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A Proposed Framework to Improve Decision-Making in The Deployment of Modern Irrigation Techniques Using Business Intelligence

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Abstract

The research problem highlights that Egypt is suffering recently from water shortage due to the severe scarcity of water. Regarding that, unequal water distribution, misuse of water resources, and inefficient irrigation techniques were playing a destructive role in water security. Egypt also faces a water deficit of 20 billion cubic meters per year. The United Nations has warned of the running out of water in Egypt by 2025. Thus, a survival strategy is required for preserving and developing water resources. This study applies business intelligence techniques to aid decision-makers in determining the amount of water needed based on crop type, appropriate irrigation system, land size, region, planting season, and development of various scenarios for the application of modern irrigation systems. The study focuses on determining the cost of modern irrigation system implementation scenarios and the best scenario for implementing various irrigation systems, as well as their cost. The findings tool aids to improve decision-making by enabling the transformation of raw data into useful information, providing good visualization of data, and identifying trends. The developed BI tool is supporting strategic water resources management and helps in guiding the experts to determine the best scenario in applying modern irrigation systems in Egypt.

Keywords: Business Intelligence, Water Resources Management, Analytical Reporting, Dashboards, Data Warehousing, decision-making, modern irrigation systems, Streamlit.

1. Introduction:

The agricultural sector is the largest user, and consumer, of water in Egypt, with its share exceeding 85% of the total water demand. Therefore, most land and water policies are mostly concerned with agriculture. The agricultural land base consists of old land in the Nile Valley and Delta, rain-fed areas, several oases, and lands reclaimed from the desert. The total irrigated area in 1977 was about 7 million feddans and the rain-fed areas along with the Mediterranean coast covered about 0.12 million feddans. Egypt's land is generally highly productive. The plan for agricultural horizontal expansion of cultivated land is considered a national plan aiming to increase agricultural land and crop production. Therefore, cultivated, and cropped areas are increasing in the past few years (the cultivated area in 1990 was only 6.92 million feddans, while the cropped area was 12.43 million feddans). [1]

Consequently, the agriculture demand is expected to increase from 57.8 to 63.6 BCM taking into consideration the rising irrigation efficiency by extending the irrigation improvement projects to cover most of the old lands, and applying modern irrigation techniques, e.g., sprinkler and drip irrigation, in the new reclamation lands. [1]

concerning the use of various advanced technologies of information technology especially computer-based decision support. A new generation of business intelligence (BI) is introduced as a constantly evolving new generation of knowledge for decision support and the following figure1 shows how these generations evolved. [2]

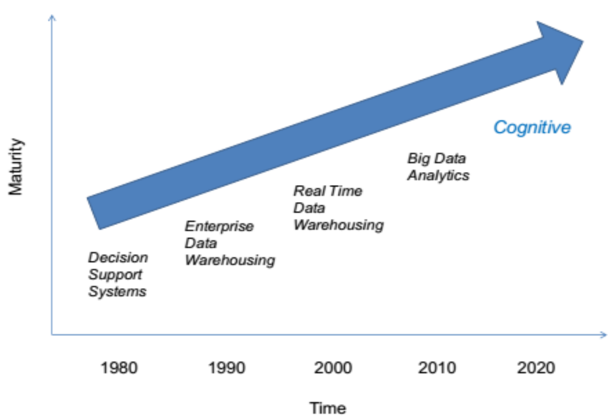


Figure 1 The Decision Support//DSS Generations [2]

As shown in figure1 above, there were DSSs in the 1980s, then by the 1990s data storage was emerged, and following that in the 2000s real-time data storage, and recently the most massive data analyses in (2010s). [2]

Technology for business intelligence (BI) provides historical, present, and predictive perspectives of company processes. Reporting, online analytical processing, analytics, data mining, operations processing, complicated event handling, business performance management, standards establishing, text mining, predictive analysis, and required analysis are examples of common business intelligence approaches. In addition, BI approaches can handle vast amounts of organized and unstructured data, assisting in the identification and development of new strategic business prospects. In addition, the goal is to make it simple to interpret large amounts of data. [4]. All organizations must use decision support and business intelligence systems to aid decision-makers to improve the decision-making process by using a good quality of data, information, and knowledge. So, the resultant benefits of researching and studying are considered worthwhile to study the role of these systems in improving the decision-making process of the water resources sector in Egypt.

This research is significant because of the subject's modernity, particularly the use of business intelligence techniques to improve decision-making in water resource management in Egypt. Applying such modern techniques to an important and strategic sector as the irrigation sector and water resources in Egypt. Egyptian water security must be highlighted to be considered at the top of academic research priorities and escalating its efforts in this regard to improve the management, development, and planning of Egyptian water resources.

2. **Literature review:**

Some research has been done on business intelligence and how it plays a role in the shaping decision-making process, many organizations are limited by making a strategic decision away from using business intelligence tools. With the need to respond quickly to both internal and external environments, and now business intelligence tools have become powerful strategies that are reformed, build their capacity and performance, and follow made decisions.

Hamdan et al. (2021) proposed of this research is to determine the impact of a business intelligence (BI) system on organizational agility. The findings also show that the business intelligence system has a major impact, with a strong direct correlation between organizational agility and decision-making. [3]

According to Farag et al (2021), the goal of this study is to create a Financial Stumbling Detection (FSD) Model that can assist SME stakeholders in making sound financial decisions. The proposed BI framework is designed to help SMEs that use the Design Science Research (DSR) methodology. The results of the applicable cases' visualization ensure Using some financial ratios and evaluating the concluded KPIs on the intended data, the empirical FSD model confirms its effectiveness in finding the initial stumble/defect in SMEs. [4]

Saxena et al. (2021) stated that the purpose of this paper is to assist the relevant authorities and any future studies. Regression methods such as Ridge Regression, Random Forest, and others have been used to forecast the objective variable (production) with high accuracy, ranging from 65 percent to 88 percent depending on the algorithm. Streamlit is used to put all this data on an interactive web application. The suggested system will help many people because all information about Indian agriculture can be available in one place, and the prediction of production amounts allows for better resource planning. [5]

Hribar Rajteric ˇ (2010) measured BIS maturity from the perspective of organizational culture, which is based on management and focuses on transforming the methods of information use. BIS maturity within an organization can be defined as the capacity of an organization to provide quality information and enhance organization performance through this system. In other words, evaluating BIS maturity is evaluating the quality and level of application of a BIS within an organization. [6]

Watson (2009) believes that business intelligence includes application, storage, process collection, techniques, interviews, and data analysis to help corporations make better decisions. In this study, BIS is regarded as a modern information technology, which extracts, integrates, and analyzes the timely and useful information internal and external to organizations, while also creating and accumulating user knowledge and insights to help them make an accurate judgment. [7]

Elbashir et al. (2008) proposed that a BIS is a specialized tool for data analysis, which can assist managerial personnel in decision-making needed in a wide range of business activities. [8]

Morgan, Asocan, and Cadambie (2004) show that business intelligence tools help in an organization's success and loyalty to customers by delivering and highlighting early decisions to ensure customer loyalty and admiration. Research workers know the concept of business intelligence as "a combination of software packages and data storage that enables organizations to collect, store, retrieve and analyze data to accelerate their decisions and improve business processes and performance as well." [9]

Williams (2007) shows that business intelligence tools are the key to business process integration and management, also a set of processes, technologies, and data that refer to a single package (software) developed to reduce the gap and achieve business that needs a high level of efficiency and effectiveness and create tools that work and support decisions and actions. It should be borne in mind that business intelligence tools work and support decisions at all levels of management from executive to operational level [10].

Both Powers and Williams (2007) agreed that BI tools lead to a correct future prediction by creating an integration environment that bridges gaps between business functions and provides specific information based on historical data. Bowers also talks about BI as a data-driven system that drives paid system more than paid model and the meaning of all results and predictions based on data collected and processed. The degree of resolution is therefore based on the accuracy of data collected [11]

Petrini and Pozzebon (2008) stated that the BI system relies on historical information that enables decision-making. They study the BI system from both administrative and technical approaches. The administrative approach consists of data generated from external and internal environments. Once these data are processed, the analysis and recovery are again supported by a semi-structured and unorganized decision. The technical approach is described as a set of tools and programs that manipulate data and provide the optimal solution [12]

Ranjan (2008) says that the BI system makes the right decisions in time to get high business performance and good use of resources. From a strategic point of view, it is shown that BI is a special application that repairs data and changes it to knowledge to support problem resolution and decision-making. [13]

3. **Research Terminologies:**

Table 1 Major components and functional subdomains within the Business Intelligence umbrella

Major Concept	Acronym	Short Explanation
Decision Support System	DSS	A computer-based information system that supports decision making resulting in ranking, sorting or choosing from among alternatives [14]
Data Warehousing	DW	Central data repository system of integrated data from one or multiple sources that stores current and historical data in one single place and format [15]
Data Mining	DM	Discovers correlations and patterns in (usually large) data sets involving methods of machine learning, statistics, and mathematical modeling [16]
Business Intelligence	BI	Umbrella term comprising the domains of DW, OLAP, and DM [17]
Data Marts	Data Marts	Data Marts are the subsets of a data warehouse. Data mart's goal is to meet the demands of the specific group of users in the organization such as HR, Sales, Accounts, etc. [18]
Dashboards/Reports	Dashboards/ Reports	Dashboards/Reports – Business Intelligence dashboard is a BI software that provides the interface with the information needed to achieve one or more objectives on a single screen [18]
Drip irrigation	Drip irrigation	water is added in this way in the form of dots around the plant. This method is suitable for sandy and desert lands. But one of its disadvantages is that it is very expensive, and needs trained and efficient workers. [19]
Sprinkler irrigation	Sprinkler irrigation	In this method, water is sprayed into the air through small holes in tubes and pipes until it falls on the surface of the soil and plants in the form of raindrops. One of the advantages of this method is that it enables farmers to add fertilizer and pesticides with water, and it can also be used on uneven lands. It does not need working hands, protects plants from frost, and works to maintain their temperature, but one of the disadvantages of this method is that it leads to the emergence of salts on the surface of the soil. Irrigation. [19]
immersion irrigation	immersion irrigation	Surface irrigation is the immersion of the soil with water, and one of its advantages is that it does not require much labor. Its disadvantages are that the amount of water cannot be controlled, so large amounts of water are lost. [19]

4. **Research Problem:**

The implementation of the transformation project for modern irrigation systems has become very important to reduce water wastage, especially since we have about 5 million acres in the Delta and Upper Egypt, the "old lands," that consume about 40 billion cubic meters of water through the flood irrigation system. In the case of applying modern systems, whether developed or drip irrigation, the availability of 15-20% of water is wasted, in addition to an increase in the quality of feddan productivity and increasing the profitability of farmers but this is done at 150 billion EGP, at a rate of 15–30 thousand per feddan, not to mention the work and extension of irrigation networks, according to experts. according to the minister of irrigation, projects worth 66 billion pounds are being implemented to improve the water management system over the next four years. [20] Concerning all the above, the research problem highlights the suffering of Egypt in recent years of severe scarcity of water. Regarding, unequal water distribution, misuse of water resources, and inefficient irrigation techniques are some of the main factors that play a destructive role in water security.

The technological progress and the existence of large amounts of data, it is necessary to preserve and develop water resources. Therefore, accumulated data must be used to obtain valuable statistics, known as "business intelligence", to make feasible strategic decisions. Business Intelligence (BI) has the capabilities to support critical business decisions by involving past and present trends and forecasting future operations of organizations. Business intelligence is a combination of product, technique, or methodology. Thus, it is considered to be an advantage that assists in achieving high-quality business performance.[10][21]

5. **Research Objectives:**

This study aims to Apply business intelligence techniques to aid decision-makers in:

- Determining the amount of water needed based on crop type, appropriate irrigation system, land size, planting season, and region.
- Development of various scenarios for the application of modern irrigation systems.
- Determining the cost of modern irrigation system implementation scenarios.
- Determining the best scenario for implementing various irrigation systems, as well as the cost.

6. **Research Methodology:**

A BI architectural framework named **irrigation systems /BI framework** composites of five **Layers** as shown in Figure 2.

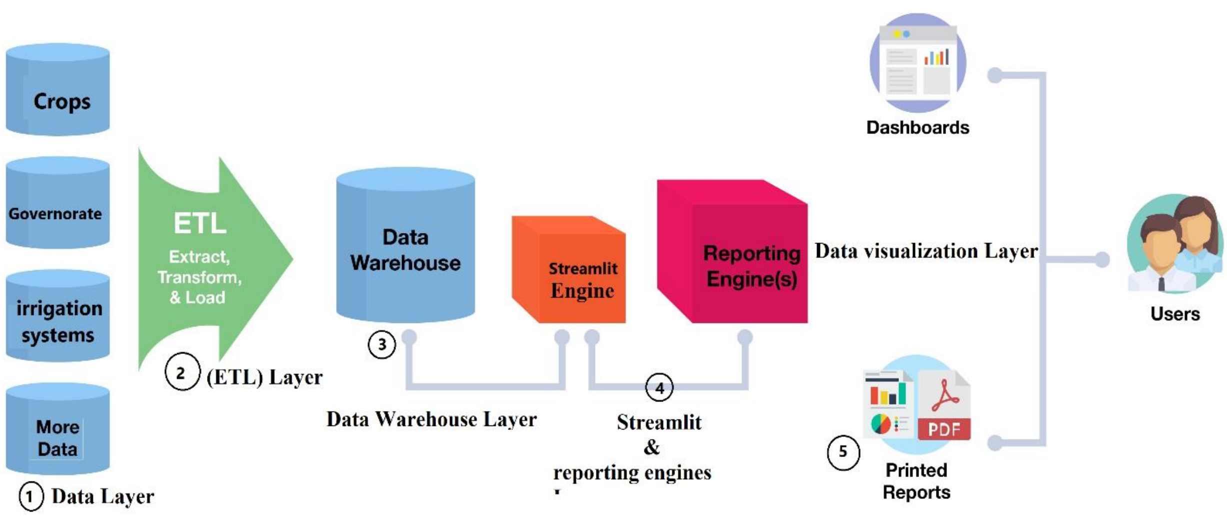


Figure 2 Irrigation systems /BI framework

6.1. **Data Layer:**

The data shall be obtained from the National Water Research Center of the Egyptian Ministry of Irrigation and Water Resources, the World Bank, and the Food and Agriculture Organization of the United Nations (FAO). These variables are shown in Table 2, and Table 3 explaining the integration and communication among Data Source Layer and ETL Layer.

Table 2 Quantities of Used Irrigation Water for Winter Crops According to Field Rations and Governorates 2018 [22]

Quantity: Thousand M^3

Crops / Governorates	G.Total	Vegetables	Others	Medical and Aromatic Plants	Garlic	Fully grown Onions	Flax	Alfalfa		Sugar Beet	Lupine	Chickpeas	Fenugreek	Lentils	Fully grown Beans	Barley	Wheat
								Forestation	Sustained								
G.Total	11058054	967737	10991	87175	79471	286718	19539	225658	2855348	1044683	147	13789	4960	1485	78122	15095	5367136
Cairo	1200	254	84	0	0	7	0	0	805	0	0	0	0	0	0	21	29
Alexandria	118183	45483	0	0	15	220	48	3932	9667	14351	0	0	0	0	1158	826	42483
port Said	138726	1071	0	104	0	0	0	0	30793	78272	33	0	0	0	248	3606	24599
Suez	23503	6128	0	0	7	498	0	0	6408	0	0	0	0	0	810	452	9200
Damietta	192098	22828	0	177	478	2589	1893	4021	99365	12318	0	0	0	180	6007	45	42197
Dakahlia	1101463	92338	7	148	3498	41166	6384	19472	341256	164638	0	0	0	957	12340	19	419240
Sharkia	1218163	101065	0	104	1179	28939	2712	5042	305969	121814	29	0	19	178	10637	3920	636556
Qaliubiya	222660	27577	0	301	349	24472	93	5936	76608	817	0	0	0	0	0	0	86507
Kafr El Sheikh	1096671	39519	0	8545	26	2688	2976	39505	224615	337721	0	0	0	0	16641	575	423860
Gharbia	633799	46633	0	2890	555	79927	4012	10835	196429	40276	0	0	0	0	3492	13	248737
Monoufia	572985	108895	0	1030	260	1791	81	12526	214486	4789	0	0	0	0	179	3	228945
Behaira	1276159	155645	0	3933	692	16825	1340	91465	287623	88363	0	0	0	0	12027	402	617844
Ismailia	150176	79336	0	0	201	317	0	4522	20531	3360	0	0	0	2	1377	762	39768
lower Egypt	6745786	726772	91	17232	7260	199439	19539	197256	1814555	866719	62	0	19	1317	64916	10644	2819965
Giza	296866	108473	10900	856	3785	7340	0	9992	88240	1218	0	0	0	0	1121	322	64619
Beni Sweif	547469	37083	0	15462	39722	19184	0	0	135360	37718	0	4035	224	0	217	0	258464
Fayoum	807134	25721	0	33726	6466	26408	0	6271	208956	68261	0	0	0	0	855	2611	427859
Minya	757069	21667	0	12950	14889	5602	0	1392	187367	45743	0	5357	1851	0	1188	206	458857
Middle Egypt	2408538	192944	10900	62994	64862	58534	0	17655	619923	152940	0	9392	2075	0	3381	3139	1209799
Assuit	768117	11236	0	5468	3058	5832	0	5185	152279	25024	22	4218	897	152	6848	120	547778
Sohag	758026	22397	0	0	1520	17639	0	5562	197306	0	58	14	800	0	1456	122	511152
Qena	248351	5482	0	1114	502	2384	0	0	43847	0	5	0	965	16	634	152	193250
Aswan	46257	1910	0	367	1549	1685	0	0	9973	0	0	0	3	0	290	185	30295
Luxor	82979	6996	0	0	720	1205	0	0	17465	0	0	165	201	0	597	733	54897
Upper Egypt	1903730	48021	0	6949	7349	28745	0	10747	420870	25024	85	4397	2866	168	9825	1312	1337372

Table 3 Quantities of Used Irrigation Water for irrigation systems 2018 [23]

Crop	Season	Region	Immersion	Sprinkler	Drip
Peanuts	Summer	lower Egypt	39566000	31664652.02	27941071
Peanuts	Summer	lower Egypt	30368000	24294400	21445545
Peanuts	Summer	Middle Egupt	11780848	9425704.606	8319504
Peanuts	Summer	Middle Egupt	4990988	3993079.23	3524580
Peanuts	Summer	Middle Egupt	142000	113615.4055	100278.8
Peanuts	Summer	Middle Egupt	28982043	23185634.4	20466798
Peanuts	Summer	Upper Egypt	4104782	3283825.6	2898752
Peanuts	Summer	Upper Egypt	11058290	8846363.073	7809242
Peanuts	Summer	Upper Egypt	171666	137341.6808	121228.6
Peanuts	Summer	Upper Egypt	2358122	1886372.135	1665280
Peanuts	Summer	Upper Egypt	435968	348694.6984	307875.8
fully grown Beans	Winter	lower Egypt	0	0	0
fully grown Beans	Winter	lower Egypt	7316777.529	5853422.023	5167027
fully grown Beans	Winter	lower Egypt	155198.4349	124154.9736	109599.4
fully grown Beans	Winter	lower Egypt	810000	647830.1887	572013
fully grown Beans	Winter	lower Egypt	2474519.285	1979859.103	1747478
fully grown Beans	Winter	lower Egypt	12340000	9872000	8714371

6.2. **Extract, Transform & Load (ETL) Layer**

This layer includes nine stages, where all are applied to the gathered data to prepare it in the proper format for the data processing layer. This layer includes the validation stage, comparing raw data, cleaning stage, correcting raw data, transforming stage, aggregating stage, preparing raw data, loading stage, and exporting raw data, where it communicates with the Data Warehouse Layer to store these sources into data marts.

6.3. Data Warehouse Layer

This layer is the source component where all the raw data are loaded from the ETL layer to Data Warehouse Layer. These loaded data are classified into smaller sets that include categories, crops, governorates, regions, irrigation systems, and seasons. Finally, they are stored in data marts, where the communication among the Data Warehouse Layer and Analytical Layer depends on these specific data from the data marts to be analyzed.

Table 4 The data format after Loading it into the data warehouse.

Crop_Name	Category_Name	Season_name	Government_name	Region_name	Land size	production	Pro./Acre	Water/Acre	Immersion	Sprinkler	Drip
Rice	cereal	Summer	Cairo	lower Egypt	0	0	0	0	0	0	0
Rice	cereal	Summer	Alexandria	lower Egypt	860	3121	3.629069767	5293.023256	4552000	NO	NO
Rice	cereal	Summer	Port said	lower Egypt	18195	54694	3.005990657	6456.99368	117485000	NO	NO
Rice	cereal	Summer	Suez	lower Egypt	0	0	0	0	0	0	0
Rice	cereal	Summer	Damietta	lower Egypt	47059	162307	3.449010816	5730.61476	269677000	NO	NO
Rice	cereal	Summer	Dakahlia	lower Egypt	228275	832509	3.646956522	5742.464133	1310861000	NO	NO
Rice	cereal	Summer	Sharkia	lower Egypt	187054	632597	3.381895068	5215.991104	975672000	NO	NO
Rice	cereal	Summer	Quliubiya	lower Egypt	1932	5945	3.077122153	6457.039337	12475000	NO	NO
Rice	cereal	Summer	Kafr el sheikh	lower Egypt	190460	760126	3.991000735	6278.740943	1195849000	NO	NO
Rice	cereal	Summer	Gharbia	lower Egypt	60067	222849	3.710007159	6457.006343	387853000	NO	NO
Rice	cereal	Summer	Monoufia	lower Egypt	0	0	0	0	0	0	0
Rice	cereal	Summer	Behaira	lower Egypt	116431	419967	3.60700329	6457.000283	751795000	NO	NO
Rice	cereal	Summer	Ismailia	lower Egypt	4710	16048	3.407218684	6347.346072	29896000	NO	NO
Rice	cereal	Summer	Giza	Middle Egupt	0	0	0	0	0	0	0
Rice	cereal	Summer	Beni sweif	Middle Egupt	207	768	3.710144928	6743.961353	1396000	NO	NO
Rice	cereal	Summer	Fayoum	Middle Egupt	479	1505	3.141962422	6743.215031	3230000	NO	NO
Rice	cereal	Summer	Minya	Middle Egupt	0	0	0	0	0	0	0
Rice	cereal	Summer	Assuit	Upper Egypt	0	0	0	0	0	0	0
Rice	cereal	Summer	Sohag	Upper Egypt	0	0	0	0	0	0	0
Rice	cereal	Summer	Qena	Upper Egypt	0	0	0	0	0	0	0
Rice	cereal	Summer	Aswan	Upper Egypt	0	0	0	0	0	0	0
Rice	cereal	Summer	Luxor	Upper Egypt	0	0	0	0	0	0	0
Others	Other items	Winter	Cairo	lower Egypt	161	2430	15.0931677	3639.751553	586000	468717.1146	413826.7
Others	Other items	Winter	Alexandria	lower Egypt	0	0	0	0	0	0	0
Others	Other items	Winter	Port said	lower Egypt	0	0	0	0	0	0	0
Others	Other items	Winter	Suez	lower Egypt	0	0	0	0	0	0	0
Others	Other items	Winter	Damietta	lower Egypt	0	0	0	0	0	0	0
Others	Other items	Winter	Dakahlia	lower Egypt	0	0	0	0	0	0	0

6.4. Streamlit engine &reporting engines Layer

Streamlit is an open-source Python library for building and sharing beautiful, unique web apps for machine learning and data research. You can create and deploy powerful data applications in a few minutes. Reporting engines Ad hoc querying, filtering, and transferring are all possible with this layer. Ad hoc querying uses relational database queries to locate and choose the data required to respond to specific queries. Filtering increases the quality of information by recognizing patterns and trends in the data. Data transmission enables the development of research data. Communication between the reporting engine layer and the BI visualization layer occurs simultaneously.

The analytical module handles a tremendous amount of raw data within data marts throughout queries. **Tables** from 5 to 9 present the overall water representation filtered by both regions and seasons throughout the water coverage over governorates.

Table 5 Summation of total water and land used in each country

1. **SET** dataCuntry **TO** df['Government_name'].drop_duplicates().to_list()
2. dataCuntry.sort()
3. **SET** Cuntry **TO** pd.DataFrame(columns **TO** ['CuntryName', 'WaterUse', 'LandSize'])
4. **FOR** name **IN** dataCuntry:
5. **SET** sumWater **TO** df.loc[df['Government_name'].isin([name])]
6. **SET** sumW **TO** sumWater['Immersion'].sum()
7. **SET** sumL **TO** sumWater['Land size'].sum()
8. **SET** Cuntry **TO** Cuntry.append({'CuntryName' : str(name), 'WaterUse' : sumW, 'LandSize' : sumL},
9. **SET** ignore_index **TO** True)

Table 6 Select crops that cannot irrigate with Sprinkler or Drip

1. **SET** df **TO** df.loc[df['Government_name'].isin(options1)]
2. **SET** Crops **TO** filter_rows_by_valuesN(df,'Sprinkler',['NO'])
3. **SET** Crops **TO** filter_rows_by_valuesN(Crops,'Drip',['NO'])
4. **PRINT** (Crop_Name)

Table 7 Get the Total of Land and water used in Immersion

1. **SET** options1 **TO** st.multiselect('Select Crop to irrigate with Immersion',df['Crop_Name'].drop_duplicates())
2. **SET** dataOfImmersion **TO** df.loc[df['Crop_Name'].isin(options1)]
3. **SET** sumW **TO** dataOfImmersion['Immersion'].sum()
4. **SET** sumL **TO** dataOfImmersion['Land size'].sum()
5. **SET** options2 **TO** st.multiselect('Select Crop to irrigate with Drip',Crops['Crop_Name'].drop_duplicates())
6. **SET** dataOfDrip **TO** df.loc[df['Crop_Name'].isin(options2)]

Table 8 Get Crops that can not irrigate with Drip

1. **SET** SprinklerW **TO** Crops[~Crops['Crop_Name'].isin(options2+options1)]
2. **SET** options3 **TO** st.multiselect('Select Crop to irrigate with Sprinkler', SprinklerW ['Crop_Name'].drop_duplicates())
3. **SET** Sprinkler **TO** df.loc[df['Crop_Name'].isin(options3)]
4. Sprinkler=Sprinkler[['Crop_Name','Category_Name','Season_name','Government_name', 'Region_name','Land size','production','Sprinkler']]

Table 9 Get the Total land and water used in each irrigate method

1. **SET** DataFrame **TO** pd.DataFrame(columns TO ['waterWay', 'waterapmount','LandSize'])
2. **SET** sumS **TO** Sprinkler['Sprinkler'].sum()
3. **SET** sumLand **TO** Sprinkler['Land size'].sum()
4. **SET** DataFrame **TO** DataFrame.append({'waterWay' :'Sprinkler', 'waterapmount' : sumS ,'LandSize':sumLand}, ignore_index **TO** True)
5. **SET** sumD **TO** dataOfDrip['Drip'].sum()
6. **SET** sumLand **TO** dataOfDrip['Land size'].sum()
7. **SET** DataFrame **TO** DataFrame.append({'waterWay' :'Drip', 'waterapmount' : sumD,'LandSize':sumLand}, ignore_index **TO** True)
8. **SET** sumI **TO** dataOfImmersion['Immersion'].sum()
9. **SET** sumLand **TO** dataOfImmersion['Land size'].sum()
10. **SET** DataFrame **TO** DataFrame.append({'waterWay' :'Immersion', 'waterapmount' : sumI,'LandSize':sumLand}, ignore_index **TO** True)

6.5. **<u>Data visualization Layer and Case Study</u>**

This layer is explained through a case study that aims to present and analyze data from the previous layer. Thus, a set of business intelligence properties has been used in creating a user-friendly interface that aids in improving decision-making in the application of modern irrigation systems. "Microsoft Power BI" and "Streamlit," has been used in the visualization process to allow fast response while building and sharing data applications. The utility of the WRM framework is available on https://irrigation-systems-bi-framewo.herokuapp.com/.

Applying the case study through the visualization is discussed in figure 3, where focusing on the total size of water and specific usage of a certain governate are applied as follow:

• Agriculture consumes 46.49 billion cubic meters of water per year, accounting for nearly 60% of Egypt's total water consumption. It is the first area of rationalization and consideration.

• The Al Sharkia governorate consumes the most water in agriculture, with an annual consumption value of approximately 4 billion 631 million cubic meters.

Sharkia Governorate will be selected to conduct a case study on the application of modern irrigation systems as it's considered a high water usage governorate.

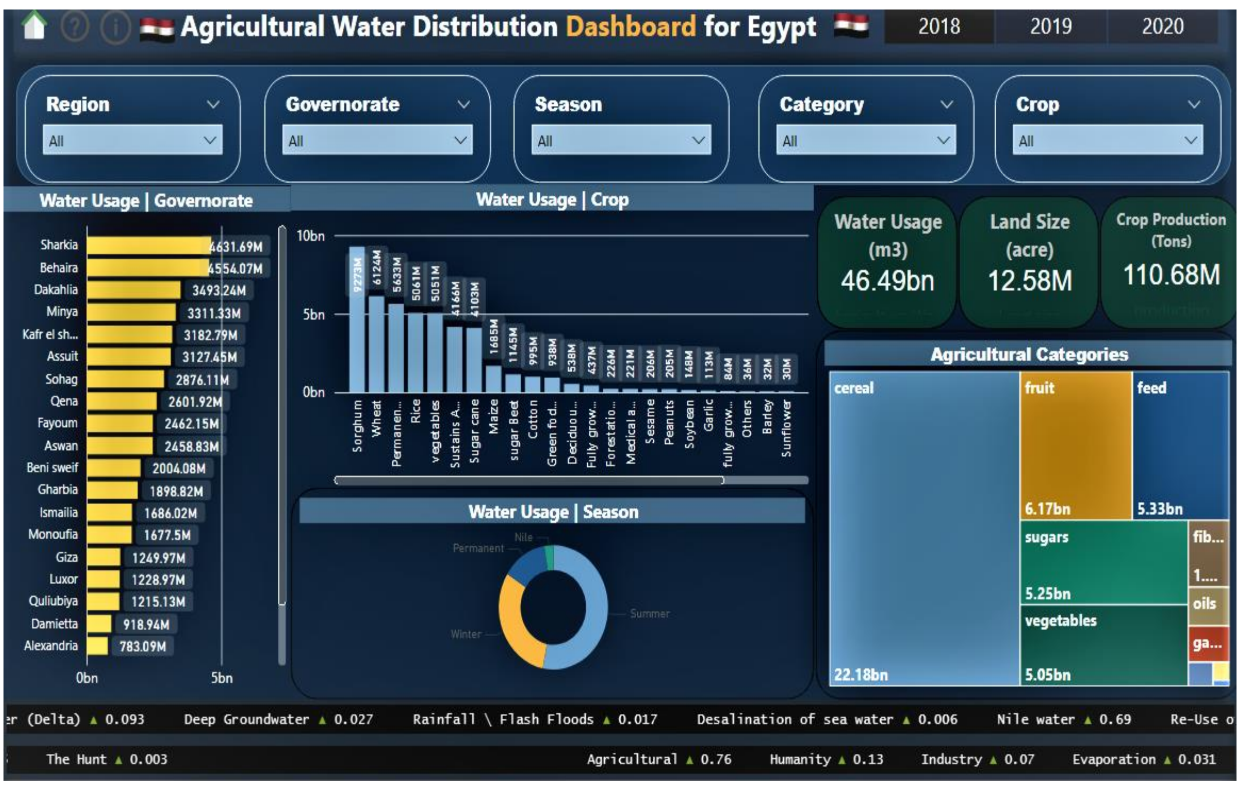


Figure 3 Agricultural Water Distribution Dashboard for Egypt

The tool allows to select the application of irrigation systems of a specific region or a specific section of crops in a specific category as shown in figure 4:

Select Region

All

Select Category

All

	CuntryName	WaterUse	LandSize
19	Sharkia	4,631,686,367.3810	1,497,796.5478
3	Behaira	4,554,073,205.4430	1,441,074.3364
6	Dakahlia	3,493,240,897.4430	1,155,242.7990
14	Minya	3,311,334,057.7500	880,459.3947
12	Kafr el sheikh	3,182,791,104.1430	1,012,294.0939
1	Assuit	3,127,449,404.9990	718,710.3543
20	Sohag	2,876,114,210.0960	640,281.3571
17	Qena	2,601,924,834.5625	360,884.5000
8	Fayoum	2,462,152,556.4960	694,898.1340
2	Aswan	2,458,833,945.3460	348,635.8583

Figure 4 Region and department selection screen

Al Sharkia Governorate is selected to apply the case study, as shown in figure 5.

Select Government

Sharkia ×

	Crop_Name	Category_Name	Season_name	Government_name	Region_name	Land size	production	Immersion	Sprinkler	Drip
4	Rice	cereal	Summer	Sharkia	lower Egypt	187,054.0000	632,597.0000	975,672,000.0000	NO	NO
16	Others	Other items	Summer	Sharkia	lower Egypt	739.0000	11,085.0000	2,916,000.0000	2333070.188	2059246.90
30	Forestation Alfalfa	feed	Winter	Sharkia	lower Egypt	3,702.0000	45,256.0000	5,042,000.0000	4032499.727	NO
48	Sustains Alfalfa	feed	Winter	Sharkia	lower Egypt	287,078.0000	5,236,148.0000	685,969,000.0000	548713233.5	NO
69	Fully grown Onions	garlic and onion	Winter	Sharkia	lower Egypt	17,618.0000	249,192.5266	32,505,210.0000	25997353.49	22954819.3
87	Fully grown Onions	garlic and onion	Summer	Sharkia	lower Egypt	2.5000	31.0000	12,072.5000	9658.42408	8525.46579
94	Lupine	legumes	Winter	Sharkia	lower Egypt	30.0000	18.0000	29,000.0000	23194.69835	20479.4788
103	Garlic	garlic and onion	Winter	Sharkia	lower Egypt	959.0000	6,267.0000	1,879,000.0000	1503200	1326928.99
119	Fenugreek	legumes	Winter	Sharkia	lower Egypt	10.0000	8.0000	19,000.0000	15202.53165	NO
138	vegetables	vegetables	Winter	Sharkia	lower Egypt	2,085.9407	32,307.5960	4,589,069.4390	3671184.891	3240750.0

['Rice']

Figure 5 Select Government to irrigate plan

Figure 5 shows all the crops grown in the Sharkia Governorate, as well as the rice crop, whose presence in this place indicates that it is the only crop that accepts cultivation only by immersion and not by any other method. Accordingly, the method of cultivation by immersion will be chosen for the rice crop, while the rest of the crops will accept any other distribution among different irrigation methods, as shown in Figure 6:

Select Crop to irrigate with Immersion

Rice ×

	Crop_Name	Category_Name	Season_name	Government_name	Region_name	Land size	production	Immersion
4	Rice	cereal	Summer	Sharkia	lower Egypt	187,054.0000	632,597.0000	975,672,000.0000

Sum of water used in Immersion

975.67M

Sum of Land used in Immersion

187.05K

Select Crop to irrigate with Drip

Others × Fully grown Onions × Lupine × Garlic × vegetables × Sorghum × Green fodder × Sesame × Peanuts × fully grown Beans × Cotton × Medical and Aroma... × sugar Beet × Sunflower × Soybean × Deciduous fruit × Permanent Greene... ×

	Crop_Name	Category_Name	Season_name	Government_name	Region_name	Land size	production	Drip
16	Others	Other items	Summer	Sharkia	lower Egypt	739.0000	11,085.0000	2059246.906
69	Fully grown Onions	garlic and onion	Winter	Sharkia	lower Egypt	17,618.0000	249,192.5266	22954819.31
87	Fully grown Onions	garlic and onion	Summer	Sharkia	lower Egypt	2.5000	31.0000	8525.465798
94	Lupine	legumes	Winter	Sharkia	lower Egypt	30.0000	18.0000	20479.47883
103	Garlic	garlic and onion	Winter	Sharkia	lower Egypt	959.0000	6,267.0000	1326928.99
138	vegetables	vegetables	Winter	Sharkia	lower Egypt	2,085.9407	32,307.5960	3240750.015
160	vegetables	vegetables	Summer	Sharkia	lower Egypt	33,595.9061	520,342.2057	82776723.19
180	vegetables	vegetables	Nile	Sharkia	lower Egypt	1,090.2010	16,885.3197	2619928.527
210	Sorghum	cereal	Summer	Sharkia	lower Egypt	290,789.0000	1,014,374.0000	713187396.4
229	Sorghum	cereal	Nile	Sharkia	lower Egypt	6,256.0000	21,824.0000	11838551.14

Figure 6 Select Crop to Immersion irrigate and drip irrigation

All products that are suitable for the drip irrigation system were selected to achieve the best possible solution. It is also clear from Figure 7 that the differences occurred when changing the irrigation system for some crops from immersion irrigation to drip irrigation showed a saving of about 30% of the water. On the contrary where they were used before in the system immersion irrigation.

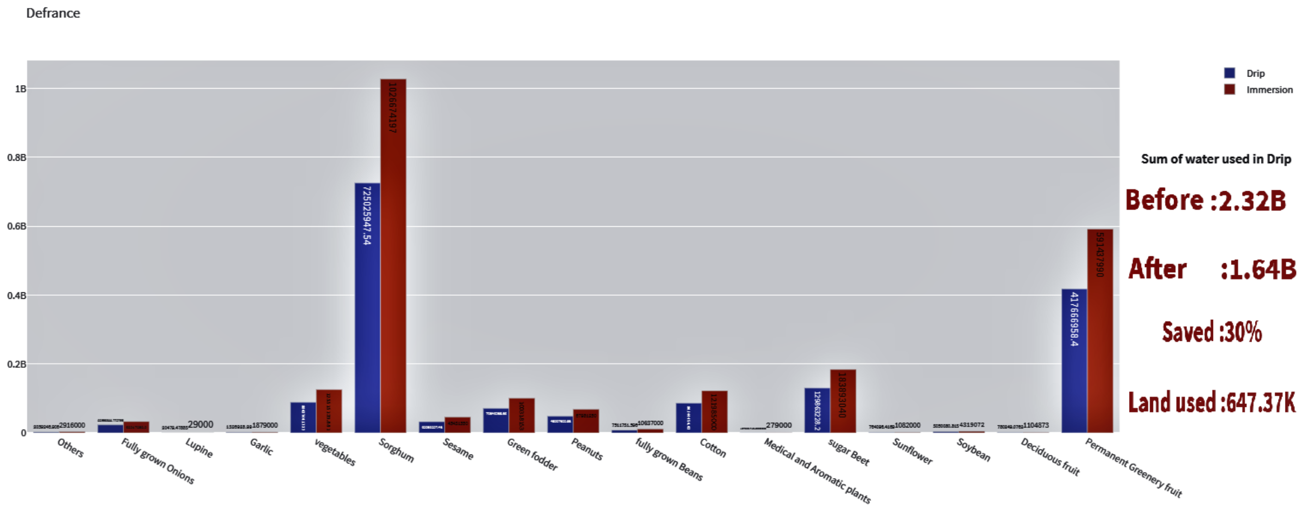


Figure 7 difference between Immersion irrigation and drip irrigation

In figure 8, crops that cannot be irrigated by the drip system will be chosen but can be irrigated by the sprinkler system.

Select Crop to irrigate with Sprinkler

Forestation Alfalfa × Sustains Alfalfa × Fenugreek × Barley × lentils × Wheat × linen ×

	Crop_Name	Category_Name	Season_name	Government_name	Region_name	Land size	production	Sprinkler
30	Forestation Alfalfa	feed	Winter	Sharkia	lower Egypt	3,702.0000	45,256.0000	4032499.727
48	Sustains Alfalfa	feed	Winter	Sharkia	lower Egypt	287,078.0000	5,236,148.0000	548713233.5
119	Fenugreek	legumes	Winter	Sharkia	lower Egypt	10.0000	8.0000	15202.53165
269	Barley	cereal	Winter	Sharkia	lower Egypt	5,835.0000	6,347.0000	6031712.692
286	lentils	legumes	Winter	Sharkia	lower Egypt	198.0000	193.0000	142405.3365
379	Wheat	cereal	Winter	Sharkia	lower Egypt	364,445.0000	906,887.0000	509207289.3
398	linen	fiber	Winter	Sharkia	lower Egypt	2,105.0000	12,199.0000	2169558.242

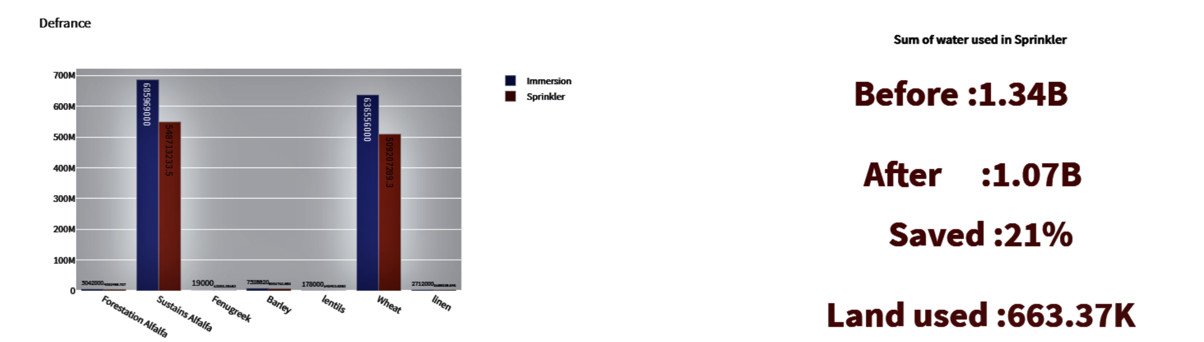
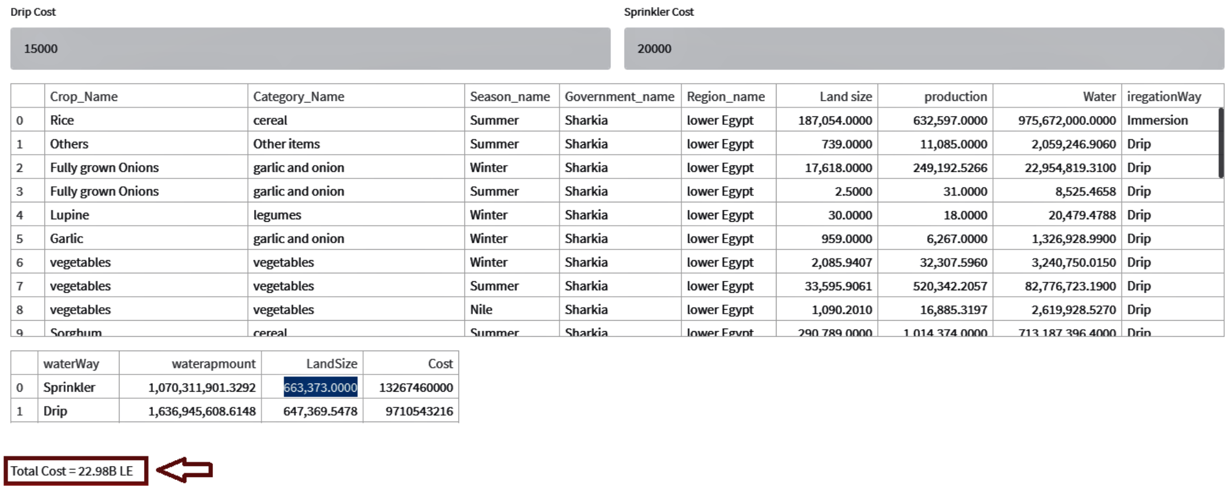


Figure 8 difference between Immersion irrigation and Sprinkler irrigation

From Figure 8, it is clear the differences that occurred when changing the irrigation system for some crops from immersion irrigation to sprinkler irrigation. The results saved about 21% of the water that was used before in the immersion irrigation system.

In Figure 9, there is a possibility to enter the cost of the acre, whether by drip or sprinkler. The average cost of converting an acre from immersion to sprinkler has been entered as 20,000 pounds, and the acre to drip, 15,000 pounds.

Also in Figure 9, the number of acres for each system and the total cost are shown.



Drip Cost

15000

Sprinkler Cost

20000

	Crop_Name	Category_Name	Season_name	Government_name	Region_name	Land size	production	Water	iregationWay
0	Rice	cereal	Summer	Sharkia	lower Egypt	187,054.0000	632,597.0000	975,672,000.0000	Immersion
1	Others	Other items	Summer	Sharkia	lower Egypt	739.0000	11,085.0000	2,059,246.9060	Drip
2	Fully grown Onions	garlic and onion	Winter	Sharkia	lower Egypt	17,618.0000	249,192.5266	22,954,819.3100	Drip
3	Fully grown Onions	garlic and onion	Summer	Sharkia	lower Egypt	2.5000	31.0000	8,525.4658	Drip
4	Lupine	legumes	Winter	Sharkia	lower Egypt	30.0000	18.0000	20,479.4788	Drip
5	Garlic	garlic and onion	Winter	Sharkia	lower Egypt	959.0000	6,267.0000	1,326,928.9900	Drip
6	vegetables	vegetables	Winter	Sharkia	lower Egypt	2,085.9407	32,307.5960	3,240,750.0150	Drip
7	vegetables	vegetables	Summer	Sharkia	lower Egypt	33,595.9061	520,342.2057	82,776,723.1900	Drip
8	vegetables	vegetables	Nile	Sharkia	lower Egypt	1,090.2010	16,885.3197	2,619,928.5270	Drip
9	Sorghum	cereal	Summer	Sharkia	lower Egypt	290,789.0000	1,014,374.0000	713,187,396.4000	Drip

	waterWay	waterapmount	LandSize	Cost
0	Sprinkler	1,070,311,901.3292	663,373.0000	13267460000
1	Drip	1,636,945,608.6148	647,369.5478	9710543216

Total Cost = 22.98B LE

Figure 9 Calculate the cost of the irrigation plan

Figure 10 shows, the percentage of water used after applying modern irrigation systems in Sharkia Governorate and the total value of water savings that were used previously.

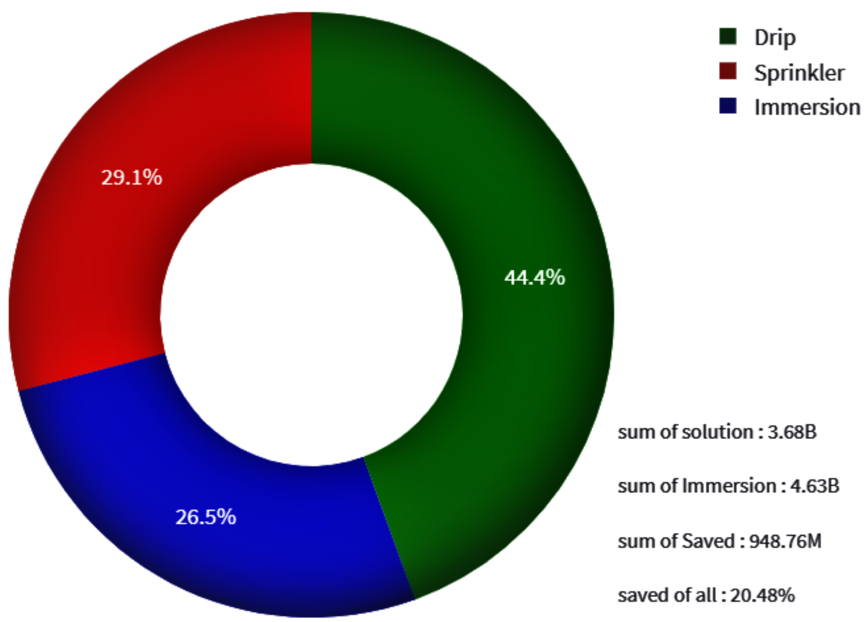


Figure 10 The proportion of water used for various irrigation systems

Figure 10 shows the amount of water saved by applying the best modern irrigation system to the Sharkia Governorate which is close to one billion cubic meters. The results exceed 20% of the water allocated to agriculture in the Sharkia Governorate.

7. **Conclusion**

The conclusion of this work shows that the tool aids in improving decision-making by enabling the transformation of raw data into useful information and providing high-quality visualization for data and identifying trends. The developed BI tool is supporting strategic water resources management and helps in guiding the experts to select the best scenario in applying modern irrigation systems in Egypt. The framework allows to creation and design of any proposal by binding the informational parameters and rendering the knowledge throughout predefined criteria and multi-filters. Thus, the Visualization Layer enables experts to manage, monitor, and determine whether the long-term goals are on-track or not. There are crops for which drip irrigation is not feasible such as rice and wheat, unlike vegetables and corn that are grown on a drip. Therefore, it is necessary to draw a specific map of the crops and coordinate with agricultural engineering to consider the issue of changing the types of crops grown in the same area. As a result, the efficiency of drip irrigation is to add water in the right quantity and time and reduce irrigation losses, unlike irrigation by immersion which is concerning managing systems and reducing losses. As well as the very expensive sprinkler irrigation that is forcing decision-makers always to choose it only in the absence of a feasible alternative or for crops that cannot be grown by dripping and need to be water-intensive.

8. **Future Work**

Future research will focus on supporting and enhancing water management as follows:

- Comparing the different methods used for irrigation and their effects on water usage in agriculture.
- Scheduling and allocating water optimally for Egyptian crop irrigation.
- Developing various solutions to raise crops' productivity based on distribution, as well as scenarios that reduce water loss gaps during water transmission starting from Aswan to the targeted agricultural arena.

References

[1] M. H. A. E. H. S. A. &. A. E. G. M. B. Amer, Water Saving In Irrigated Agriculture in Egypt. , Saarbrücken, Germany.: LAP LAMBERT Academic Publishing:, (2017).

[2] Watson, H. J., "Preparing for the Cognitive Generation of Decision Support ," *MIS Quarterly Executive,* p. 153, (2017).

[3] Hamdan, H., & Rahman, A. A. A., "EFFECT OF BUSINESS INTELLIGENCE SYSTEM ON ORGANIZATIONAL AGILITY: EVIDENCE FROM SYRIA.," *Journal of Southwest Jiaotong University,* vol. 56(4), p. 288–299., (2021).

[4] N. A.-W. M. S. H. Reham Nasser Farag, "Financial Stumbling Detection Model for SMEs," *(IJACSA) International Journal of Advanced Computer Science and Applications,* Vols. Vol. 12, no. No. 8, 2021.

[5] M. D. M. K. A. Saxena, " Indian Crop Production: Prediction And Model Deployment Using Ml And Streamlit," *Turkish Journal of Physiotherapy and Rehabilitation,* vol. 32, (2021)..

[6] I. Hribar Rajterič, "Overview of business intelligence maturity models. Management,,"*: Journal of Contemporary Management Issues,* Vols. 15(1), pp. 47-67., (2010).

[7] H. J. Watson, "Tutorial: Business intelligence-Past, present, and future.," *Communications of the Association for Information Systems,* Vols. 25(1), p. 39., (2009).

[8] M. C. P. D. M. Elbashir, " Measuring the effects of business intelligence systems: the relationship between business process and organizational performance.,". *Int. J. Account. Inf. Syst.* , Vols. 9 (3), p. 135–153, 2008.

[9] M. A. Al-ma, "The role of business intelligence tools in the decision-making process.," *International Journal of Computer Applications,* p. 73(13)., (2013).

[10] Williams, Williams, The Profit Impact of Business Intelligence, UK: Elsevier, 2010.

[11] D. a. J. „. Power, "Understanding data-driven decision support systems," *Information Systems Management,* Vols. Vol.25, No.2, (, p. pp: 149–154., 2008),.

[12] M. A. P. F. A. &. P. M. Pozzebon, "Corporate Sustainability and Information Management: The Case of Tropico Brazil. ," Vols. In ASAC (Vol. 29, No. 29)., (2008, May).

[13] J. Ranjan, "Business Intelligence: Concept Component, Technique, and Benefits"," *Journal of Theoretical and Applied Information Technology,* pp. pp: 60-70, 2009.

[14] F. &. H. C. W. (. Burstein, "," in *Handbook on decision support systems 2: variations.,* Springer Science & Business Media., (2008).

[15] T. W. M. J. &. B. B. R. R. M., in *The data warehouse lifecycle toolkit.,* John Wiley & Sons., (2008).

[16] O. Rud, in *Business Intelligence Success Factors: Tools for Aligning Your Business in the Global,* (2009),.

[17] R. a. R. M. Kimball, in *The Kimball group reader – Relentlessly practical tools for Data,* (2016),.

[18] "business-intelligence," Puneet's Blog, 17 7 2018. [Online]. Available: http://puneet.dbsdataprojects.com/2016/04/24/business-intelligence/.

[19] A. G. Samjstria, Efficiencies of Florida agricultural irrigation systems. , Florida: the University of Florida., 1988.

[20] M. Abdelati, "Minister of Water Resources and Irrigationreviews the management, development, and planning of water resources (text of the word).," 12 8 2018. [Online]. Available: https://www.almasryalyoum.com/news/details/1314752.

[21] "Life Cycle of Business Intelligence," 17 7 2018. [Online]. Available: http://www.sliceofbi.com/2015/07/life-of-bi-business-intelligence.html.

[22] Central Agency for Public Mobilization and Statistics, "Irrigation and Water Resources Statistics Annual Bulletin 2018," 2020, Egypt, 2018.

[23] Samia Mahmoud El Marsafawy, "kenanaonline," [Online]. Available: http://kenanaonline.com/users/WaClAg/topics/194172. [Accessed 12 3 2021].