Article

Exploitation survey of sea water in agriculture of coastal deserts in Libya

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Abstract
This paper examines the possibility of exploitation sea water in the agriculture of coastal deserts in Libya, some of which salt-tolerant plants (Halophyte), especially that used to feed animals, and convert marshes coastal useless life to nature reserves attract many kinds of migratory birds and marine lives after the cultivation of these marshes by type of plants, which grow in saltwater. In other words this paper will present a study of how to use the seawater as a renewable resource for agriculture in Libya and how this will contribute in sustainable development in this sprawling country. The advantage of this resource can be taken to fill up the gap of natural grassland and the growing demand for animal feed which has caused rising prices of livestock and meats, not to mention the tribal conflicts that occur because of the dispute over grasslands. The most significant reasons that force us to exploit the seawater are: (1) Lack of inventory of underground water in the coastal areas and overlapping with seawater in several areas. In contrast, Libya has the longest coastline on the Mediterranean with a length of more than 1,900 kilometers; (2) Fluctuation rate of the amount of rainfall, which has affected negatively on the natural grassland; (3) More than 90% of the country's population in the coastal areas, that causing a large drain of groundwater which already meager in this region, for this reason the government has worked to establish Artificial River project, which delivers water from the south to the northern areas to reduce this problem, and (4) Depletion and degradation of natural grassland is largely due to overgrazing.

Keywords seawater; halophyte; mangrove cultivation; sustainable development; animal fodder; greening the deserts.

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1 Introduction

Earth may be an ocean planet, but most terrestrial creatures including humans depend for food on plants irrigated by freshwater from rainfall, rivers, lakes, springs and streams. None of the top five plants eaten by people wheat, corn, rice, potatoes and soybeans can tolerate salt: expose them to seawater, and they droop, shrivel and die within days. One of the most urgent global problems is finding enough water and land to support the world's food needs. The United Nations Food and Agriculture Organization estimates that an additional 200 million hectares (494.2 million acres) of new cropland (an area the size of Arizona, New Mexico, Utah, Colorado, Idaho, Wyoming and Montana combined) will be needed over the next 30 years just to feed the burgeoning populations of the tropics and subtropics. Yet only 93 million hectares are available in these nations for farms to expand and much of that land is forested and should be preserved. Clearly, we need alternative sources of water and land on which to grow crops (Glenn et al., 1998).

The feasibility of seawater agriculture was tested and it has found that it works well in the sandy soils of desert environments. Seawater agriculture is defined as growing salt-tolerant crops on land using water pumped from the ocean for irrigation. There is no shortage of seawater: 97 percent of the water on earth is in the oceans. Desert land is also plentiful: 43 percent of the earth's total land surface is arid or semiarid.

Seawater agriculture is an old idea that was first taken seriously after World War II. In 1949 ecologist Hugo Boyko and horticulturalist Elisabeth Boyko went to the Red Sea town of Eilat during the formation of the state of Israel to create landscaping that would attract settlers. Lacking freshwater, the Boykos used a brackish well and seawater pumped directly from the ocean and showed that many plants would grow beyond their normal salinity limits in sandy soil (Glenn et al., 1998).

Seawater agriculture must fulfill two requirements to be cost-effective. First, it must produce useful crops at yields high enough to justify the expense of pumping irrigation water from the sea. Second, researchers must develop agronomic techniques for growing seawater irrigated crops in a sustainable manner — one that does not damage the environment (Glenn et al., 1998).

Saline water is already used by many irrigators around the world to produce food due to limited fresh water supplies, Such as some countries in the Middle East, Saudi Arabia, United Arab Emirates and Iran, Also in the United States and Australia.

We chose Libya for the study area of application of this project, because it is in my opinion one of the most countries need it. Libya is from the countries that have the longest coast and a large part from this coast is desert and lack of groundwater reserves in the coastal region. The country is suffering from the severe shortage of pasture because of dry and semi-dry regions with instability of rainfall.

We will focus in our study on halophyte that use as animal feed, which led to rising prices of livestock and meat significantly.

2 Halophyte

A halophyte is a plant that grows in waters of high salinity, coming into contact with saline water through its roots or by salt spray, such as in saline semi-deserts, mangrove swamps, marshes and sloughs, and seashores. An example of a halophyte is the salt marsh grass *Spartina alterniflora* (smooth cordgrass). Relatively few plant species are halophytes - perhaps only 2% of all plant species. The large majority of plant species are glycophytes, plants which are not salt-tolerant, and are damaged fairly easily by high salinity (Glenn et al., 1999).

Recently, some research has shown the possibility of using wild plants tolerant to salinity or the so-called Halophytes (Plants grow in saline soils naturally) with a view to use crops feed the animals, or the production of oils, aromatic and medical supplies or even food for humans directly . We find, for example, the seeds of the plant *Distichlis palmeri* (Planer's grass) was eaten by primitive peoples *Cocopa* like the people who lived around the mouth of the River Colorado in United States of America. The researchers confirmed that there are between 2000 - 3000 type of halophytes in the form of herbs and shrubs such as *Mangrove,* which grows on the coasts of the sea (Abdel-Sabour, 2003).

There are some benefits from experiences of some countries in the exploitation of *halophyte* plants, about 15 years ago University of Arizona began field trials for the cultivation of halophyte in many regions of the world desert Such as Mexico, Gulf of California, United Arab Emirates, the Gulf of Oman, Egypt and in different areas in Arabian Gulf.

We can take advantage of these past experiences to find out three types of halophyte plants proved economic feasibility that can be planted in the Libyan coast:

Salicornia is a genus of succulent, halophyte (salt tolerant) plants that grow in salt marshes, on beaches, and among mangroves. *Salicornia* species are native to North America, Europe, South Africa, and South Asia. Common names for the genus include glasswort, pickleweed, and marsh samphire; these common names are also used for some species not in *Salicornia* (ITIS report, 2010).

Salicornia bigelovii can be grown using saltwater and its seeds contain high levels of unsaturated oil (30%, mostly linoleic acid) and protein (35%), it can be used to produce animal feedstuff and as a biofuel feedstock on coastal land where conventional crops cannot be grown. Adding nitrogen-based fertilizer to the seawater appears to increase the rate of growth and the eventual height of the plant (Glenn et al., 1998; Clark, 1994; Alsaeedi, 2008).

Atriplex is a plant genus of 250-300 species, known by the common names of saltbush and orache (or orach). It belongs to the subfamily Chenopodioideae of the family Amaranthaceae (which include the Chenopodiaceae of the Cronquist system). The genus is quite variable and widely distributed. It includes many desert and seashore plants and halophytes, as well as plants of moist environments. The generic name originated in Latin and was applied by Pliny the Elder to the edible oraches. The name saltbush derives from the fact that the plants retain salt in their leaves, which makes them of great use in areas affected by soil salination. Atriplex used as food for some people since ancient times, and livestock feed Salt bushes are also used as an ornamental plant in landscaping and can be used to prevent soil erosion in coastal areas (Quattrocchi, 2000).

Mangrove (Mangal) are various types of trees up to medium height and shrubs that grow in saline coastal sediment habitats in the tropics and subtropics – mainly between latitudes 25 N and 25 S. The remaining mangrove forest areas of the world in 2000 was 53,190 square miles (137,760 km²) spanning 118 countries and territories (Giri et al., 2011).

Mangrove swamps are found in tropical and subtropical tidal areas. Areas where mangal occurs include estuaries and marine shorelines (Mildred E. Mathias Botanical Garden, 2012). The intertidal existence to which these trees are adapted represents the major limitation to the number of species able to thrive in their habitat. High tide brings in salt water, and when the tide recedes, solar evaporation of the seawater in the soil leads to further increases in salinity. The return of tide can flush out these soils, bringing them back to salinity levels comparable to that of seawater. At low tide, organisms are also exposed to increases in temperature and desiccation, and are then cooled and flooded by the tide. Thus, for a plant to survive in this environment, it must tolerate broad ranges of salinity, temperature, and moisture, as well as a number of other key environmental factors-thus only a select few species make up the mangrove tree community .Red mangroves are the most common choice for cultivation, used particularly in marine aquariums in a sump to reduce nitrates and other nutrients in the water. Mangroves also appear in home aquariums, and as ornamental plants, such as in Japan. As of 2007, after six years of planting, 700,000 mangroves are growing; providing stock feed for sheep and habitat for oysters, crabs, other bivalves, and fish (Warne and Tim, 2007).

3 Irrigation Methods

We can use the techniques of irrigation conventional to irrigation areas to be cultivated by Seawater, these techniques include:

3.1 Surface irrigation

Surface irrigation is defined as the group of application techniques where water is applied and distributed over the soil surface by gravity. It is by far the most common form of irrigation throughout the world and has been practiced in many areas virtually unchanged for thousands of years. Surface irrigation is often referred to as flood irrigation.

Surface irrigation can be practiced effectively using the right management under the right conditions; it is often associated with a number of issues undermining productivity and environmental sustainability (ILRI, 1989).

Irrigation pipeline was set to bring sea water (by pumps) into the field and the flow of water in the canals and streams already worked in the field. It is advisable to have water pipes made of plastic because metal pipes prone to rust dramatically under these conditions.

3.2 Center pivot irrigation

Center-pivot irrigation (sometimes called central pivot irrigation), also called circle irrigation, is a method of crop irrigation in which equipment rotates around a pivot and crops are watered with sprinklers (Mader, 2010). A circular area centered on the pivot is irrigated, often creating a circular pattern in crops when viewed from above (sometimes referred to as crop circles) (Gray, 2012). Center pivot irrigation typically uses less water compared to many surface irrigation and furrow irrigation techniques (Missouri research program, 2008).

This method has achieved success in the Agriculture the plant Salicornia, It was tested at a farm in Jubail Saudi Arabia, has been tested on a wider range - about 300 hectares in a farm dedicated to the Irrigation. (Seawater in a RS-Zour in Saudi Arabia). Use pivot irrigation with sea water in the first 100 day (even configuration phase flowers) and then uses tubes dotting placed on top of all points to connect Water to ground level next to the growing plants and the amount of water used for irrigation was about 2-3m the length of the crop growth period of 250 days (see Fig. 1). Machinery and pipes used in this system must be resistant to the effects of sea water Abdel-Sabour, 2003).

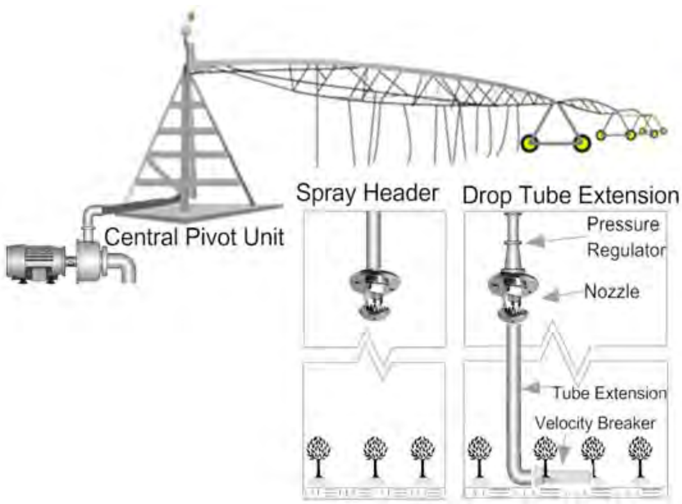

Fig. 1 Center-Pivot irrigation technology in agriculture by seawater.

4 Drip Irrigation

Drip irrigation system is using sea water to irrigate Atriplex plants, to get a high yield, and did not show accumulating problems of salt and clogging drippers where irrigation is constantly a day, as well as at least more than the accumulation of salt when buried in the drippers Soil rather than placed on the soil surface (Abdel-Sabour, 2003).

5 Submerged Method for Marsh Basins

This method is based on the phenomenon of tidal in irrigation of cultivated targeted areas. Many designs of basins submerged land has been successfully applied on the salt marsh in Abu Dhabi (United Arab Emirates) and it has been modified in Jubail (Saudi Arabia) so that the design takes advantage of the movement of the tides rather than the use of the pumps in the basins immersion areas.

Marshes are usually lands of low leak rate (impermeability), which can be submerged one hectare or more by one irrigation socket, where the marsh field cannot be divided into separated marshes and the entire area immersed to depth of 2-5cm at once.

In this method the field is surrounded by a tight protective berm of soil and install main irrigation pipe inside the berm between the sea and the field to pass seawater through the main pipe when tide occurring and use this seawater to immerse the irrigation channels, which covering the whole field to reach all plants' root. Also there is a possibility to install a control gate at the main pipe to control the seawater level inside the field. In other words when we want to immerse the field we just open the gate when sea level is rising to allow the seawater to pass through the main pipe and in its turn to the irrigation channels, then close the gate when the field is full of seawater, finally to drain the seawater from the field just open the gate when the sea level is falling and the water goes out by itself (see Fig. 2 and 3) (Abdel-Sabour, 2003).

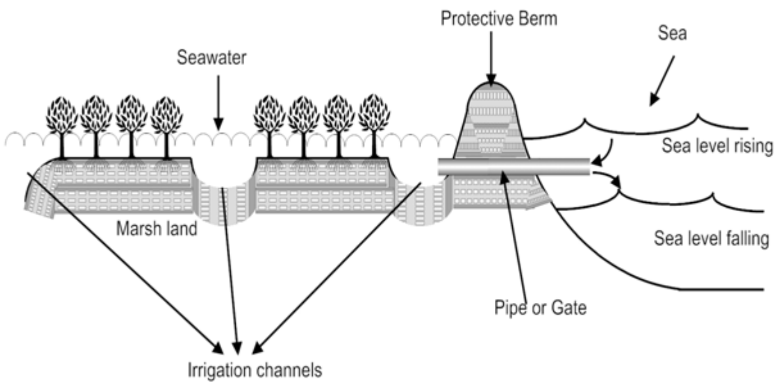

Fig. 2 Submerged method for marsh basins.

Fig. 3 Submerged method for marsh basins.

This method has successfully proved in cultivating Mangrove and we can use it to cultivating marshes scattered on the Libyan coast like Misratah and Tawergha, which are the largest marshes of the country, also marshes of Zuwarah, Ras gdeer and some marshes in Ajdabiya and Benghazi, figure 4, shows some locations of these marshes.

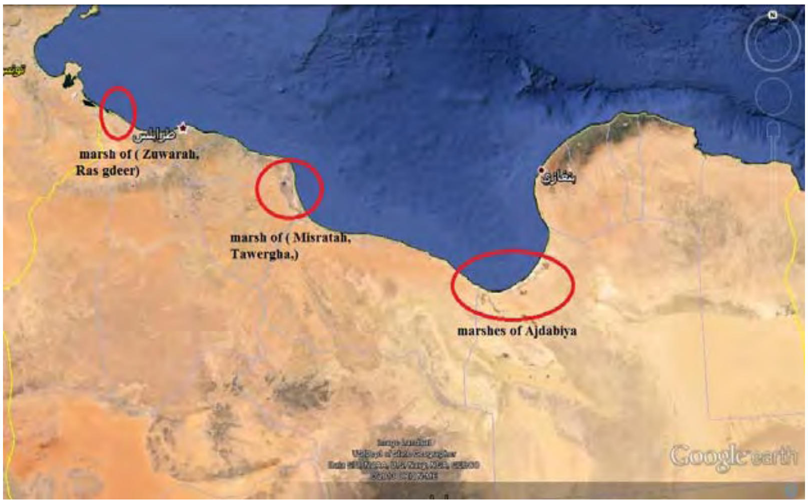

Fig. 4 Some location of coastal marshes in Libya.

6 Halophyte as Animal Food

Plants Halophyte known as a traditional source of animal feed, although some of the problems that accompanied such containing high concentrations of salts, low energy and low palatability by animals compared to traditional fodder. The cultivation Halophyte to be economically feasible as a fodder it should performance as fodder will be greater or at least equal to the traditional fodder, a lot of studies have proven that in lack case of fodder, especially in the conditions of the desert areas, certain categories have grown successfully and can used as an alternative fodder. Take into account if we use Halophyte as fodder, animals will increase consumption of drinking water. The results by University of Arizona on sheep, showed that Salicornia (seeds - Stalks) can be used as alternative fodder instead of others which produced from Bermuda grass or cottonseed fodder. Salicornia have been cultivated to produce oil seeds and straw, also can extract oil from seeds by milling and use the oil as a source of high-energy to feed animals especially poultry. After extracting oil, the rest of milling process is free of salt organic materials, which can be used as animal fodder. The rest materials after extraction of oil contain 33-43% crude protein (where this percentage depends on the amount of oil after extraction). Salicornia straw contains 30 - 40 % minerals and small amount of protein (4 - 6 %). It was noted that the rate of growth of the animals which feed on Salicornia equal to the same group which feed on wheat straw or a mixture of wheat straw and trefoil as long as Salicornia fodder is balanced in protein and energy (Abdel-Sabour, 2003).

Sheep and Camels are the main source of meat in Libya, unlike a lot of countries that depend on the beef. The Halophyte plants are good food resource for camels, because they are used to eat grass of low nutrition (desert plants) compared with Halophyte plants, which have higher nutritional value and palatable.

7 Conclusion

Libya is a big country in terms of area and has a coast overlooking the Mediterranean sea with more than 1,900 km, this wide area has not been exploited yet in the cultivation of halophytes, although of the availability of all appropriate conditions of coastal marshes, good soil and a favorable climate, This study is one of solutions to problems which country suffering, such as the low level of groundwater in the northern regions, shrinking green spaces, urban encroachment on forests, the acute shortage of pasture and animal fodder. We expect to get several benefits from this study as below:

(1) Salicornia cultivation

- Salicornia is a halophytic ("salt-loving"), oil-bearing plant that can be readily grown on untreated seawater;
- Other products from Salicornia include protein meal, green tips and biomass (straw) that remains after harvesting;
- Additionally, the root structures of the plant absorb between 2 to 3 MTs ("metric tons") of atmospheric carbon per hectare per year (Whitfield and Chairman, 2010).

(2) Mangrove forests

- Mangrove trees are well-known for their massive root structures and enormous growth rates;
- Within 18 months a mangrove tree can grow up to 6 feet;
- Mangroves are selectively harvested for wood, animal fodder, and absorb up to 8 MTs of atmospheric carbon per hectare per year in their root structures.

Fig. 5 shows the food web of a mangrove forest. Sunlight provides energy for the trees which become the food source for herbivores, insects etc. that are then eaten by birds, small predators. These are food for large predator fish which are consumed by humans and tree itself as a fodder which consumed by animals (Mangrove Forests, 2014).

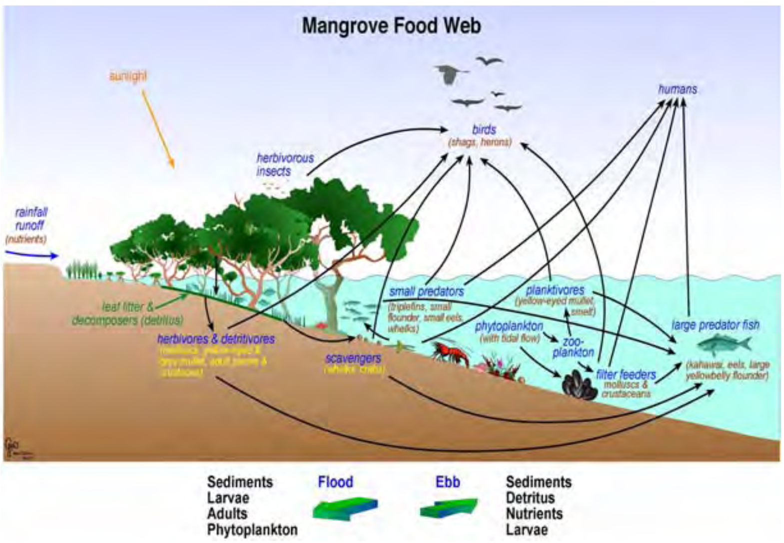

Fig. 5 Mangrove food web.

(3) Greening the deserts

- Transform deserts into wetlands and forests. Wetlands are dynamic, complex habitats that increase biodiversity and biologically clean the water before it returns to the sea (see Fig. 6);
- Creating green spaces in the country such as Libya lacks a lot to green space and is one of the desert states;

- When the Eritrean project began, for the use of sea water in agriculture. For example, ecologists have identified 13 species of birds. Three years later, surveys revealed over 200 species of birds in the same area. This encourage us to turn the Libyan coastal marshes, which are now desolate and useless life to nature reserves full of wildlife and sea slugs and many kinds of birds (see Fig. 5) (Whitfield and Chairman, 2010).

Fig. 6 Greening the desert.

(4) Reducing the impact of global warming, because each hectare of agriculture will permanently absorb, on average, 6.5 MTs of carbon annually (Whitfield and Chairman, 2010).
(5) Economic development, this project will create jobs for the citizens with the possibility of the emergence of some complementary industries.
(6) Create a new source for the production of animal fodder and try to satisfy the market needs, and reduce the fodder rising price.
(7) Exploitation of sea water in agriculture is one of the sustainable development projects, which maintains the integrity of the environment and increase bio-diversity. We expect that the project achieves success in Libya because the data says that Libya has the right conditions for the success of this project, such as natural factors represented along the coasts, good soil and appropriate climate. In addition to the financial factor**-** Libya is one of the richest countries in Africa.

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