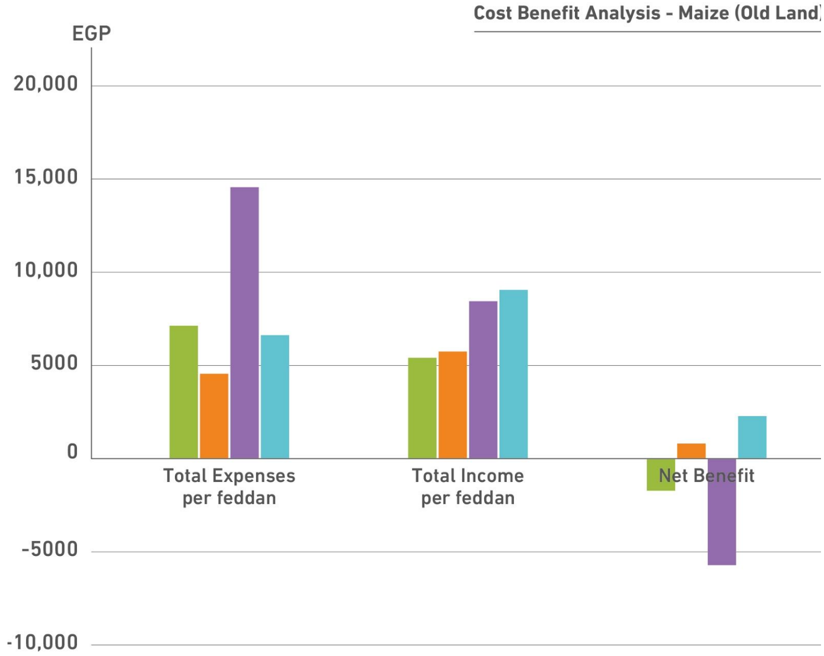
Cost Overview - Maize (Old Land)



	Conventional Cost 2015	Conventional Cost 2019	Organic Cost 2015	Organic Cost 2019
Soil Erosion	0	0	0	0
Atmosphere Damage	1,762	3,669	0	0
Water Damage	1,709	3,660	0	0
Damage Costs	3,471	7,328	0	0
Certification	0	0	100	150
Labour & Machinary	1,996	1,800	2,120	2,500
Raw Materials	1,765	5,441	2,493	4,387
Direct Costs	3,761	7,241	4,713	7,037

As shown in Figure 6, in 2015, the total expenses per feddan for conventional farming were 7,232 EGP, while the total income was 5,506 EGP, which results in a deficit of 1,726- EGP. In organic farming, the total expenses were 4,713 EGP and the total income was 5,580 EGP. Thus there is a small net benefit of 866 EGP. While in 2019, the total expenses per feddan for conventional farming was 14,570 EGP, the total income was 8,793 EGP, which results in a deficit of 5,776 EGP. In organic farming, the total expenses were 7,037 EGP and the total income was 9,100 EGP, thus there is a small net benefit of 2,063 EGP.

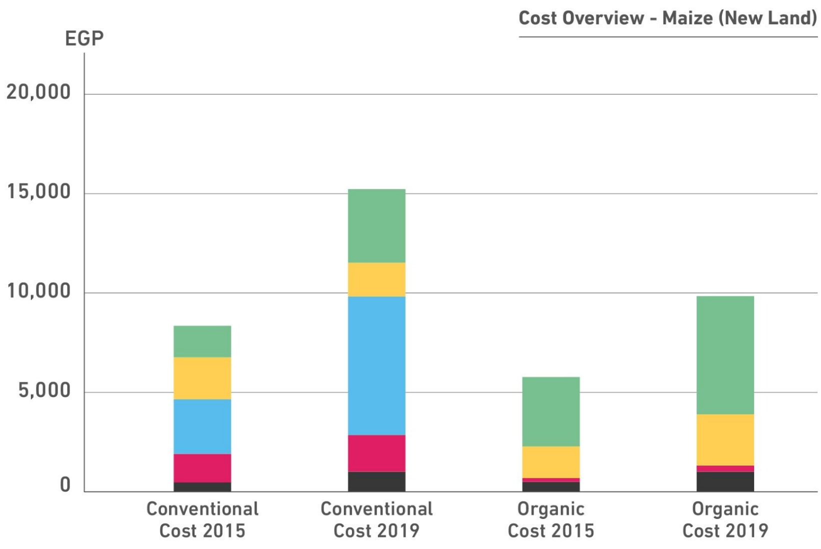
Cost Benefit Analysis - Maize (Old Land)



	Total Expenses per feddan	Total Income per feddan	Net Benefit
Conventional 2015	7323	5506	-1726
Organic 2015	4713	5580	867
Conventional 2019	14570	8793	-5776
Organic 2019	7037	9100	2063

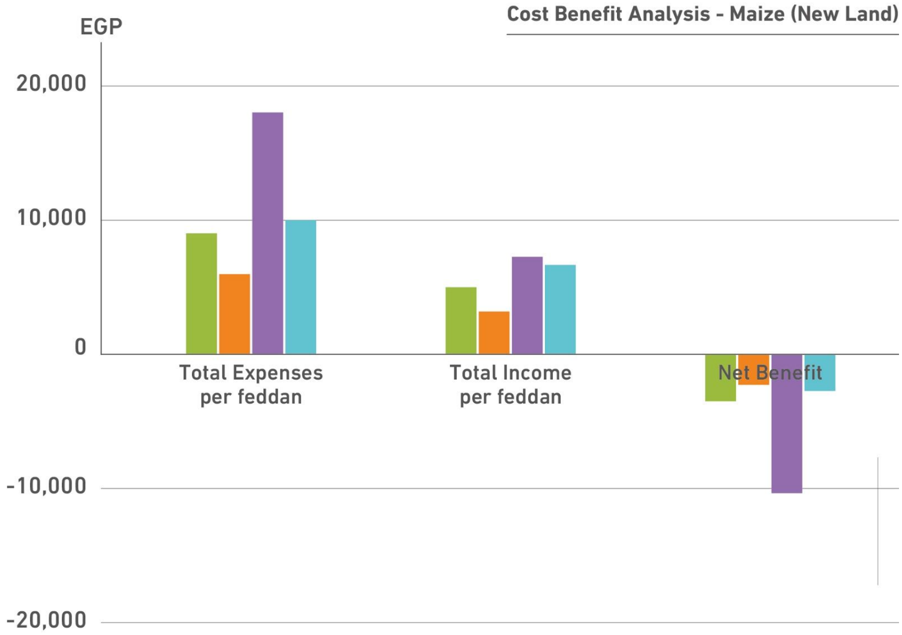
4.2.2 Maize New Land

In 2015 The direct costs for Maize production in a new land area were higher for organic farming, calculated to be 5,513 EGP per feddan, while at conventional farming the direct cost was around EGP 3,472. On the other hand, the damage costs in conventional farming were around EGP 4,767 and EGP 407 for organic farming in the new land. In 2019, the direct costs for Maize production in a new land area are higher for organic farming, calculated to be 9,050 EGP, while at conventional farming the direct cost was around EGP 5,173. On the other hand, the damage costs in conventional farming were around EGP 9,872 and EGP 894 for organic farming in the new land.



	Conventional Cost 2015	Conventional Cost 2019	Organic Cost 2015	Organic Cost 2019
Soil Erosion	485	1,065	408	894
Atmosphere Damage	1,134	2,068	0	0
Water Damage	3,148	6,738	0	0
Damage Costs	4,767	9,872	408	894
Certification	0	0	100	150
Labour & Machinary	1,996	1,800	1,950	3,050
Raw Materials	1,477	3,373	3,464	5,850
Direct Costs	3,473	5,173	5,514	9,050

As shown in figure 8 using conventional farming, in 2015, the total expenses were 8,240 EGP, while the total income was 5,316 EGP. Thus, it creates a loss of –2,924 EGP. Organic farming shows a similar result, through total expenses of 5,922 EGP and a total income of 3,168 EGP generating a total loss of –2,754 EGP, which is slightly lower than the net loss of conventional farming. In 2019, the total expenses were 15,045 EGP, while the total income was 7,436 EGP. Thus, it creates a loss of –7,609 EGP. Organic farming shows a similar result, through total expenses of 9,944 EGP and a total income of 6,825 EGP generating a total loss of –3,119 EGP, which is slightly lower than the deficit of conventional farming.

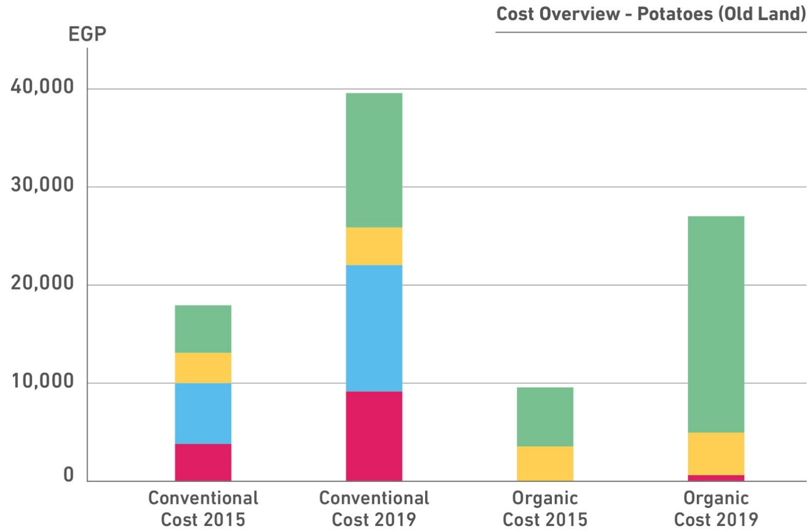


	Total Expenses per feddan	Total Income per feddan	Net Benefit
Conventional 2015	8,240	5,316	-2,924
Organic 2015	5,922	3,168	-2,754
Conventional 2019	15,045	7,436	-7,609
Organic 2019	9,944	6,825	-3,119

4.3 Potatoes Cost per Feddan

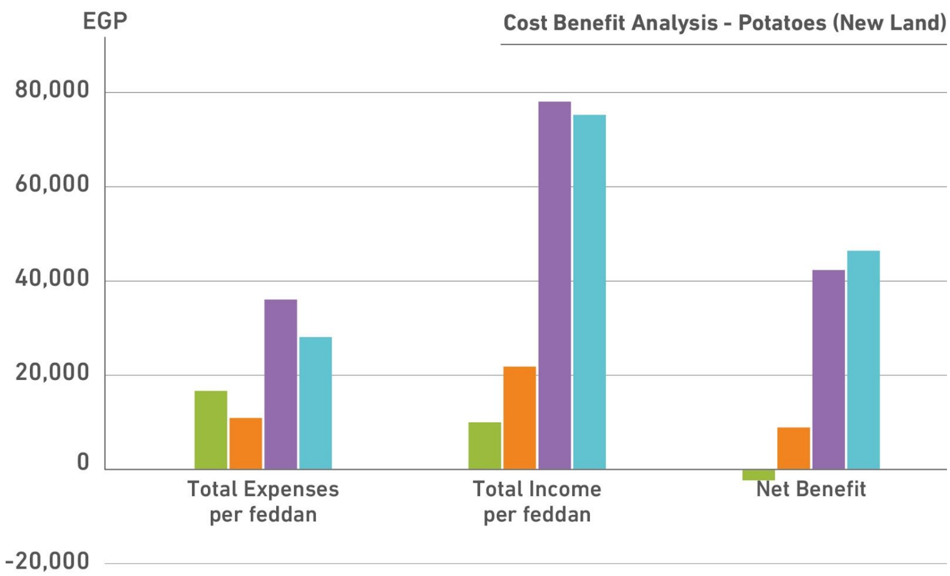
4.3.1 Potatoes Old Land

Figure 9 shows that in 2015, the average direct cost per feddan for potato production in conventional farming at old land was 8,075 EGP, and the damage cost was EGP 9,940. The Figure also shows that the average direct cost per feddan for potato production in organic farming was EGP 9,614, and the damage cost was 0.0 EGP. While in 2019, the average direct cost per feddan for potato production in conventional farming at old land was 17,328 EGP, and the damage cost was EGP 22,210. The Figure also shows that the average direct cost per feddan for potato production in organic farming was EGP 26,315, and the damage cost was 0.0 EGP.



Soil Erosion	0	0	0	0
Atmosphere Damage	3,846	9,164	0	0
Water Damage	6,094	13,046	0	0
Damage Costs	9,940	22,210	0	0
Certification	0	0	100	150
Labour & Machinary	3,199	4,050	3,740	4,540
Raw Materials	4,876	13,278	5,774	21,625
Direct Costs	8,075	17,328	9,614	26,315

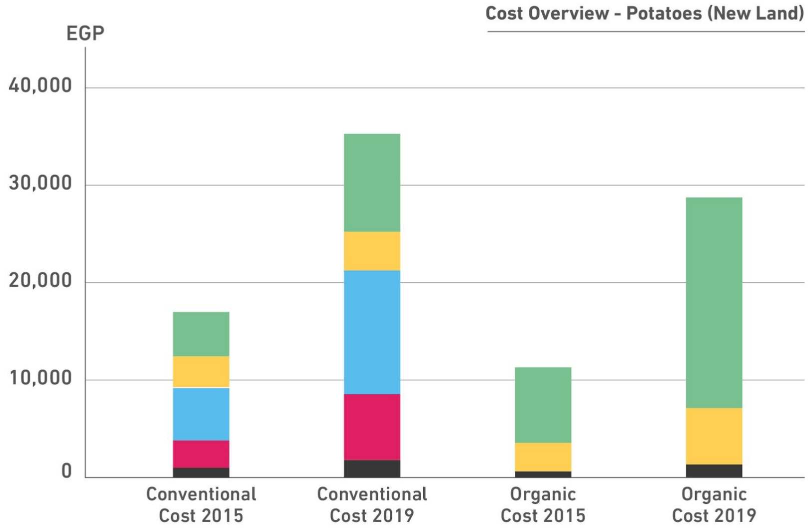
As Figure 10 illustrates, the total expenses per feddan in 2015 are a total of 18,014 EGP and total income per feddan is 13,604 EGP for conventional farming, equaling a deficit of **–4,411** EGP. In contrast, organic farming produces a net benefit of **10,966** EGP through the total expenses of **9,614** EGP and a total income of **20,580** EGP. Therefore, after including the damage cost, potato production is much more sustainable in organic farming than in conventional, while in 2019, as Figure 10 illustrates, the total expenses per feddan are a total of 39,675 EGP and total income per feddan is 78,840 EGP for conventional farming, equaling a deficit of 39,165 EGP. In contrast, organic farming produces a net benefit of 47,558 EGP through the total expenses of 28,822 EGP and a total income of 76,380 EGP. Therefore, after including the damage cost, potato production is much more sustainable in organic farming than in conventional.



Conventional 2015	18,486	13,754	-4,732
Organic 2015	11,288	22,050	10,762
Conventional 2019	39,675	78,840	39,165
Organic 2019	28,822	76,380	47,558

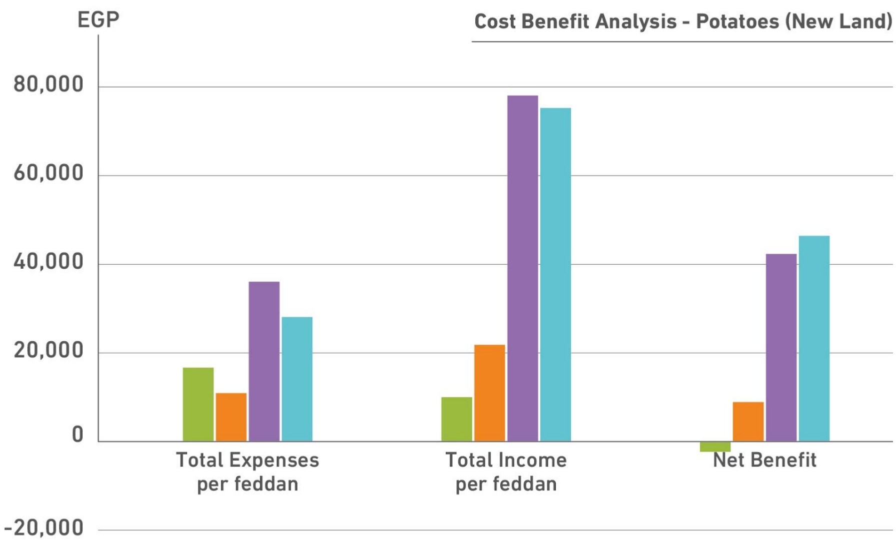
4.3.2 Potatoes New Land

The comparison in Figure 11 shows, in 2015, the conventional farming at new land direct costs 6,846 EGP per feddan, in addition to damage cost of EGP **6,505**. It also shows the average direct cost per feddan of potato production in organic farming in new land areas of EGP 10,880, and damage costs of 407.9 EGP. In 2019, the comparison in Figure 11 shows the conventional farming at new land direct costs of 14,271 EGP per feddan, and additional damage cost of EGP 21,643. It also shows the average direct cost per feddan of potato production in organic farming in new land areas of EGP 27,928 and damage costs of 894 EGP.



Soil Erosion	485	1,065	408	894
Atmosphere Damage	2,917	7,439	0	0
Water Damage	6,138	13,139	0	0
Damage Costs	9,540	21,643	408	894
Certification	0	0	100	150
Labour & Machinary	3,199	4,050	2,840	5,430
Raw Materials	3,647	10,221	7,940	22,348
Direct Costs	6,846	14,271	10,880	27,928

Under the conventional farming system, the total expenses were 13,352 EGP, while the total income was 13,754 EGP. Accordingly, the net benefit was 402.8 EGP. Under the organic farming system, the total expenses were 11,288 EGP, while the total income was 22,050 EGP and thus, the net benefit was 10,762 EGP. After including the damage cost, potato production is more sustainable in organic farming than in conventional. In 2019, the total expenses were 13,352 EGP, while the total income was 13,754 EGP. Accordingly, the net benefit was 402.8 EGP. Under the organic farming system, the total expenses were 11,288 EGP, while the total income was 22,050 EGP and thus, the net benefit was 10,762 EGP. After including the damage cost, potato production is more sustainable in organic farming than in conventional.

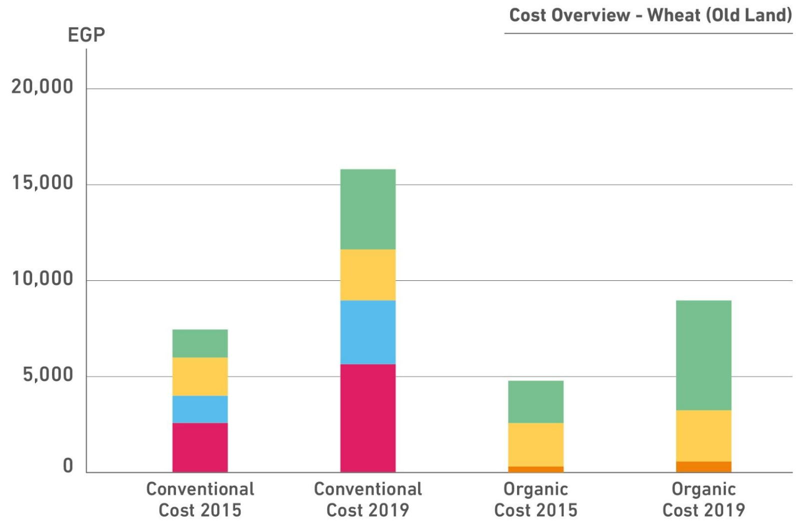


Conventional 2015	18,486	13,754	-4,732
Organic 2015	11,288	22,050	10,762
Conventional 2019	39,675	78,840	39,165
Organic 2019	28,822	76,380	47,558

4.4 Wheat Cost per Feddan

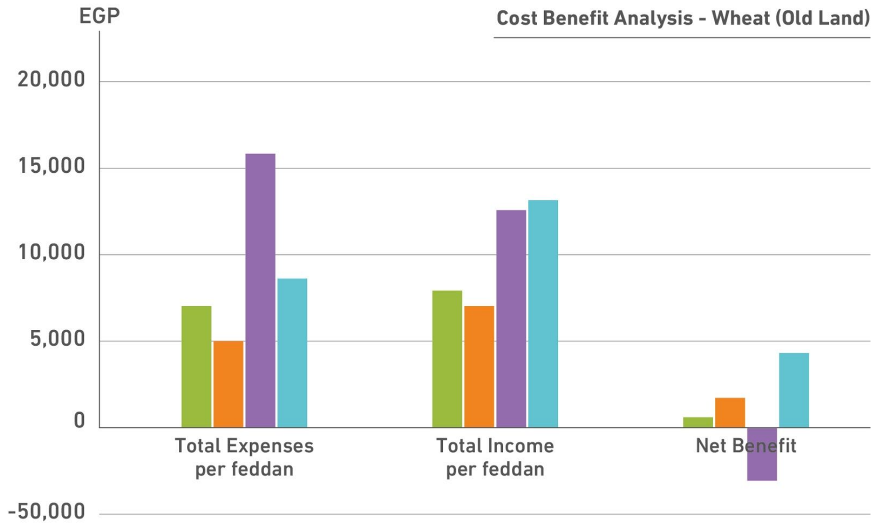
4.4.1 Wheat Old Land

For old land, wheat production, in 2015, in organic farming generates a direct cost of around 4,893 EGP per feddan as shown in Figure 13. However, in conventional farming, the direct cost was slightly lower, at EGP 3,373, while the damage cost for conventional farming was EGP 4,147 and for organic farming 0 EGP. In 2019, in old land, wheat production in organic farming generates a direct cost of around 8,591 EGP as shown in Figure 13. However, in conventional farming, the direct cost was slightly lower, at EGP 6,993, while the damage cost for conventional farming was EGP 8,710 and for organic farming 0 EGP.



Soil Erosion	0	0	0	894
Atmosphere Damage	2,538	5,265	0	0
Water Damage	1,609	3,445	0	0
Damage Costs	4,146	8,710	0	0
Certification	0	0	100	150
Labour & Machinary	1,853	2,950	2,470	3,050
Raw Materials	1,520	4,043	2,323	5,391
Direct Costs	3,373	6,993	4,893	8,591

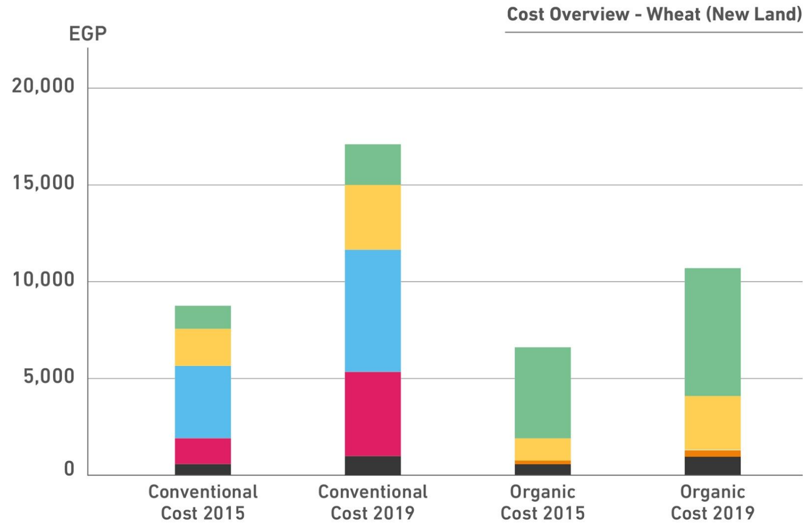
Figure 14 shows the total expenses per feddan of 7,520 EGP and the total income per feddan of 7,889 EGP for conventional farming, therefore it generates a small benefit of 368.8 EGP. In contrast, organic farming shows a net benefit of 2,187 EGP, calculated by total expenses of 4,893 EGP and a total income of 7,080 EGP. In 2019, Figure 14 shows the total expenses per feddan of 15,702 EGP and the total income per feddan of 12,742 EGP for conventional farming, therefore it generates a small benefit of -2,960 EGP. In contrast, organic farming shows a net benefit of 4,409 EGP, calculated by total expenses of 8,591 EGP and a total income of 13,000 EGP.



Conventional 2015	7,520	7,888	369
Organic 2015	4,893	7,080	2,187
Conventional 2019	15,702	12,742	-2,960
Organic 2019	8,591	13,000	4,409

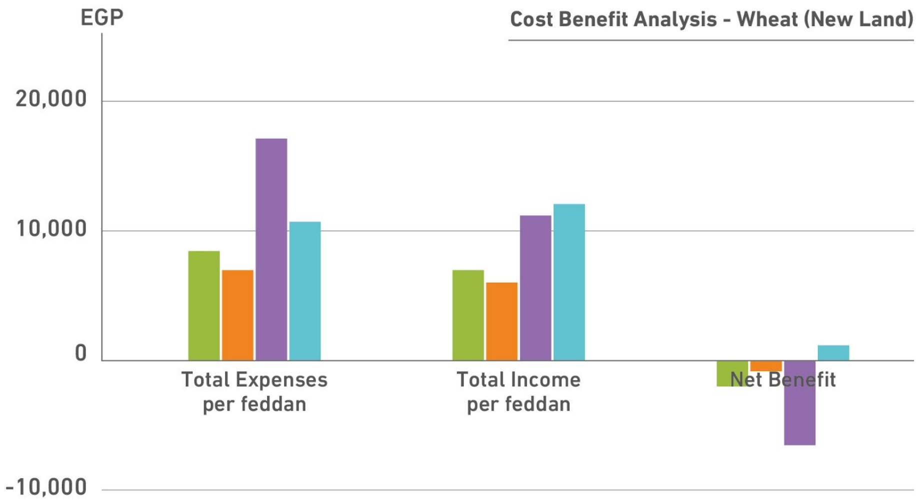
4.4.2 Wheat New Land

In 2015, conventional farming producing wheat in new land generated direct costs of 3,067 EGP, and damage costs at 5,584 EGP as shown in Figure 15. Furthermore, it shows the average direct cost per feddan of wheat production in organic farming of around EGP 6,507 and damage cost around EGP 408, while in 2019 conventional farming producing wheat in new land generates direct costs of 5,243 EGP, and damage costs at 11,896 EGP as shown in Figure 15. Furthermore, it shows the average direct cost per feddan of wheat production in organic farming of around EGP 9,542 and damage cost around EGP 894.



	Conventional Cost 2015	Conventional Cost 2019	Organic Cost 2015	Organic Cost 2019
Soil Erosion	485	1,065	408	894
Atmosphere Damage	1,951	4,093	0	0
Water Damage	3,148	6,738	0	0
Damage Costs	5,584	11,896	408	894
Certification	0	0	100	150
Labour & Machinary	1,853	2,950	1,950	2,810
Raw Materials	1,214	2,293	4,457	6,582
Direct Costs	3,067	5,243	6,507	9,542

The cost-benefit analysis for wheat production at new land shows as a result of conventional farming, in 2015, total expenses of 8,651 EGP and a total income of 6,738 EGP. Consequently, there is a net deficit generated of around 1,913- EGP. On the other hand, the figure shows the slightly smaller loss of organic farming around 602-EGP, which is calculated by the total expenses of 6,915 EGP, and the total income of 6.313 EGP. In 2019, the cost benefit analysis for wheat production at new land shows as a result for conventional farming total expenses of 17,193 EGP and a total income of 11,006 EGP. Consequently, there is a net deficit generated of around 6,133-EGP. On the other hand, the figure shows the slightly smaller loss of organic farming around 1,056 EGP, which is calculated by the total expenses of 10,436 EGP and the total income of 11.006 EGP.

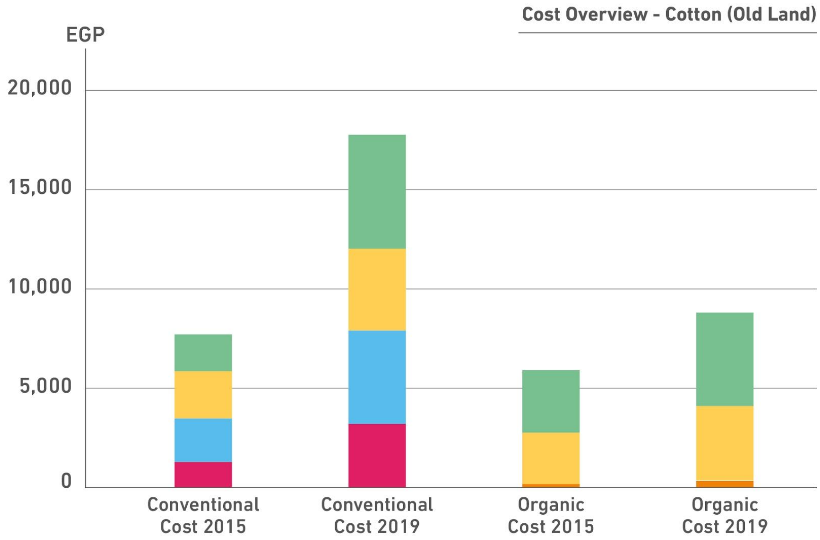


	Total Expenses per feddan	Total Income per feddan	Net Benefit
Conventional 2015	8,651	6,738	-1,913
Organic 2015	6,915	6,313	-602
Conventional 2019	17,139	11,006	-6,133
Organic 2019	10,436	11,492	1,056

4.5 Cotton Cost per Feddan

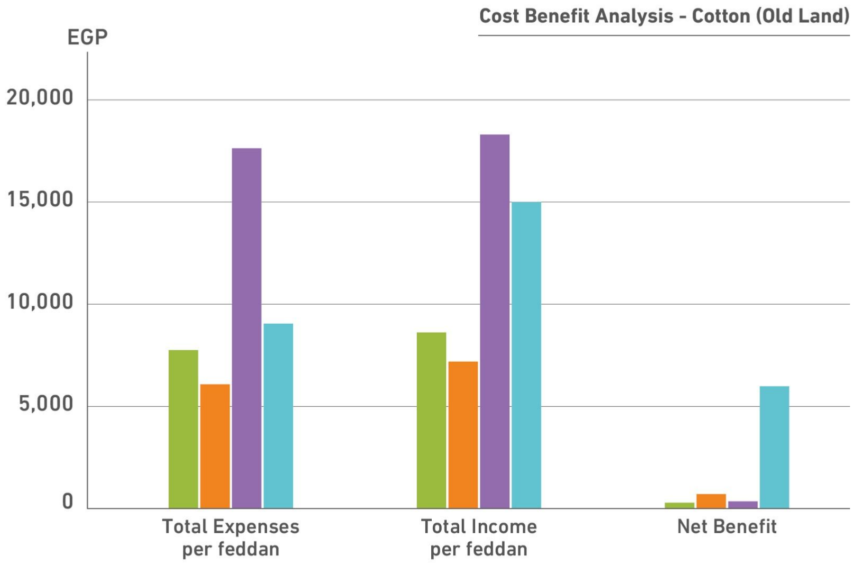
4.5.1 Cotton Old Land

Figure 17 shows the average direct cost per feddan of cotton production at conventional farming in the old land, which was 4,280 EGP, and the damage cost, at around EGP 3,556. The graph also shows the direct cost of cotton production in organic farming which was 6,109 EGP, and the damage cost for organic farming at EGP 0 in the old land, in 2019. Figure 17 shows the average direct cost per feddan of cotton production at conventional farming in the old land, which was 9,420 EGP, and the damage cost, at around EGP 4,280. The graph also shows the direct cost of cotton production in organic farming which was 8,955 EGP, and the damage Cost for organic farming at EGP 0 in the old land.



Soil Erosion	0	0	0	0
Atmosphere Damage	1,261	3,291	0	0
Water Damage	2,295	4,914	0	0
Damage Costs	3,556	8,205	0	0
Certification	0	0	100	150
Labour & Machinary	2,360	4,000	2,688	4,050
Raw Materials	1,920	5,420	3,321	4,755
Direct Costs	4,280	9,420	6,109	8,955

Figure 18 shows the total expenses per feddan (7,836 EGP) and the total income per feddan (8,340 EGP) for conventional farming, resulting in a very small net benefit of 504.3 EGP. In contrast, the organic farming generated total expenses of 6,109 EGP and a total income of 6,824 EGP. Consequently, it shows a higher net benefit of 715 EGP, while in 2019 the total expenses per feddan (17,625 EGP) and the total income per feddan (18,181 EGP) for conventional farming, resulting in a very small net benefit of 557 EGP. In contrast, organic farming generated total expenses of 8,955 EGP and a total income of 15,112 EGP. Consequently, it shows a higher net benefit of 6,157 EGP.

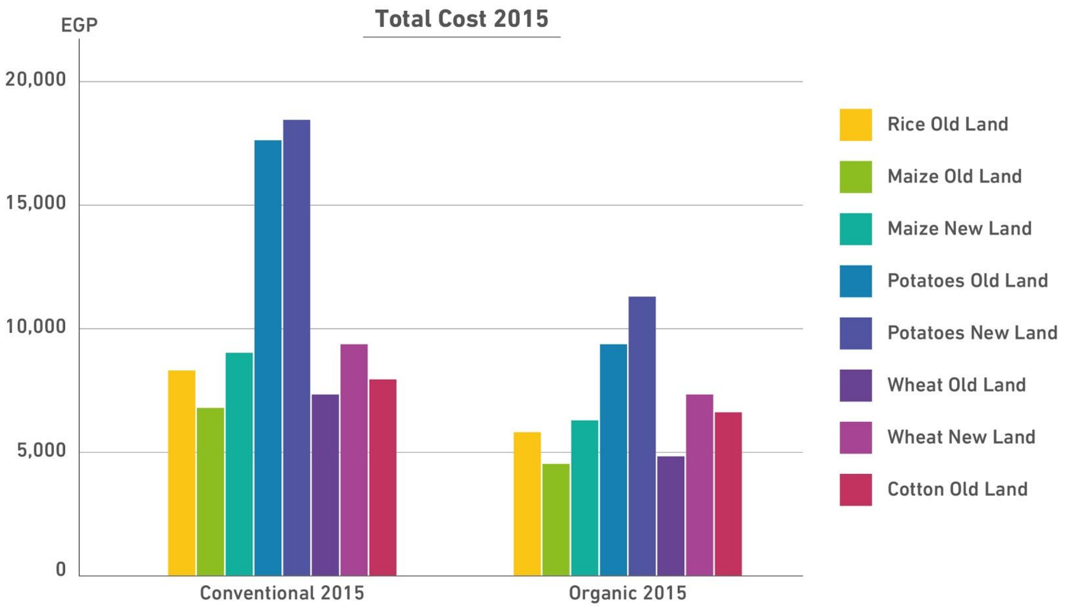


Conventional 2015	7,836	8,340	504
Organic 2015	6,109	6,824	715
Conventional 2019	17,625	18,181	557
Organic 2019	8,955	15,112	6,157

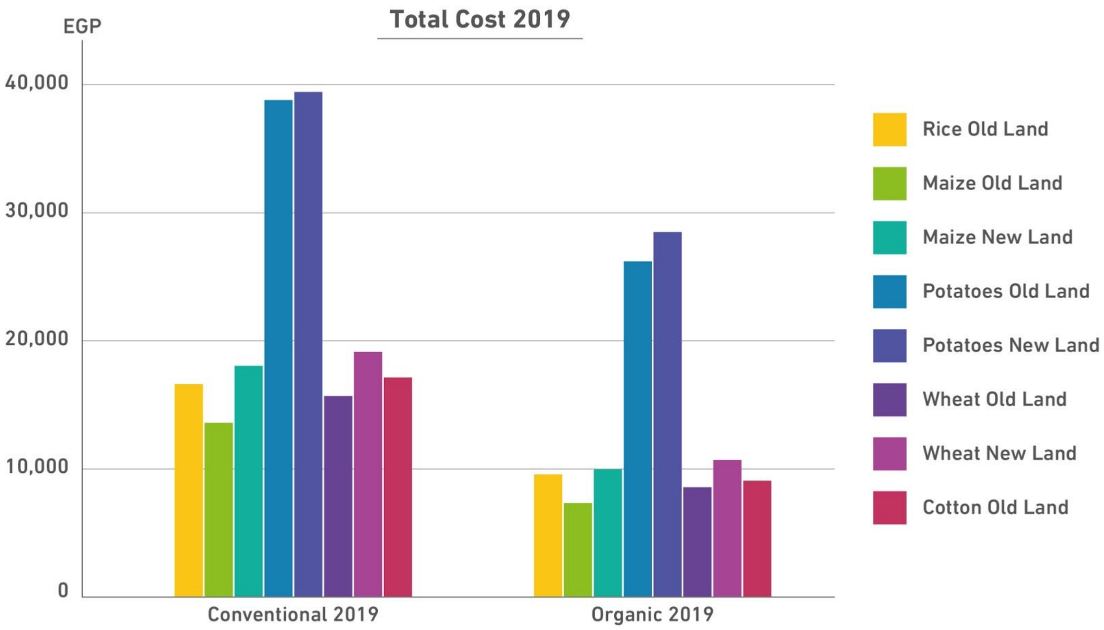
5. Results and Conclusion

5.1 Summary of Results

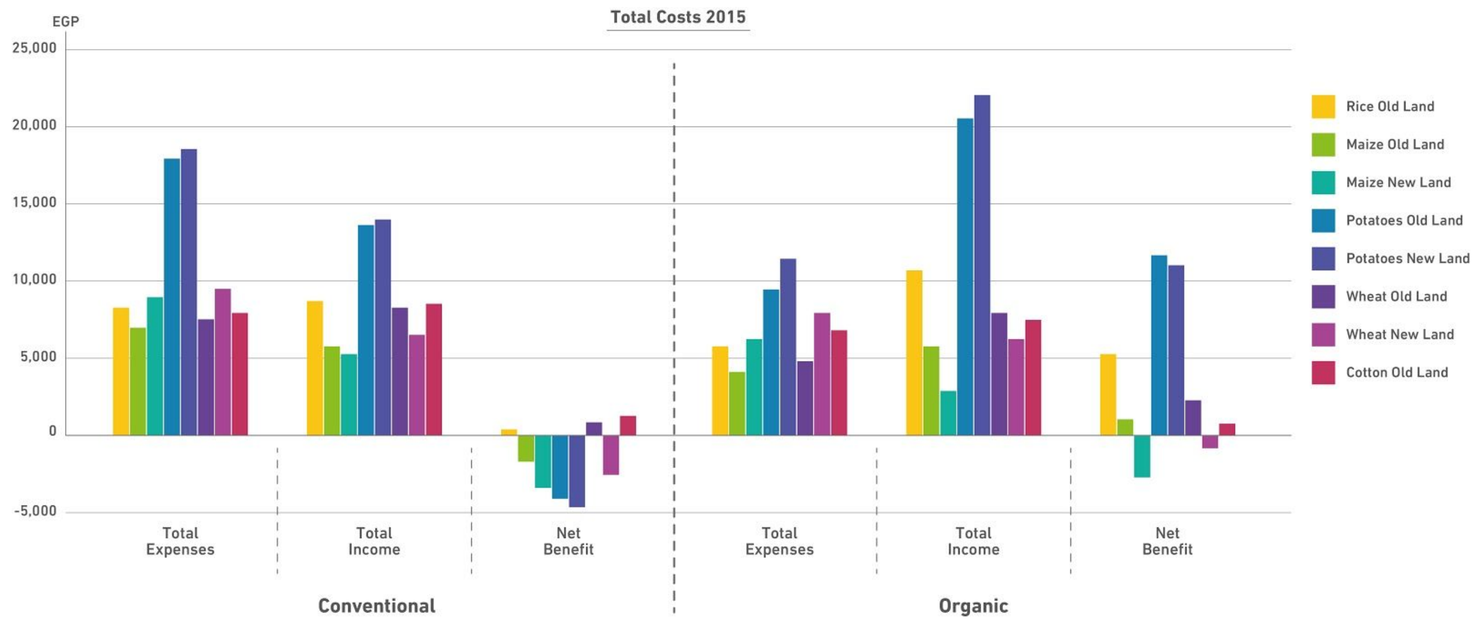
The aim of this chapter is to summarize the results in two graphs, to give an overview, and show the main outcome of the previously described results in 2015, while updating calculation for the results of 2019. Figure 19 compares the total production costs of organic and conventional farming considering all five evaluated crops.

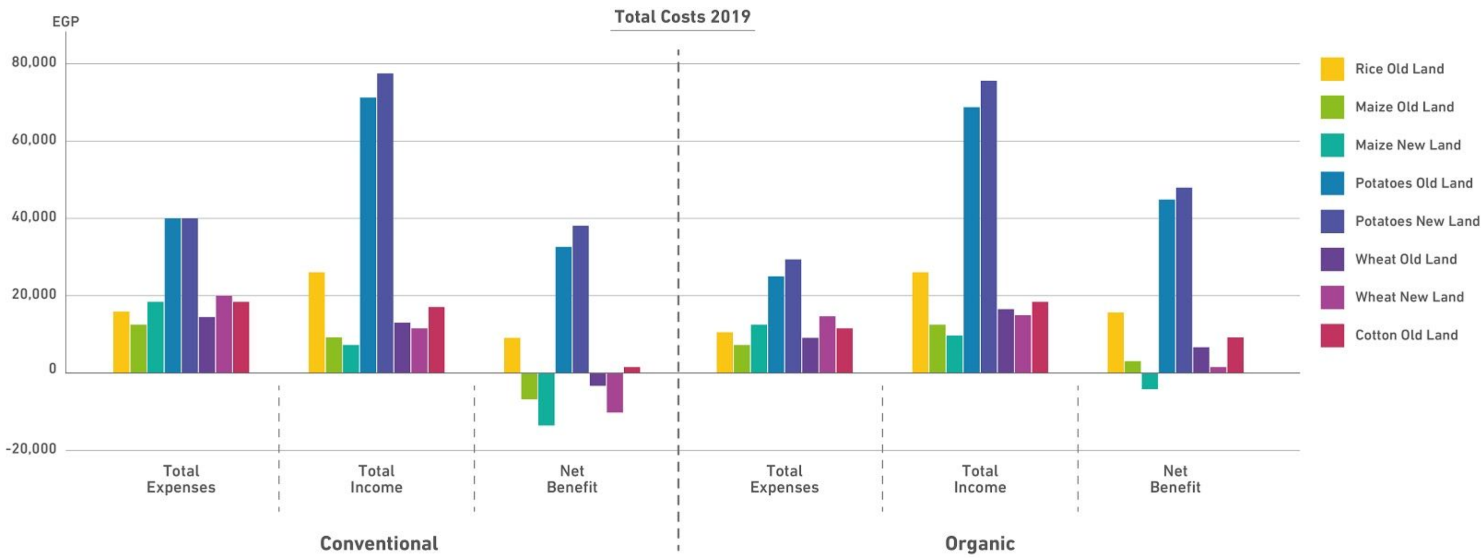


The graph outlines the higher costs for the environment and society occurring through the use of conventional farming methods since they include higher damage costs. Organic farming enables a cost reduction for society per feddan for nearly every crop evaluated in this study, because of the low damage costs included in the calculation.



To summarize the results of the study, figure 20 below, gives an overview of the five evaluated crops in terms of total income and total expenses, calculating the net benefit and comparing it between organic farming and conventional farming methodologies. The result of this comparison shows that the net benefit for society and the environment using conventional farming methodologies is negative, while organic farming produces a positive net benefit for the most part.





5.2 Conclusion

Organic farming has proven to be remarkably effective in reversing the negative impact of agriculture on the environment. The research concludes that although organic agriculture has a slightly higher direct input cost of production, it enables a reduction of the environmental damage costs, and therefore, results in better cost-effectiveness and profitability in the long term for society as a whole.

The study shows that, with regard to prices, organic food is in fact already cheaper to produce than conventional products, if the externalized costs for pollution, CO_2 emissions, energy, and water consumption are considered. These are currently transferred to society or future generations, but if they would appear on supermarket bills, this would already be obvious to everyone.

Organic agriculture has recently gained importance as an alternative farming system because under the current situation, soil organic matter (SOM) plays a key role in sustainable agriculture in terms of ecology and farm economics. The agricultural inputs in organic farming systems are not subsidized, but they improve the soil structure, maintain water quality, increase soil organic matter, increase biodiversity and yields while decreasing the total cost to produce one ton of any crop.

As a matter of fact, organic farming enables a cost reduction for the society for every crop evaluated in this study, because of the low damage costs included in the calculation. Even if the selling price of organic products was equal to conventional products, the organic products would still be more profitable for the farmer and cheaper for the society, when including the true cost.

After establishing that organic farming is cheaper even if we sell the organic products at conventional prices if true cost is included, this study calls for:

- 100% organic agriculture in Egypt.
- Future studies to include a more comprehensive set of indicators to measure the true cost of products. The results of the TEEB studies, for example, to mainstream the values of biodiversity and ecosystem services into decision-making at all levels, should be included. Similarly, the impact on health and related costs should be incorporated, using the concept of Disability Adjusted Life Year (DALY), developed by WHO. It is a measuring unit that indicates the negative impact on health and looks at the loss of “productive years” of a person due to death or illness.
- The Egyptian government is to implement a polluter tax that reflects the true price to the society.
- Government, researchers, and farmers to calculate the true cost of all crops in Egypt.
- Governments, researchers, and farmers in all countries of the world to calculate true costs in order to determine the best possible future of agriculture in their countries.
- All members of the organic, biodynamic, agroecological, and sustainable agriculture movements worldwide to promote this kind of studies.
- Researchers worldwide to study the economic impact of organic agriculture regarding water consumption, land use, health, social and environmental impact as well as climate mitigation and adaptation.
- Entrepreneurs and companies worldwide to include true cost accounting into their business models.
- The governments and education institutions worldwide to increase the education and training opportunities in organic agriculture to enable more farmers worldwide to benefit from the economic, ecological, cultural, and social benefits of organic agriculture.
- The governments and all media representatives to increase awareness of all the benefits of organic agriculture among their citizens.
- All consumers of the world are to contribute to a better future for forthcoming generations by their educated and responsible purchase decisions today.

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