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An Agro-Climatic Zoning Approach to Achieve Optimum Agricultural Production in the Kurdistan Region, Iraq

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ABSTRACT

The Kurdistan region is suited for agriculture as it possesses suitable agricultural land and climate. However, agriculture suffers from low productivity and is incapable of meeting local needs or competing in a free market with imported produce from neighboring countries. This paper examined and proposed a way forward for managing the issue of low agricultural productivity in Kurdistan region through identifying the major parameters that affect productivity in the region as being; nutrition represented by soil types and climatic needs represented by rainfall and temperature. Then, a GIS based approach was developed to create the necessary datasets and to develop specific agro-climatic zone maps for growing 16 strategic crops including Wheat and Barley within the region. This research is of a strategic importance for the region to increase productivity through matching optimum growing conditions (soils, rainfall and temperature) with growth boundary conditions for the strategic crops. It is hoped that it will assist with the planning process for the cultivation of strategic crops to increase productivity and also to be a helpful dynamic in the economic integration of the region as one planning and management unit as well as accounting for the impacts of climate change.

Key words: Agriculture, Strategic Crops, Agro-Climatic Zoning, Kurdistan, Iraq; GIS.

Introduction

The Kurdistan region (Fig. 1) boasts large areas of arable land, fertile soil and suitable climate (Fig 2). It is fundamentally agricultural in nature, tradition and is highly suited for agriculture. In fact, records show that the Kurdistan Region (Fig 1) in the 1960's used to provide central and southern Iraq with wheat, chick-peas, apples, peaches, grapes, and other products (Baban 2005, 2013, 2014). The Region has followed a steep development curve since gaining autonomy despite several challenging conditions which include geopolitics, national trauma and harsh economic circumstances (Baban, 2005, 2014). However, agriculture did not progress adequately and currently agricultural production is not able to meet the actual requirements for the nation as presented in (Fig 3) which shows a comparison between real production and actual needs for crops in the region during 2012 (Baban 2014, 2015a, 2015b).

Fig. 1: Location map

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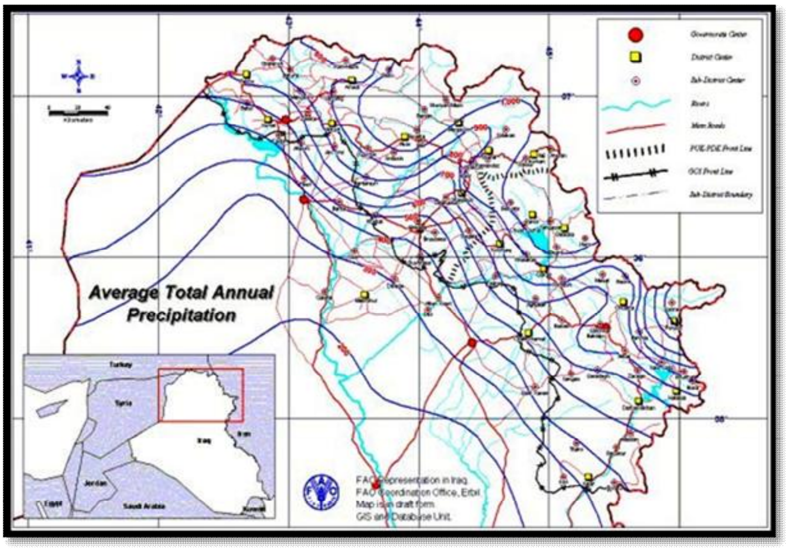

Fig. 2: Rainfall Map

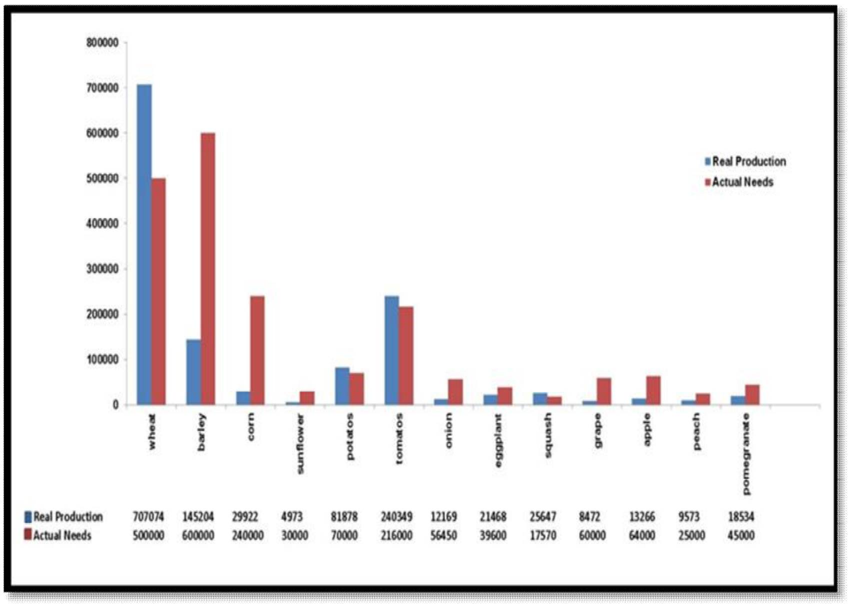

Fig. 3: A comparison between real production and actual needs for crops in the region during 2012 (Baban, 2014).

An examination of the farming practices in the region shows that main agricultural crops are traditionally produced by repeating annual growing patterns based on local indigenous experience without much consideration for bio-climatic factors; thus, the production levels are not stable and may ultimately be damaged due to changes in biological boundary conditions imposed on the region by climate change (Baban, 2015c). Furthermore, government subsidies to enhance agricultural productivity do not always follow the principles of sustainable agriculture and more specifically soil capability and the climatic conditions of temperature and rainfall are not adhered to in farming and food production, consequently not achieving optimum productivity. (Baban 2015a, 2015b, 2015c).

Literature shows attempts to manage the challenge of increasing productivity through matching agricultural produce with favorable geographical and climatic conditions. For example, FAO (1976, 1996) classified agricultural potential based on soil and environmental characteristics. Kamali, 1991, studied the importance of relating cultivating different agricultural crops to bio-climatic potentials in each region. Whilst, Venkateshwarlu *et al.*, 1996, highlighted the relationships between climatic variables and crops in a region. Zhang (1994) examined the impacts of temperature and precipitation on the growth of winter wheat in China. whereas, Robertson (1974) considered the relationship between climatic variables and wheat growth in Canada.

Kurdistan region suffers from a scarcity of information, plus a lack of reliable data sets in terms of land use/cover, soils and topographic maps in terms of detail and scale makes it difficult to effectively develop management plans for agriculture (Baban, 2014). Hence, as some researchers (Baban, 2005; Steven, 1993; Atzberger, 2013), have indicated, the success in this context lies in the adoption of remote sensing (RS) and geographic information systems (GIS) technologies for inventorying and mapping (crop acreage estimation, crop condition assessment, crop yield forecasting and soil mapping) as well as developing highly productive agriculture based on cropping system analysis, precision farming and agro-climatic zones of production (Baban, 2005, 2012, 2014).

This paper examines the issue of low agricultural productivity and propose a way forward through identifying the major physical and climatic parameters influencing the growth and productivity of agricultural produce and will develop a GIS based approach to create agro-climatic zone maps to guide the cultivation of 16 strategic crops within the region and additionally accounting for the impacts of climate change which will also, if not planned, will impact on agriculture resulting in low productivity.

Developing a Composite Criterion for Agro-Climatic Zones for the KRG (Kurdistan Region Government).

Criteria Development

In terms of criteria development, Science driven criteria for developing and implementing Agro-Climatic Zones focus on the cause/effect as well as associations between inputs/influence factors and the outputs. Hence, it tends to be similar and include physical and environmental characteristics such as soils, temperature and rainfall. For example, Bazgir, 1999 indicated that the accurate recognition and employment of the necessary information on soil types and climatic needs for crops and cultivation of agricultural products will achieve higher levels of productivity.

Based on the literature and available expertise in the Ministry of Agriculture including field scientists as well as local farmers, the criteria for identifying agro-climatic zones for 16 agricultural strategic products in the Kurdistan region was developed (Table 1). The criteria recognized that the major parameters that affect crop growth and productivity in the region are available nutrition represented by soil types and climatic needs represented by rainfall and temperature.

Table 1: Boundary conditions for listed strategic agricultural production

No	Production	Soil Type (Reconnaissance Soil Legend)	Temperatures (Centigrade)			CWR (mm)
			Min.	Max.	Optimal	
1	Wheat	Loam-Sand-Clay	5	38	20-25	350
2	Barley	Loam-Sand-Clay	5	38	20-25	250
3	Corn	Loam	20	32-34	22-25	817.41
4	Tomato	Loam	12	28-34	15-20	758.3
5	Potato	Loam	12	28-34	15-20	875.13
6	Sunflower	Sand-Clay	20	25	25	837.37
7	Apple	Clay- Loam	-5	32	30	567.53
8	Courgette	Loam	15	45	25-30	400.41
9	Grape	Clay-Loam-Sand	0	35	5-25	567.53
10	Peach	Sand-Loam	15	45	25-30	567.53
11	Cucumber	Loam-Sand-Clay	25	30	25-30	400.41
12	Pomegranate	Clay-Loam-Sand	15	45	25-30	567.53
13	Rice	Clay	18-22	37-40	30-33	1408
14	Soybean	Sand-Clay	10-14	37-40	25-28	959.75
15	Onion	Sand	15	45	25-30	400.41
16	Eggplant	Sand-Clay	16	45	25-30	400.41

In terms of criteria justification, soils, has been identified by FAO (1976, 1996) as key factor in determining agricultural potential and productivity. In terms of temperature and rainfall, Robertson (1974) determined that wheat growth response to climatic changes. In addition, the association between successful crop production in a given region and bio-climatic conditions was highlighted by Kamali (1991) and Venkateshwarlu *et al.*, 1996. Moreover, Zhang (1994) has determined the significant influence of temperature and precipitation on the growth of winter wheat in China. The results indicated that the changes of temperature degree are more important than precipitation in wheat seeds growth (Zhang, 1994).

Data Preparation, Compilation and Development

Data preparation and compilation involved preparing and developing the following datasets;

1. The Digital Elevation Model (DEM) was obtained from the United States Geological Survey (USGS) website (http://gdex.cr.usgs.gov/gdex/). The DEM has a 30 m resolution. The format of the data is raster data. The datum of the data is WGS-84.
2. Climate data were provided by the Ministry of agriculture and water resources of the Kurdistan Region Government, Iraq. The monthly rainfall and temperature data for 2012- 2014, as tabular data has been pre-processed using an Excel program, and then it has been post-processed using a Surfer program creating rainfall and temperature contour lines.
3. The soil map of the region was obtained from the Ministry of Agriculture and Water resources of the Kurdistan Region Government, Iraq. The soil map was prepared by the FAO coordinate office in Erbil city, 2001 (Fig 4). The soil map describes the texture, depth and colour of the soil in the region. The data type of this map is in raster format JPG. The scale of the original paper map is 1:1,000,000.
4. Satellite Imagery (Landsat 7 ETM+) was obtained from the Earth Science Data Interface (ESDI) (http://glcfapp.glcf.umd.edu:8080/esdi/index.jsp). The image was taken by the satellite on May 19th, 2006. The resolution of the six bands, including bands number 1 to 5 and band number 7, since the raster layer is 30 m. These data are used to describe the land use of the study area. The geo-reference of the satellite image is WGS_84 Datum project 38N.

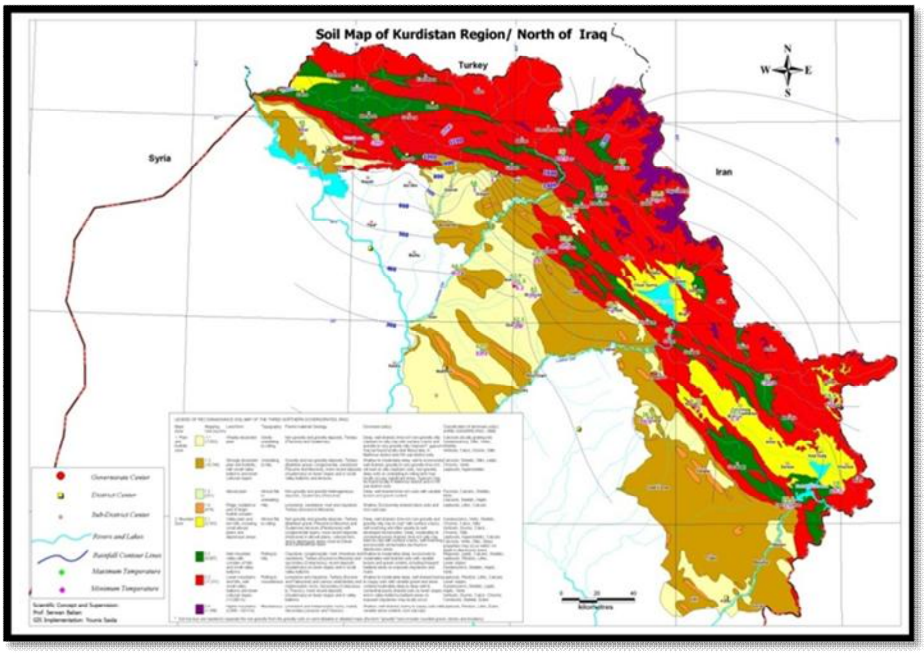

Fig. 4: The soil map developed by digitising a map prepared by the FAO coordinate the office in Erbil city.

Results and Analysis

Examining the DEM and the rainfall datasets shows that the varied topography and associated rainfall regimes have created three basic micro-climatic zones (Fig 2); high rainfall (700-1100 mm), medium rainfall (400-700 mm), and low rainfall (under 400 mm). In terms of produce; the high-rainfall zone contains mainly fruit orchards, wheat occupies most of the medium-rainfall zone, and barley is the main crop in the low-rainfall zone. Winter wheat and barley are planted in the Autumn (October-November) and harvested in the late spring (April-June) in accordance with the rainfall pattern (Mahdi, 2000).

Overall, soil characteristics and spatial distribution in the region show that in the mountain areas, which are located in the north and northeast, the soil is shallow and consists of sandy clay, loam silt or loam clay sand. Whilst in the valley and plain area, which is located in the south of the study area, it is rather deep and consists of loam clay sand, loam silt and silt clay. Hence the soil characterises are dependent on topography and the valley and plain area have favourable conditions for agriculture (Baban, 2015b, 2015c). Suitable soil maps were developed for each of the 16 strategic produce through identifying and mapping favorable range of temperatures for different types of produce (Table 1). All the acquired and developed data layers were geo-referenced based on the Landsat images and ground referenced data.

To create the suitability map some data conversion had to take place, once the conversions had been completed for each file, the attribute scores were assigned to the image files and Buffer zones were created thereby creating layers for each of the constraints criterion. Then, the GIS based data layers were combined based on the developed criterion (Table 1) using GIS overlay analysis. Each of the three constraints maps were considered to be of equal importance so they were weighted equally.

The final outcomes are showing specific geographical areas fulfilling all the conditions for the growth of a specific crop in Kurdistan Region as described in Table 1. The outcomes include maps showing suitable areas for Wheat production (5), Barely production (6) and Potato production (7). The quality of data and information were investigated and corrected based on available secondary data and field based data and knowledge sourced from Ministry experts and farmers.

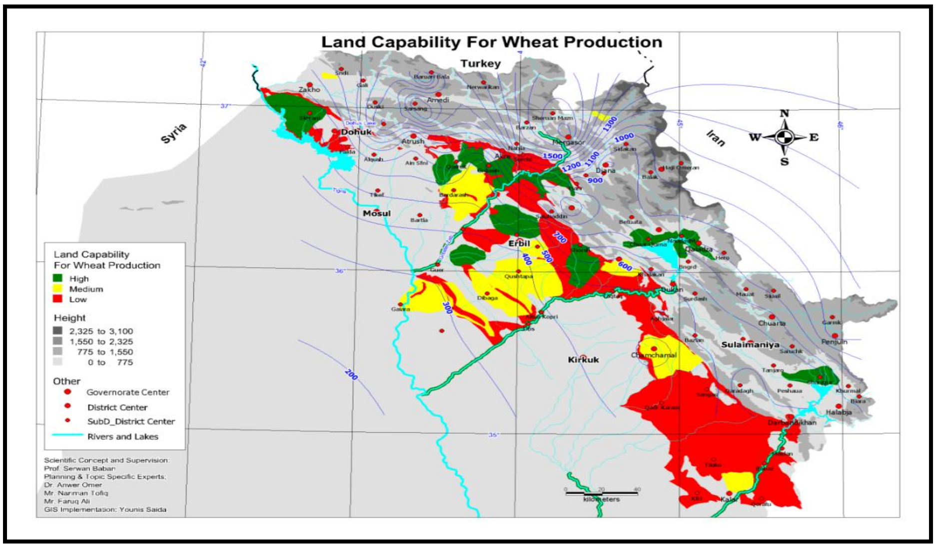

Fig. 5: A map showing the specific geographical areas fulfilling all the conditions for Wheat production in Kurdistan Region.

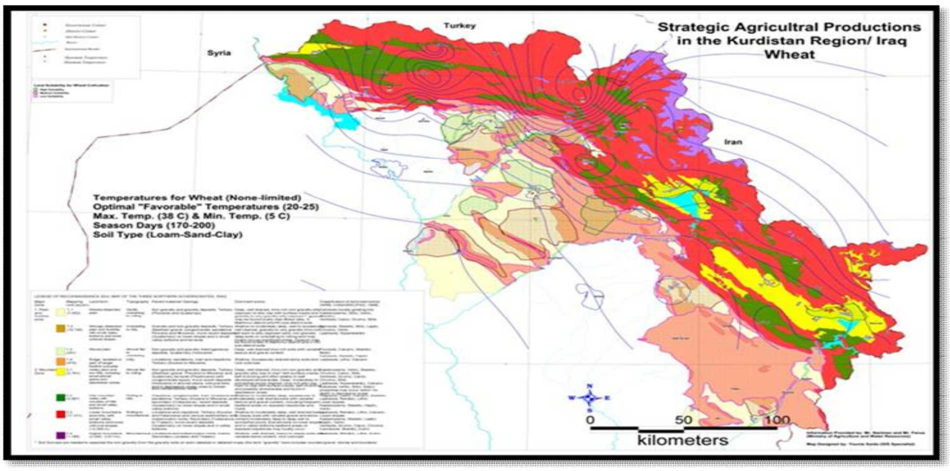

Fig. 6: A map showing the specific geographical areas fulfilling all the conditions for Barely production in Kurdistan Region.

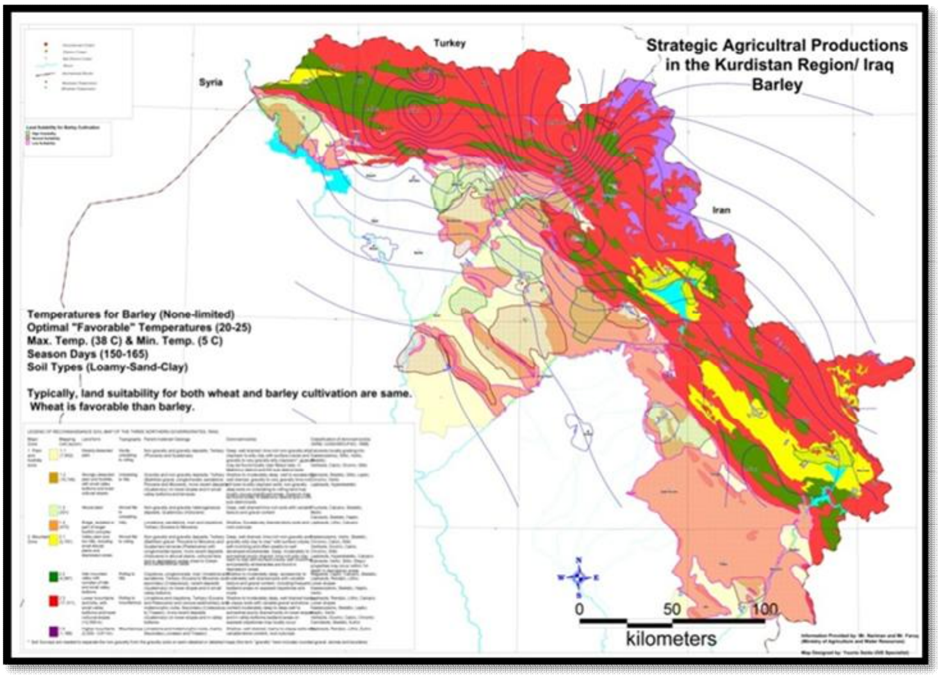

Fig. 7: A map showing the specific geographical areas fulfilling all the conditions for Potato production in Kurdistan Region.

Conclusion

In Kurdistan region, traditional farming methods dominate and the government policy and practice tends to provide all provinces in the Region with similar propositional subsidies, even though they seemingly cultivate identical crops during the same season. The outcome is low productivity as suitability of geographical areas for various agriculture alternatives are not utilized. In addition to flooding the market with large quantities of identical local agricultural produce during a narrow time frame, lower's demand and prices are not competitive.

This paper has examined the issue of low agricultural productivity in Kurdistan region and developed a GIS based approach for managing this issue through recognizing that the major parameters that affect crop growth and productivity in the region are nutrition represented by soil types and climatic needs represented by rainfall and temperature. The final outcomes show that by using the Agro-Climatic Zoning approach, mapping the geographical locations containing the optimum growing conditions for 16 strategic crops, including wheat and barley, with the view to achieve maximum yields from available lands.

Achieving successful outcomes from this research will depend on farmers adapting to the new conditions. The adaptation involves a change in the dominant traditional agricultural practices in response to a change in climatic conditions. It includes changes in management practices, such as timing of sowing and harvesting, the intensification of inputs, and changes in the crop mix.

Evidently, as climate changes, the Agro-Climatic Zones change and adjustments need to be made to identify most suited crops for the new conditions. Determining the new conditions can be identified through using available climate scenarios, theses can range from simple uniform changes across the region to complex geographic distributions of changes based on used global climate models. Hence, the need to base projections on multiple climate scenarios.

The issue of information poverty was managed through implementing the proposed criteria (Table 1) using remotely sensed data to establish or update a geographically referenced inventory for the necessary data layers. The GIS was used to identify optimum locations for cultivating particular crops and also as a guide to the work of planners to guide Government support to farmers as well as minimizing the impacts of climate change on agricultural productivity.

While important agricultural factors such as length and intensity of the rainy and dry seasons and annual variations are not accounted for in this approach, the approach and results obtained provide a basic tool for researchers to plan for agricultural activities in the study area and also to carry out further research on climatic change in the region.

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