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Sustainable Development Goals for the Circular Economy and the Water-Food Nexus: Full Implementation of New Drip Irrigation Technologies in Upper Egypt

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Abstract: Saving fresh water is a big challenge for the next generation due to enhanced living standards and population growth. In addition, the expansion of agricultural and industrial activities is causing unmatched demands for fresh water supplies across Egypt. The Nile River is Egypt's main water resource, representing 69.4% of the total water resources, while rainwater, torrential water and groundwater, as well as recycled agricultural and sanitary drainage water and desalinated seawater, are estimated at about 30.6%. Smart drip irrigation systems are in great demand, especially in Upper Egypt. SDG's of the circular economy and the WEF nexus lead to full implementation of drip irrigation systems, achieving ~6.6 BM^3/year of direct saving from fresh water and/or doubling the cultivated area. In addition to PV tubes and other utilities, renewable energy, e.g, photovoltaic panels, will posses an important role in low-energy driven drip irrigation systems, reducing fossil-uses, CO_2 emissions and devolving more sustainable processes that are less dependent on conventional energy sources. The current research work is a case study of the substitution of flood with drip irrigation, and its positive advantages for the Egyptian agricultural economy and capital expenditures (capex), which depends on the country's infrastructure and availability of utilities.

Keywords: Nile River; new drip irrigation; water-food nexus; renewable energy; capex

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1. Introduction

Egypt attaches the utmost importance to the issue of water, in terms of preserving its water resources and good management, which has been translated into many comprehensive and specific legal agreements with the Nile Basin countries, which obligate everyone to respect them and not violate them [1,2]. In return, Egypt cooperates with other Nile Basin countries and participates in many of its development projects [3]. Egypt has also contributed to the establishment of many dams and underground drinking water stations, and has prepared the essential investigations for projects to build multi-aim dams, to provide drinking water and electricity to the African country's citizens. Among the major agreements is the agreement of 1959 [4], according to which Egypt obtains 55.5 BM^3 of water annually, whereas Sudan gets 18.5 BM^3, and the total river revenue is 84 BM^3. Approximately 10 BM^3 of the river's revenue is lost during the flow from south to north due to leakage and evaporation. In addition, the 2015 principles agreement declaration among Ethiopia, Sudan and Egypt, in Khartoum city, confirmed cooperation based on the understanding, benefit and gains for all under international law principles, and an understanding of the water requirements of downstream and upstream countries in their various aspects [5]. Egypt's water resources are estimated at about 81.39 BM^3 annually, most of which comes from the Nile River water, as well as very limited amounts of desalination, rainwater, deep groundwater and treated wastewater. In contrast, the total water needs in Egypt reach about 114 BM^3 annually (as per the Water Resources Ministry reports on

28 March 2021) [6]. The gap is reimbursed by the surface groundwater and agricultural wastewater re-use in the valley and Delta, as well as the importing of food products from abroad corresponding to 32.61% of water annually as shown in Figure 1 [7,8].

Figure 1. Water resources in Egypt.

1.1. Egyptian Water Policy & Strategy

Successive Egyptian governments have worked on preparing water strategies, policies, and national plans, which would contribute to achieving the maximum benefit from Egypt's river water. At the beginning of 1998, the first integrated strategy for Egypt's water policy was drawn up, based on its implementation on the theory of "integrated management of water resources" [9], with the participation of various ministries and authorities. The cost of the strategy's [10] projects, with its various axes, amounted to £145 billion GBP. Egypt continued to implement it until 2017. The strategy is divided into three main axes: (a) maximizing the use of every drop of water, (b) eliminating pollution and confronting its problem and (c) cooperating with the countries of the Nile River Basin to preserve and develop it. The major strategy included two main axes: (1) the first axis is concerned with what we might call the pursuit of good use of water resources, through the theory of integrated water-food resource management, which takes into account all the available and required resources to meet all uses and strike a balance between them through the adoption of a number of targeted policies that maximize the benefit of the water unit [10]. (2) the second axis is to offer foreign alternatives, aimed at cooperating with the Nile Basin countries in order to develop their water resources and their proper exploitation, on the one hand, and the implementation of Upper Nile projects with the purpose of increasing river drainage and reducing losses for the basin countries benefit, on the other hand. At the end of 2020, Egypt launched a strategy for water resources management until 2050, within the axes of the National Water Resources Plan, at a cost of 50 B$, called "4T", with the participation of a number of ministries [11–13]. Among the most important projects that the ministry is currently implementing within the framework of this plan are the national project for rehabilitation and canals lining, as shown in Figure 2; the project of transformation from flood irrigation (FI) systems to drip irrigation (DI) systems; programs for adaptation to climate changes; protection from sea level rise; and rain harvesting projects [14–20]. This plan pays special attention to the middle years 2022 and 2030, for several reasons, including that Egypt has prepared a strategy of sustainable development goals (SDGs) for the country until 2030, with the aim of placing Egypt among the top 30 countries in the world, economically and socially, by 2030. In addition, the plan takes into account the objectives of the sustainable development strategy in Egypt [18].

Figure 2. Project for rehabilitation and canals lining.

1.2. Water Resources and Usages

Water resources and footprint in Egypt, 2021 can be found in Tables 1 and 2.

Table 1. Water resources in Egypt, 2021 [16–19].

Water Sources	Description	Quantity of BM^3/Year	Percentage %
The Nile River	It is the main water source in Egypt,	55.5	68.19%
Underground water	The amount can be enhanced to reach 7.5 BM^3/year without endangering the groundwater reserves.	6.11	7.50%
Rainfall	It is not the major water source in Egypt due to the small amount that falls in winter.	1.37	1.68%
Desalination	Treated seawater (salinity $\geq$ 45,000 ppm).	0.41	0.51%
Reuse of agricultural wastewater	Agricultural drainage water is a significant water resource.	7.88	9.68%
Treated wastewater	It is used in irrigation, only if it meets the recognizably international health conditions.	10.12	12.44%
Total water resources		81.39	100.00%

Table 2. Water footprint in Egypt, 2021 [21].

Water Usages	Description	Quantity of BM^3/Year	Percent %
Agriculture	To cultivate 10.38 million acres, with the possibility of increasing the agricultural area to 12 million acres in 2030. The statistics indicated that the governorates of Lower Egypt ranked first, with an area of 6.3 million acres (60.6%), followed by the governorates of Upper Egypt, with an area of 3.2 million acres (30.6%). The urban governorates came in third place with an area of 0.8 million acres (8.1%), then the border governorates (New Valley) with an area of 0.08 million acres (0.7%) of the total area of control in 2021.	61.63	75.74%
Municipal	It consists of sewage water (gray and black).	11.86	14.56%
Industrial	Industrial wastewater.	5.40	6.63%
Evaporation	Loss in water at the Nile River from its source to its estuary, excluding evaporation resulting from Lake Nasser (abut 10 BM^3/year).	2.50	3.07%
Total water resources		81.39	100.00%

1.3. Targeted Water Resources

There are several projects in Upper Nile with the aim of controlling its water loss and managing extra resources [18,22–24], the most important of which are:

1. The "Jonglei Canal (JC) project" in South Sudan, which could provide ~ 4 BM^3/year in its first stage and around 3 BM^3/year in its second stage, to be divided evenly between South Sudan and Egypt.
2. The "Bahr al-Ghazal (BG) project", which provides about 7 BM^3/year, to be divided evenly between South Sudan and Egypt.
3. The "Mushar Swamps (MS) project", which provides about 4 BM^3/year of water.
4. Seawater desalination is one of the future prospecting for increasing water resources, especially since its cost is decreasing by using modern technologies. It is about 0.41 BM^3/year in 2021.
5. Amending the existing cropping structure in line with the State's water, productivity, export policy, and reducing the quantities of irrigation water for the cropped area, as the State's plan aims to provide about 1.5 BM^3/year by substituting beet cultivation for sugar cane and decreasing the cultivated rice area from 1.3 million acres to 0.95 million acres.
6. Reducing water losses; the Water Resources and Irrigation Ministry estimated water losses at approximately 35% of the total water discharge from the High Dam, or approximately 19.4 BM^3, and it is likely that it is lost by evaporation and leakage, and the loss in channels of irrigation represents approximately 2.3 BM^3/year.
7. Conservation of water resources by getting rid of weeds and aquatic plants resulting from their growth and saving about 0.75 BM^3/year.

This study discusses Egypt's drip irrigation development strategy to conserve water resources. The process of implementing drip irrigation systems aims to raise the efficiency of water management and reduce losses resulting from transport and evaporation, especially the national project for lining the canals. Furthermore, it highlights the importance of training farmers on the operation and maintenance of modern drip irrigation systems and raising their awareness in the media, to introduce the benefits of modern and smart drip irrigation systems and vertical agriculture. We intend to move towards the use of the smart agricultural irrigation system technologies by producing advanced sensor devices at appropriate prices and quantities, to be accessible to farmers in order to measure the level of moisture in the soil with high accuracy, which achieves multiple benefits, the most important of which is the provision of irrigation water quantities, and increased productivity. Egypt announced on 7 May 2021 that about 35% have been transferred to the modern drip irrigation system, in addition to submitting requests to convert another 9.9% in 2022, at a cost of 18 billion GBP. On May 29 2021, we began the integration of the water desalination strategy with the State's general policy for rational water management, in addition to making maximum use of the water generated by all the various water plants, whether for treatment or desalination, as well as the localization of all components of water desalination technology in Egypt in an effort to possess the capacity in this field.

1.4. Per Capita Share of Water in Egypt for the Last 60 Years

The population increase in Egypt represents a major challenge to water resources, as the total population is expected to be more than 125 million persons in 2030, and approximately 175 million persons in 2050, putting pressure on water resources. In addition, changes in the climate, such as the noticeable rise in temperatures, as well as the sporadic and unprecedented climatic phenomena that Egypt is witnessing in the scarcity of rain, as well as the rising sea level and its dangerous negative repercussions on cities and coastal areas. Figure 3 shows the water consumption per capita at the last 60 years; the sharp decline in water consumption versus population increase, from 1962 to now, is clear. The water resources are fixed, and with the growing population, the water crisis gap is becoming out of control; the future projections of water consumption reach

250 m^3/y. The Intergovernmental Panel on Climate Change (IPCC) predicts that midstream sea levels are to increase by up to 59 cm in the worst-case scenario that is expected to come in 2100 [21–25]. A rise of 0.5 m in the sea level would cause losses in land, tourism and facilities of more than $32.5 billion in Alexandria alone, and will cut off Alexandria from the Delta. Indeed, the process of erosion has increased in the Delta of Nile since the High Dam construction in Aswan during the nineteen-seventies, after many of the Nile sediments were confined. Moreover, significant losses of agricultural land are likely to occur because of soil salinization [25–30]. Water-use data for agriculture in Egypt is inaccurate and often contradictory. The total area prepared for irrigation in 2002 reached 85% in the Nile Delta and Valley [31]. The fresh water consumption amount in the agricultural sector in 2000 reached 86% of the total use. All wastewater in Upper Egypt flows back into irrigation canals and the Nile, which is estimated at 4.0km^3/year, and the amount of wastewater in the Delta of Nile region is estimated at ~14km^3/year. Approximately 10km^3/year of wastewater in the Delta region is pumped into fresh water streams, where it is transferred, after a while, into the sea [32,33]. Wastewater re-use takes place in three ways:

1. Using public pumping stations, which pump water from sewers into irrigation canals. The amount used in this way is estimated at ~4.5 BM^3/y in the Delta and 0.9 BM^3/y in Fayoum and Upper Egypt.
2. In an informal way, by the farmers themselves when they suffer from canal water shortage. This is estimated at 2.8 BM^3/y in the Delta alone.
3. Indirectly from drains in Upper Egypt, which drain into the Nile River, and this quantity is ~4 BM^3/y.

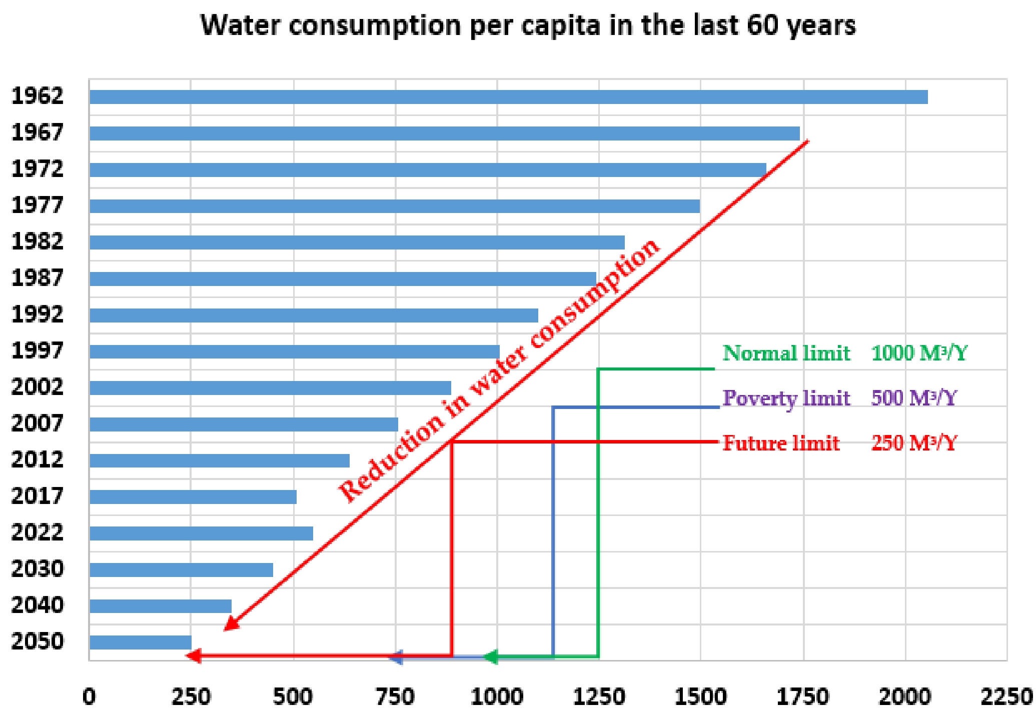

Figure 3. Water consumption per capita in the last 60 years vs. population and future prospects for both.

2. Methods

Although Egypt has the necessary ingredients for the cultivation of all crop kinds, the annual population increase and Egypt's shared stability in the Nile River has led to a shortfall in the quantities of crop production and in the ability to meet their needs. A large gap between production and consumption led to dependence on imports, which constitutes a financial burden on the economy. Maximizing the use of water resources and switching to modern agricultural methods is a necessity to maintain the country's food and water security. Data were collected from the Central Agency for Public Mobilization and Statistics to realistically assess the current situation; Table 3 presents the strategic crops in the Egyptian governorates [34].

Table 3. The strategic crops in the Egyptian governorates with the population.

Governorate	Rice Tons	Sugar Cane Tons	Cotton Tons	Wheat Tons	Population Million
Cairo [(a)]	–	11	–	–	10.110
Alexandria [(a)]	380	3	966	75,635	5.475
Port-Said [(b)]	20,434	–	2619	12,106	0.784
Suez [(b)]	–	–	–	5401	0.780
Damietta [(b)]	57,008	3	7840	20,835	1.595
Dakahlia [(a)]	391,981	315	31,542	188,913	6.947
Sharkia [(b)]	276,726	–	25,722	357,573	7.766
Kalyoubia [(a)]	9159	549	34	50,217	6.035
Kafr-ElSheikh [(b)]	258,338	115	79,307	206,242	3.646
Gharbia [(a)]	119,619	–	9943	103,499	5.353
Menoufia [(a)]	25	–	1746	121,763	4.652
Behera [(a)]	164,083	124	32,016	308,580	6.747
Ismailia [(b)]	4827	–	797	34,333	1.426
Giza [(a)]	-	1769	–	41,714	9.342
Beni-Suef [(b)]	1357	699	6597	119,910	3.510
Fayoum [(b)]	1381	450	13,092	184,715	3.994
Menia [(a)]	–	38,432	306	230,780	6.157
Asyout [(b)]	–	1175	3370	210,756	4.923
Suhag [(a)]	–	13,710	430	193,939	5.572
Qena [(a)]	–	116,616	–	90,621	5.535
Aswan [(c)]	–	85,491	–	53,043	1.629
Luxor [(c)]	–	66,684	–	33,540	1.371
El Wadi-El Gidid [(b)]	2625	–	12	155,408	0.261
Matrouh [(c)]	–	–	–	9367	0.523
North Sinai [(c)]	–	–	–	3200	0.450
South Sinai [(c)]	–	–	–	1270	0.112
El Nubaria [(b)]	315	90	611	114,355	0.394

[(a)] High water consumption; [(b)] Medium water consumption; [(c)] Low water consumption.

2.1. Current Diagnosis

After decades of neglecting agriculture and the deterioration of farmers' conditions, in current years, the agricultural sector has received support and attention as the backbone of the Egyptian economy and farming, in order to obtain a high quality and increase crop productivity. Wheat, rice, sugarcane and cotton are among the most important strategic crops that consume ~89% of the total agricultural water in Egypt [35–37]. Egyptians focus on cultivating both rice and cotton in the Delta, and wheat and sugar cane in Upper Egypt, as plotted in Figure 4.

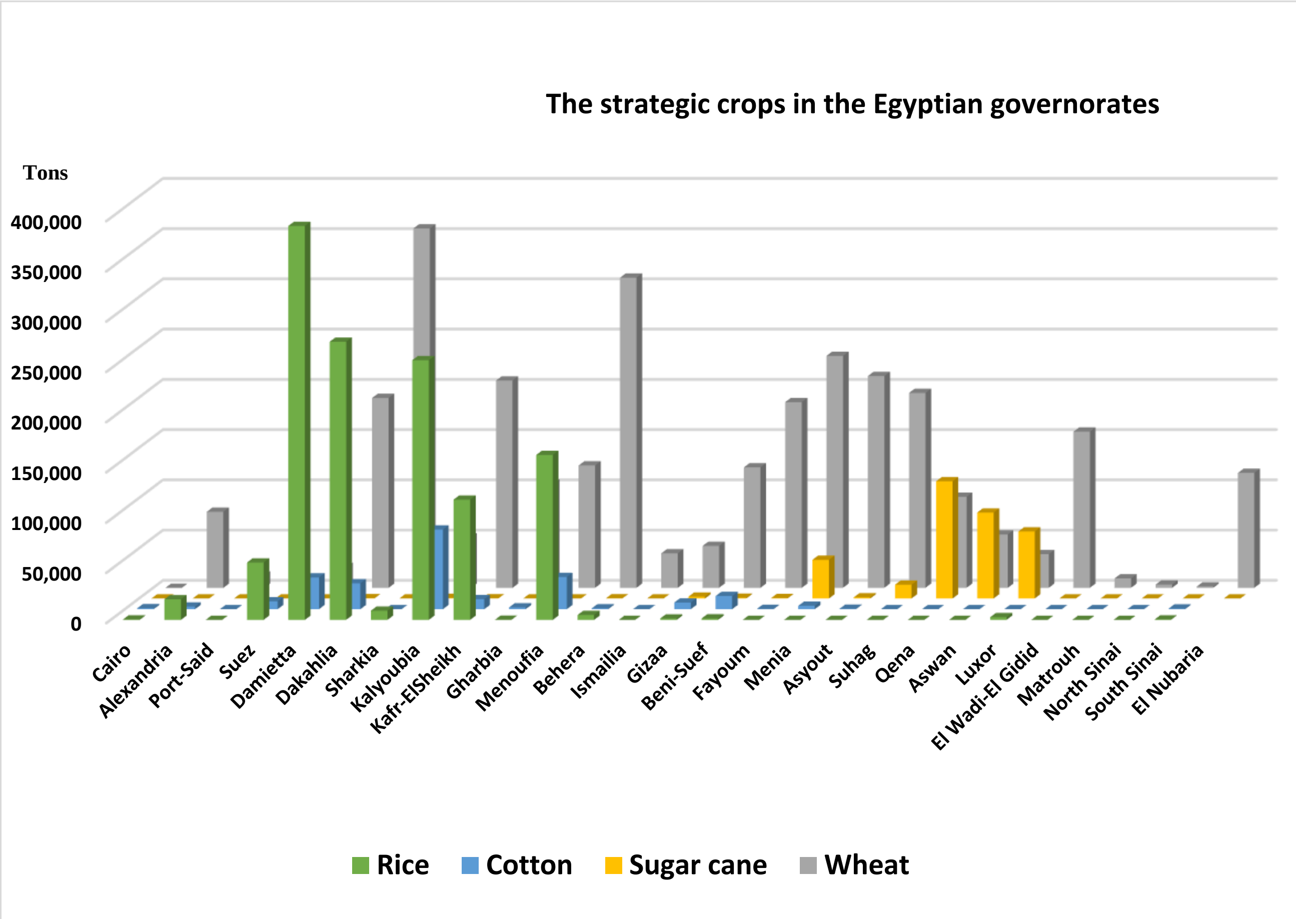

Figure 4. The strategic crops that consumed the most agricultural water all over Egypt.

2.1.1. The New Delta Project

The New Delta project is located in an area of one million acres as a first phase on the northwest coast of El-Dabaa, where the "Egypt's future" project for agricultural production is located. New agricultural and urban features are characterized by modern administrative systems and industrial complexes based on agricultural production. The area of the New Delta project is about 2.2 million acres, and the cultivation of one million acres is scheduled to be completed by 2025, which will be suitable for the cultivation of all crop kinds that are commensurate with the climate and environment in this region. The project will add 15% of the cultivated areas to Egypt to achieve food security. The phenomenon of sea-level increases and climate change pose a major challenge to the coastal areas of the Delta, which are characterized by a low groundwater level, exposing them to seawater inundation and increased soil salinity. The project's daily net water needs are estimated between 12.5 and 15 million cubic meters; the project relies on modern irrigation systems to ensure water consumption rationalization, as well as non-traditional water sources, such as treated agricultural wastewater through withdrawal and use controls to ensure the aquifer sustainability.

2.1.2. New Upper Egypt Project

The project to reclaim the 20,000 acres in western Upper Egypt is one of the significant agricultural projects. The West Minya project is a pilot research farm that includes farms for animal production and greenhouses, located within an area of more than 420,000 acres [38,39]. The Egyptian state has developed an agricultural strategy that is compatible in its objectives with the sustainable development goals, as it aims to enhance food security, improve nutrition in a healthy and safe manner, meanwhile promoting sustainable agriculture, eliminating poverty in rural areas in Upper Egypt, improving the standard of living and increasing the competitiveness of agricultural exports [40,41]. The development of Upper Egypt faced great challenges, but the will of the State stood in front of them, and plans were drawn up to develop the governorates of Upper Egypt in a comprehensive manner that guarantees the citizen a "Hayat Karima i.e.: Dignified Life". Despite all of these challenges, cultivation of plants still depends on flood irrigation that consumes huge amounts of fresh water. The New Upper Egypt project focused on re-using pure treated wastewater in the shredder, as there is no agricultural wastewater system in Upper Egypt to dilute its pollutant. Both high salinity and heavy metal precipitation are the negative drawbacks on the farmer's health and safety.

3. Results and Discussion

3.1. Drip Irrigations Technology

Egypt faces water scarcity in the future, and with the agriculture sector accounting for 25 % of the country's GDP, the government is desperately looking for ways to optimize water use. The country is struggling with a rapid population growth of approximately 2%, annually; in addition, climate change is expected to lead to sharp fluctuations in rainfall in the headwaters of the Nile. Meanwhile, the construction of a large new dam, upstream in Ethiopia, has heightened regional tension over entitlement to the Nile's waters. About 90% of Egypt's fresh water comes from the Nile River, where millions of farmers depend on it to irrigate their land, and with concerns growing, Egypt is considering a range of water-saving measures. The government is also accelerating a scheme that will line thousands of kilometers of canals with concrete in order to reduce seepage, evaporation and reduce the cultivation of water-intensive crops, such as rice. To make a significant impact, authorities need to force millions of farmers to switch to irrigation methods that are more efficient. It is clear that only countries with heavy rainfalls are able to provide the luxury of flood irrigation, which is not available to Egypt, therefore, we need to change the prevailing culture in which modern irrigation provides 30% to 40% of the water use. In order to encourage predominately poor farmers to make this shift, phase one is underway to cover just over 1.2 million hectares, mostly in reclaimed desert lands where farmers face fines and taxes if they do not use the modern systems. However, smallholders work in the "old lands" of the Delta, Upper Egypt and the Nile Valley, where water is available.

The changes we need for modern agriculture are proposed in Figure 5. We suggest using PV panels and storage as a clean energy source, used to collect and store energy needed to run and operate the pump for the drip irrigation systems [42,43]. Drip irrigation systems are mainly selected to enhance and improve the use of available water resources in order to optimize crop productivity [44]. Most drip irrigation systems are also known as poly micro plastics tube irrigation, designed as horizontal lateral lines which supply fresh water, either onto plant surfaces directly to the root zone or onto the soil surface, through low pressurized tube lines, solenoid valves and drippers, to make water flow slowly. It is known that drip irrigation conserves around 40–70% of fresh water compared to conventional flood irrigation systems. Drip irrigation conserves a large amount of fresh water, from the start feed preparation levels to the last step of plant harvesting. The paddy (a common type of rice) shows that around 1.3 M/L of fresh water is required for feeding an acre of paddy under conventional flood irrigation system; in addition, the drip irrigation system uses only about 0.4 M/L of fresh water [45]. It has become possible by using DI that all growing vegetables and crops can be cultivated by the least amount of fresh water.

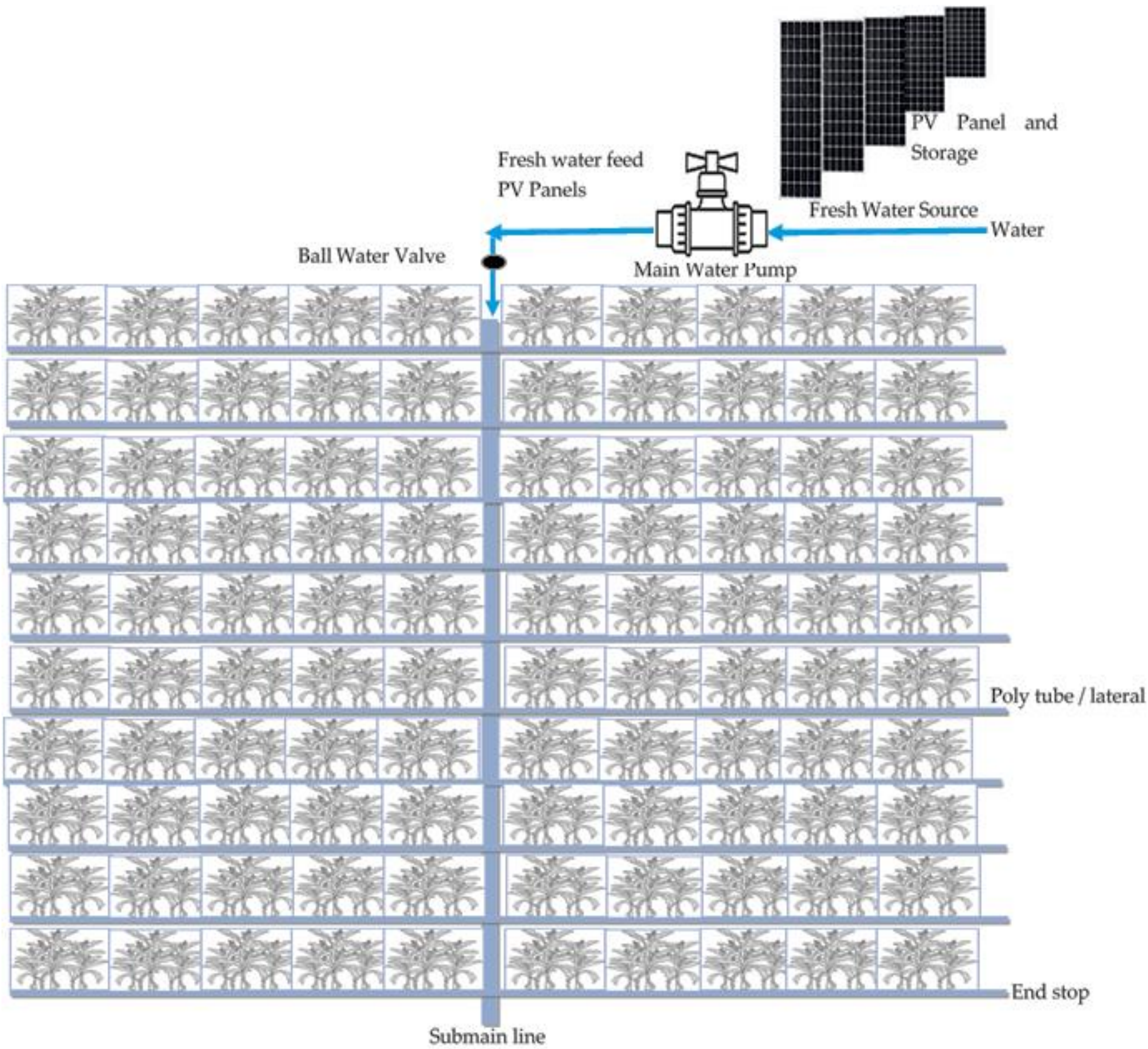

Figure 5. Proposed drip irrigation system for modern agriculture.

3.2. Diagnosing the Future State

Eventually, the Egyptian government will force the farmer to implement the smart farming technologies in agriculture in order to achieve SDGs goals and circular economy. Figure 6 reports the smart farming and modern agriculture techniques in developing countries [46,47]. Flow, temperature, humidity, rain fall and sun light radiation are the major sensoria used in smart farming techniques. In addition, reporting these data through analogue or smart phones helps the farmers to perform all the farming processes to enhance the quality and quantity of the final products, while reducing the pesticides, manpower, time, fuel, fertilizer and indeed fresh water [48,49]. Software applications and communication systems, such as cellular (drip irrigation application), have become the second and third processes in smart farming technologies. These techniques are useful for reporting environmental conditions such as soil moisture, weather, and prevailing climatic conditions, thus saving time, manpower, and fresh water. It is suggested that the data should be stored continuously for a maximum of 15 days in order to update the farmer with any changes in the growing conditions [50,51].

Telematics—online positioning technologies using hardware and software —are the core data used for the smart drip irrigation application, that is the mind and hands of farmers. Undoubtedly, the improvements made by smart drip techniques will be positively reflected in the income of the farmer and the economy of the country, but only if all the techniques are implemented in a proper way [52,53]. Finally, the data analytics solution is the controller used to adapt the drip irrigation process in cultivation, in order to reach the efficient use of fresh water in the cultivation of strategic crops [54]. According to the data from the Egyptian general authority for mobilization and statistics, the amount of fresh water used in agriculture has decreased by 40% while using drip irrigation, whereas this percentage can be reduced by 55–60% through the implementation of smart drip irrigation, as explained in the above paragraph, and shown in Figure 7.

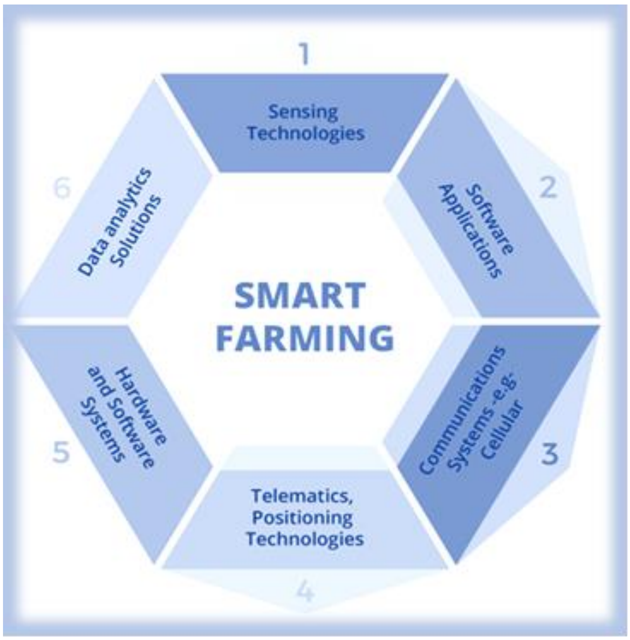

Figure 6. Smart farming and modern agriculture techniques.

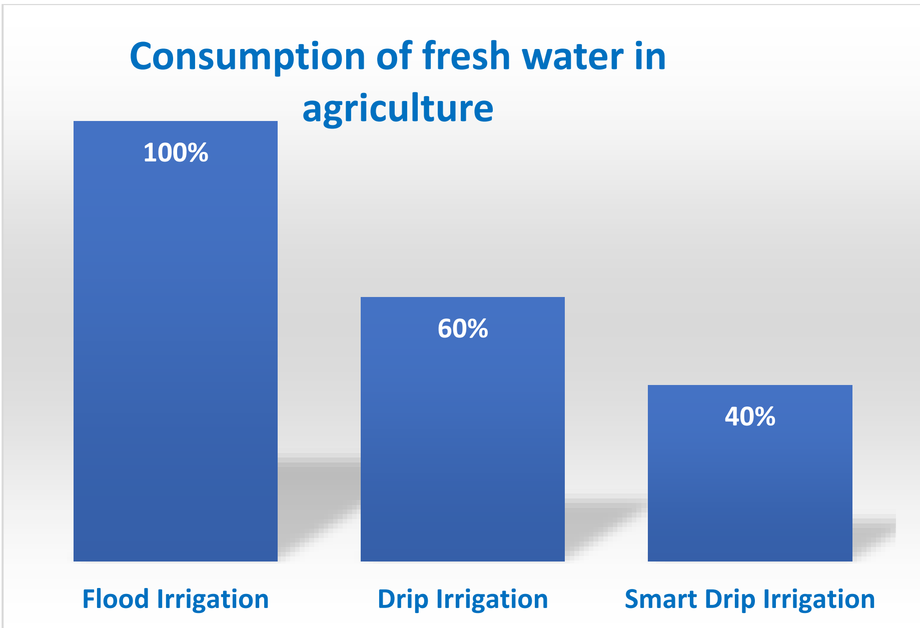

Figure 7. Assumption of fresh water consumption in relation to the irrigation process.

3.3. Capex and SDGs

Water means money, therefore, optimizing water utilization is the main goal for sustainable development goals. Six main goals can be achieved by implementing drip irrigation techniques in Egypt agriculture sector,: G1—no poverty, G2—zero hunger, G3—good health, G6—clean water, G8—economic growth and G11—sustainability, as shown in Figure 8. It aims to enhance food security, improve nutrition in a healthy and safe way, while promoting sustainable agriculture, eradicating poverty in rural areas, improving the standard of living, increasing the competitiveness of agricultural exports, and creating job opportunities, especially for youth and women. The most important six objectives of the strategy and projects adopted by the political leadership to enhance food security are:

(1) Horizontal expansion, which aims to increase the agricultural area, compensating for the areas that were lost because of encroachments on it; achieving integrated development; increasing employment opportunities; and creating urban communities and areas that attract residents to reduce population density in some areas. The most important horizontal expansion projects are the New Delta project, which aims to achieve comprehensive development of an area 2.2 million acres, depending on modern technology in agriculture, drip irrigation, the use of artificial intelligence mechanisms; and it aims to grow strategic crops to reduce the food gap, including (wheat, maize, legumes, and oil crops), and expand related projects such as agricultural manufacturing, animal and poultry production stations, and farming integrated fish filling and export stations, silos for storage and others.

(2) The North and Central Sinai development project of about 500,000 acres and the Toshka, South Valley and West Minya areas development project, in contrast to the new Egyptian rural development project, is for an area of 1.5 million acres. All of these projects aim to increase the agricultural area by about 4 million acres, which is equivalent to more than 65% of the old land area, as the implementation of such projects requires huge sums of money to provide water from multiple sources, whether from agricultural wastewater treatment, seawater desalination, or of groundwater, which the state seeks to implement, despite the high costs, in order to achieve the targeted food security.

(3) In the field of vertical expansion, the Egyptian State, through experts, researchers and agricultural producers, has been able to improve farming methods, rely on mechanisms that reduce water needs, and devise early-maturing varieties that are able to withstand climate change, which has greatly contributed to raising the average productivity and maximizing the efficiency of the use of land and water resources.

(4) In light of the water poverty that the Egyptian state suffers from, an initiative has been implemented to encourage farmers to switch to modern irrigation systems, within the framework of the State's direction, in order to maximize and raise the efficiency of water use, whether in new lands or in old lands. An initiative was launched to encourage transformation processes with easy financing from banks, to be paid over 10 years without interest, and with supervision and technical support from the Ministries of Agriculture, Land Reclamation, Water Resources and Irrigation, and this aims to convert an area of 3.7 million acres from flood irrigation systems to drip irrigation systems, in addition to the national project for lining canals at a cost of more than 20 billion Egyptian pounds [55].

Figure 8. The expected SDGs outcome through implementation of drip irrigation system.

It is clear that the implementation of drip irrigation systems in the Upper Egypt region will save around 40% of active fresh water used in agriculture. According to data reported from the Egyptian general authority for mobilization and statistics, approximately 37 BM^3/Year of fresh water is used in cultivation in Upper Egypt [56,57], which may be reduced by 40% (14 BM^3/Year of fresh water). The current cost of 1M of fresh water = 0.90 EGP, saving around 12 BEGP/Year, which can be used for other crops or building new urban communities.

The process of implementing drip irrigation systems will raise the efficiency of water management and reduce losses resulting from transport and evaporation, especially the national project for lining the canals. The utilization of poly-tubes, its quantity, lifecycle and other environmental issues connected to irrigation systems, are very important issues. The quantity of poly-tubes is about 121 m for each 7-row planting basin. The life cycle of poly-tubes is clearly explained elsewhere [58].

4. Conclusions

The full implementation of the new irrigation techniques in Upper Egypt will have positive advantages on both the stockholders and the farmers. It can be summarized in the following points:

(1) Environmentally, the project will contribute to reducing agricultural waste-water usage, reducing pollution, and greenhouse gas emissions.
(2) For the farmer, it will reduce irrigation time, labor costs and increase the income of rural families.
(3) Increase productivity, new land areas, improve water transfer efficiency, improve field irrigation efficiency, and achieve equitable distribution of irrigation water.
(4) Drip irrigation systems are important to support farms to meet the challenges facing the agricultural sector, which effect agricultural productivity, adverse climatic changes and water scarcity.
(5) The drip irrigation system maintains the sustainability of water and agriculture by using the optimum available water resources and increasing the acres' productivity in order to achieve a circular economy.
(6) Holding awareness seminars and workshops in Upper Egypt governorates and agricultural directorates to educate farmers about the importance of switching to drip irrigation systems.

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