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PRECISION IRRIGATION EFFICIENT TECHNOLOGIES PRACTICE IN LIBYA FROM THE WATER AND ENERGY POINT OF VIEW

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ABSTRACT

Precision irrigation is defined as a method of applying the right amount of irrigation/water as per the requirements of the individual plants with less impact on the environment. Accordingly, this task is performed by variable rate sprinklers in Libya with capability of position determination to apply water at variable rates at different locations in (Kufra area and Garaboulli).

The unstudied wide spread of agriculture projects depending on fossil groundwater has added to the water imbalance and to increase the salinity levels of the fossil groundwater resources of Libya. Due to increase in the irrigation practices, ground water salinity levels have led to soil salinization in many places over the years. As a result, the demand for irrigation water increased and crop yields decreased.

In spite of precision irrigation practiced to a certain limit in Libya, but it is still need to have a strategy managing the steps of application. National and international studies concerning evaluation of using precision irrigation, subjected to state of art reviews. Those studies evaluating Libya's agricultural irrigation practice, indicated that Libya is suffering from various problems in the issue of using irrigation systems.

KEYWORDS: *Precision Irrigation, Libya, Irrigation Effeciency, Water Demand, Irrigation System*

Article History

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INTRODUCTION

The irrigated area in Libya has increased over the past 40 year as a result of improving economic conditions, urbanization, and improving standards of living. At present it is expected that area under irrigation is between 350000 ha to 500000 ha[1]. Their water necessities vary from less than 10000 m3/ha to over 20000 m3/ha, depending on the location, type of crop and irrigation method [1]. Agriculture continues to be the major water consumer, It represents about 85% of the current water demand (Table, 1).

Table 1: Projected Agricultural Water Use [1]

YEAR	1995	2000	2005	2010	2015	2020	2025
Irrigated area ($x10^3$ ha)	350	400	450	500	550	600	650
Water demand ($\times 10^6 m^3$)	3 376	3 860	4 342	4 825	5 307	5 790	6 272

The fertile lands in the coastal belt restricted in Jeffara Plain in the northwest of the country, and in Jebel Al-Akhder in the northeast, east of Sirt city. To the south separated by a strip of semi-desert, the desert is encroaching ever nearer upon the Gulf of Sirt [2].

The prevailing climatic conditions along the coast are of the Mediterranean region characterized by inconsistency and unpredictability. The rainfall is changeable in quantity, frequency and distribution [3].

Rainfall is the only source replenishes groundwater resources in Libya showing various amount falling on the area. In the eastern part of the coastal belt, Jebel Al-Akhder receives about 500 millimeters annually, diminishes gradually from around Benghazi (150 mm) until it reaches only few millimeters annually at Sarir in the southeast and Sabha in the southwest. While in western part of the coast an amount of 200 – 250 millimeter fall annually along Jebel Nefussa, while coastal area where the Gulf of Sirt lays, the annual rainfall decreases rapidly with distance inland and to the south of Jebel Nefussa (Figure, 1). Therefore, water resources in Libya rely heavily on groundwater which suffers from increasing demand particularly in the fertile lands [1]. Information on water quality is sparse, and a as a result of irrigation use, groundwater across Libya tends towards salinisation [4].

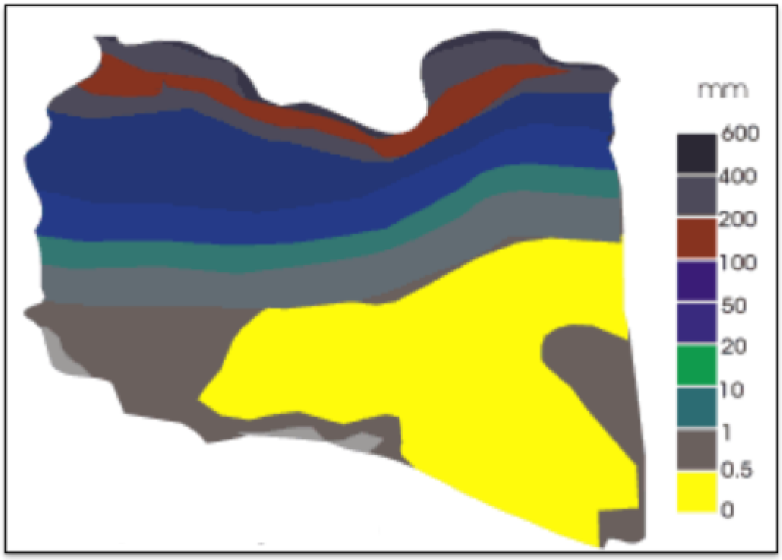

Figure 1: Rainfall Distribution within the Area of Libya [1].

Water Demand

Water demand in Libya increased so significantly, which urged the need for immediate actions to avoid a potential water crisis. The solutions must cover all demand sectors taking in consideration the nexus of water with energy and food. Table (2) shows water demand by the year 2025 within the five segment basins to which Libya area divides[1]. Although, the agricultural sector consumes about 85 percent of the total freshwater withdrawl, it does not have a significant share in the economy of Libya especially during the last 10 years [1]. Libya needs to produce most of its own food in order to balance the economy of its life, therefore it is necessary that new measures be taken to achieve economical sustainability and, expanding agriculture is quite an important component. There challenge in this subject is the shift from managing water supply to managing water demand. This shift is essential to balance Libya's water budget and face water shortages, which makes the statement that no real economic crisis will arise [1].

Efficiency of Water Use

Libya had practiced irrigation systems using water efficiently in several large-scale irrigation projects since 1970. Sprinkler and drip or localized irrigation is the most common used irrigation methods, implemented in Kufra area in the east of Libya (Figure, 2) [5] and in Garaboulli 60 km east of Tripoli in the west part of the coastal belt (Figure 3) [6]. The average efficiencies estimated sprinkler method is 65 – 75%,while the value for localized irrigation method reached to more than 80% [1].

The methods used to irrigate crops efficiently showed no tendency for over irrigation [1], while under conventional irrigation (Uniform Rate Irrigation, URI) many parts of irrigated fields are over or under-irrigated due to spatial variability in soil water-holding capacity, infiltration rates and topography. Under-irrigated areas are subject to water stress, resulting in production loss, while over-irrigated areas suffer from poor plant health and nutrient leaching.

Table 2: Population and Water Demand

Segment	Population in 1995,(1000 capita)	Population in 2025,(1000 capita)	Water demand in 2025 (million m^3)		
			Domestic	Industry	Irrigation
Jabal Al-akhdar	1158	2637	252	20	77
Kufra As-Sarir	218	841	102	51	1370
Jefarah plain	1919	4002	248	33	2418
Nafusah Al-Hamada	826	2132	131	18	1266
Murzuq	284	824	162	43	1849
Total	4405	10436	995	165	6980

Figure 2: Sprinkler Irrigation System in El-Kufra Area [5].

Figure 3: Precision Irrigation Practiced in Garaboulli Area [6].

According to (Raine et al. 2007) [7], precision irrigation is a method of applying the right amount of irrigation/water as per the requirements of the individual plants with less impact on the environment. Recently this task is performed by variable rate sprinklers with capability of position determination to apply water at variable rates at different locations [8]. Precision irrigation techniques, according to the definition given by Rain et al., (2007) is found very suitable to manage irrigation practice in Libya in a sense of saving water and energy with increasing crop yield. However, Libya practiced using sprinkler, drip and localized irrigation system but all farming areas, application rates are still among the highest in the world [1]. This is mainly due to the unsuitable climatic and soil conditions as well as management considered providing water for the sake of varying crops yield (The total installed capacity is 590000 m^3/day at 33 plants [1]. Precising irrigation systems could bring benefits to decrease the water use efficiency up to 80-90% in contrast to the surface irrigation methods where only 40-45% of water can be preserved [9].

METHODOLOGY

Recognized national and international studies concerning evaluation of using precision irrigation, subjected to state of art reviews. Those studies evaluating Libya's agricultural irrigation practice, indicated that Libya is suffering from different problems in the issue of using irrigation systems. Studying water crop requirement is very rare in Libya. The only study consider the subject of crop water requirement, carried out by General Directory of Drainage and Irrigation of the General Water Authority (GWA) in 1999 [10]. The study based on international organization (FAO, ICID and ILRI) results in assessing its targets, using (16) climatic station distributed in all the area of Libya (Figure, 4), aiming to calculate cash crop water requirement using different irrigation systems and the best time for planting. The strategy of the study concentrate on location, climate conditions prevailed, soil type, existing of natural or artificial drainage system, crop type and irrigated water quality. The analyses of this study showed the following issues:

- Before executing this study best time for planting research not exist, as this factor affects the total time for producing crop.
- Crop water needs to be secured from effective rainfall, in case effective rainfall not enough then water supplied from another sources must be secured with adopting effective irrigation system
- Water added by irrigation system whatever the practice used in Libya, added salt to the soil root. In such case more water needed and energy to drain salt from the root zone.

The challenge observed by this study is that irrigation water quality differs in Libya from region to other within the same basin and that the results reached stayed formal and in most cases neglected.

EU executed in Libya a project in (2012 – 2014) [1] for interrelating water and energy management, focusing on problems and challenges in both sectors. The project showed the major challenges and problems in water sectors are:

- The imbalance between supply and demand amounted to 1,940 million m^3/yr (48% of the total supply in 2012). This imbalance is expected to grow wider in the future as a result of uneven distribution of population and the intensive agricultural activities in the coastal belt.
- Inadequacy of Institutional Framework
- Illegal Use of Groundwater
- Poor Crop Yields
- Fragmentation of Agricultural Land Holdings

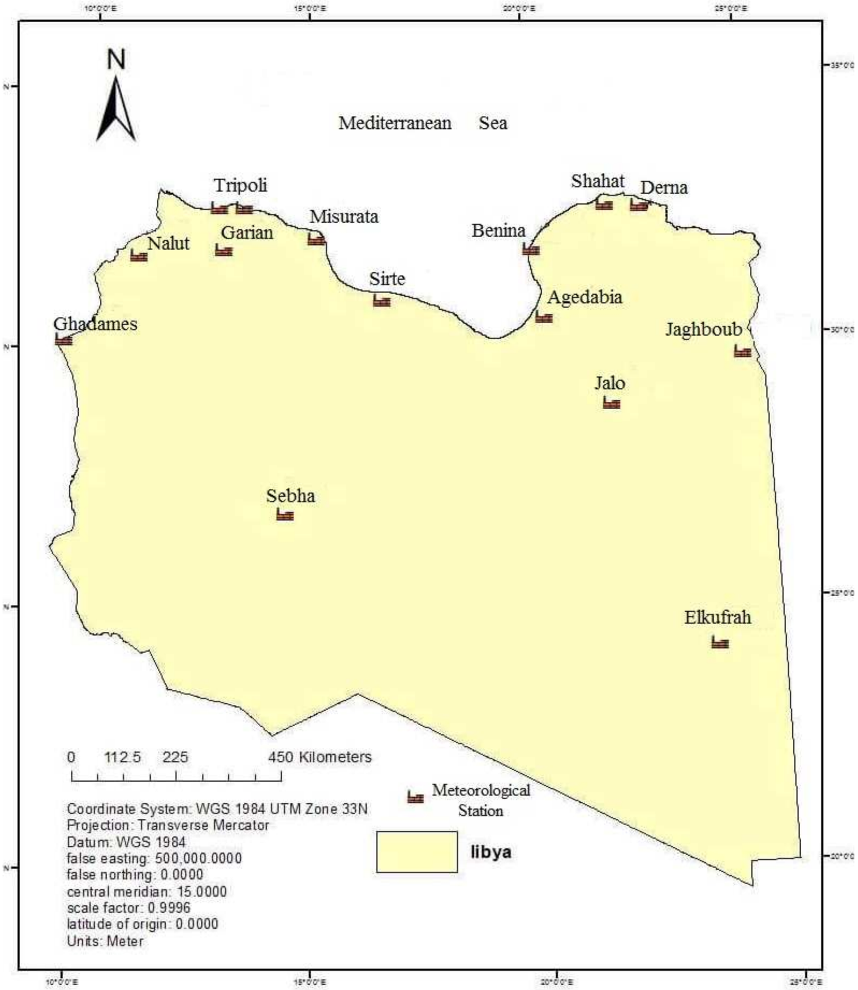

Figure 4: Locations of the (16) Meteorological Stations.

The unstudied wide spread of agriculture projects depending on fossil groundwater has added to the water imbalance and to increasing the salinity levels of the fossil groundwater resources of Libya.

Due to increase in the irrigation practices, ground water salinity levels over the years in many places have led to s oil salinization. As a result, irrigation water demand increased and crop yields decreased

During the last four decades (1970-2010), Libya's official policy had been focused on land reform. All Italian-owned farms (about 38,000 hectares) had been confiscated and redistributed to Libyans in smaller plots. The EU project indications could form barriers to implement effective precision systems unless adopting nexus concept in managing water energy and food.

A case study evaluated the relationship between crop yield, and irrigation water and soil quality carried out in the eastern part of Libya, particularly in Kufra area where sprinkler irrigation practiced by government and private farms.[2] The evaluation indicates the same problems found by other studies reviewed in this work [1, 10]. The problem of irrigation water quality found in both farms (State and Private) which is related to the farmers' skills and the practice of irrigation (Figure, 5). A problem of water infiltration rate was also mentioned by Aiad (2015) linked to the water quality used by the irrigation system.

Figure 5: White Crusts of Salts on Irrigated Soil Supplied by Shallow Wells.

IAEA, Biotechnology Research Centre, Agriculture Research Centre and the Tajoura Nuclear Research Centre in Libya, held project between 2004 to 2007 [11], quantifying water and nutrient requirements for potato production in the coastal belt. The project compared 400 mm of drip fertigation with conventional overhead sprinkler irrigation of 1000 mm. To measure soil water content for getting better irrigation scheduling, soil moisture neutron probe was used. The project result concluded that 400 mm of drip irrigation yields 34 to 37 t/ha potato, while the yield with overhead sprinkler using 1000 mm of water reaches to 12 t/ha. The corresponding water use efficiency ranged from 7.6 to 8.2 kg/m^3 with drip fertigation compared to only 1.1 kg/m^3 with the overhead sprinkler [11].

Bearing in mind that water is a vital natural resources, it is very important to not isolate water issue in planning sustainable agricultural development. The analysed studies indicate different problems arose in practicing irrigation in the farms in Libya not paid any attention to be solved in addition those studies showing good results to conserve water were ignored. Accordingly, it is essential to adopt strategies for irrigation system and in depth practice.

CURRENT EMPLOYED TECHNOLOGIES

The constant growth of water requirements for agriculture worldwide is due to two main reasons; firstly there is an increasing demand for food from the fast-increasing population and secondly there is a need to improve living standards for a large part of the population [12]. The solution to these two reasons solved by using the different types of precision irrigation systems (sprinkler, drip, automated and).

Although, precision irrigation practiced to a certain limit in Libya but it is still need to have a strategy managing the steps of application. Definition of Rain et al., (2207) and concepts given by Smith et al., (2010) [13] were set in this work as a baseline to outline the strategy of employing precision irrigation. Precision irrigation defined as a method of applying the right amount of irrigation/water as per the requirements of the individual plants with less impact on the environment. While Smith et al., (2010) concepts include:

- An agreed conceptualisation and definition of precision irrigation,
- Conceptualisation of how precision irrigation might be implemented for each of,
- The current irrigation application systems (sprinkler surface and micro), including as appropriate the sensing, control and decision support requirements, identification of opportunities for and potential benefits from precision irrigation,
- Identification of current research in precision irrigation and more particularly,
- Clear direction for future research in precision irrigation, and development of a series of case studies where precision irrigation is being implemented in whole or part.

To move toward precision irrigation according to Smiths' concepts, whatever the cases are, there will be a need to:

- Sense the water application and crop response at a scale appropriate for management,
- Make a decision for improved irrigation management using both historical and possibly predictive data, and
- Control either the current (in real-time) or subsequent irrigation applications at an appropriate spatial scale.

The Smiths' concepts can be followed using four steps (Data acquisition, Interpretation, Application and Control irrigation system, and System evaluation) (Figure, 5).

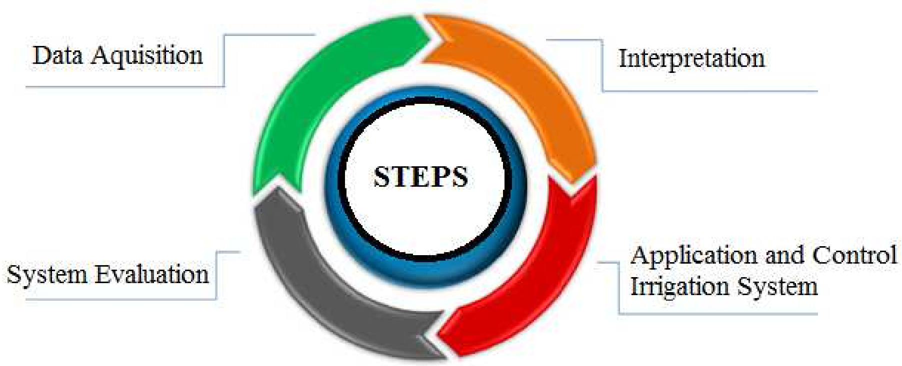

Figure 6: Four Steps of Smiths' Concepts Follow Up.

The review of the published literature by smith etal., (2010) indicated little is given on the benefits of precision irrigation and what has been published tends to focus on the single feature of spatially varied applications. Precision irrigation has the capability to increase both the water use and economic efficiencies by optimally matching irrigation inputs to yields in each area of a field and reduce the cost of inputs or increasing yield for the same inputs.[13] They added that the yield benefits may not cover the costs of the technology required. These technologies allowed the use of water efficiently and conservatively without decrease in the yield and cost of growing the crops, water energy nexus must be evaluated which in turn increased the profits. None of the precision irrigation research reviewed considered the energy in their optimizing the cost and yield.

To strengthen decision making, reinforcement learning proposed by Shivaram (2015) is recommended as this approach is studied in many different disciplines, which includes game theory, multi-agent systems, genetic algorithms, operations research, statistics, control theory and swarm intelligence [RL]. Reinforcement learning model learns by trial and error method to find out which action to take to yield maximum reward in a particular state. The model does not require any prior knowledge of the system but if any prior data is available, then it will use the obtainable data to speed up the convergence [8].

RECOMMENDATIONS

Libyan agricultural sector faces significant challenges to quickly reduce its enormous water consumption. Agricultural water management, including improved irrigation methods, fertilisation and the consumption of crops that use water efficiently, is important in facing the increasing demand for freshwater as it is expected to exceed in the coming decades. To overcome the water shortage and avoid harming the performance of irrigation practice, an intensive in depth studies must be carried out (by methods and by application) for conservation of water and energy resources (Figure, 6).

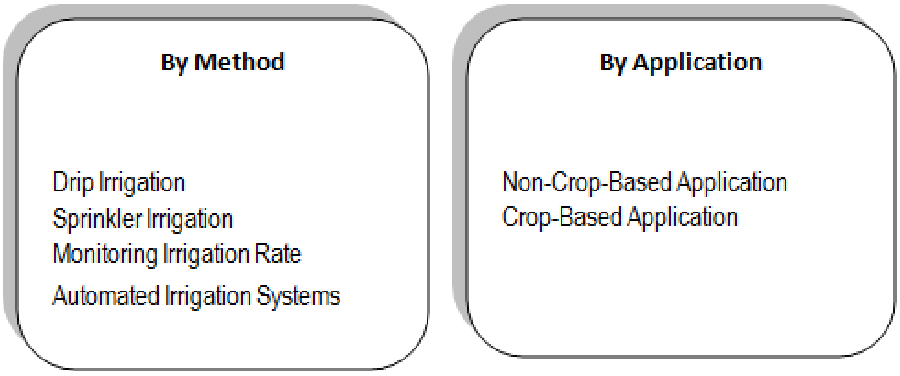

Figure 7: Suggested Model for Future Studies of Pricision Irrigation.

Traditional irrigation practice based on full irrigation with intensive cropping systems showed probably no longer sustainable considering the actual constraints, investment costs as well as environmental degradation. In contrast, practices such as precision irrigation involves both the irrigation system and water management and its generalization should be an important objective for water intensive crops in Libya. The implementation will help farmers to use water more efficiently, reducing water abstraction, percolation and groundwater pollution and then reducing environmental risks.

International studies reviewed and few national projects demonstrated that precision irrigation involves accurate evaluation of plant water requirements and precise application of the required volume at the required time. Therefore, it is also important to determine the appropriate irrigation frequency/strategy in order to avoid leaching of the soils (typically very sandy) towards deeper layers and the possibility of aquifers contamination. This can be achieved through precision irrigation technologies which certainly would increase Water Use Efficiency (WUE) for crop production and its environmental sustainability.

In order to enhance the strategy of using precision irrigation efficiently, further studies required taking in consideration the assessment of water/area/energy, on which selection of precision irrigation technology should be based.

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