Middle-East Journal of Scientific Research 21 (10): 1751-1756, 2014
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2014.21.10.21757

Zoning of the Agro-Ecological Potential in Ramsar Basin with Geographical Databases

Hasan Zabihi, Anuar Ahmad and Mohamad Nor Said

Department of Geoinformation, Faculty of Geoinformation and Real Estate,
Universiti Teknologi Malaysia. 81310 Johor Bahru, Johor, Malaysia

Abstract: This study was conducted to evaluate the agro-ecological potential of the resources in Ramsar basin which is used in agriculture in accordance with different sources of geographical information. Topographic attributes, meteorological statistics, satellite image, geographical database are used in this study. The study process, including the identification of ecological resources, geographic assessment, establish databases, data manipulation and identify the ecological potential were performed regarding to agricultural activities. The limited factors in the area consist of temperature, rainfall, elevation and slope conditions which are determinants for tillage and sowing. The application is valuable contribution to agro-ecological capability assessment. Finally, to prepare bio-environmental units map, the layers of sustainable ecological resources were overlaid in geographical information systems (GIS) for environmental management procedure. The results show that 30% of lands placed in this area are used in agriculture. Furthermore, in terms of limitations, the environmental units are at least, in one of the ecological resources for agricultural activities.

Key words: Ramsar basin · Systematical analysis · Agro-ecological potential · Environmental units · GIS

INTRODUCTION

Providing food needs for the earth residents through crops involve preserving and stabling use of environmental resources. The population growth and reduction of agricultural land have raised the optimum utilization of the resources than before. Exploiting the environment during last decades showed that a great deal of natural resources was destroyed due to improper utilization and it goes on in a near future [1-12]. Therefore, we must evaluate all the aspects of agri-ecological potentials then programming how to exploit the farmland. Decision making about agronomic activities need to assess all the ecological potentials. Topography is of great importance in precision agriculture for which is highly related to crop yield and easy to obtain compared to soil physical property measurements [2, 5]. Hence, Geographical information system (GIS) plays as a powerful tool to analyze a place data which mostly it can be used to commuting between descriptive data and the map or vice versa [6]. Agro-ecological zonation was based on the approach of Stol *et al*. [8] and van Keulen and Stol [9] where it was carried out without taking into account knowledge on current spread of the crops. In general, we identified suitable and unsuitable conditions in terms of elevation, slope, combination of slope and elevation. Caldiz, *et al*. [1] started zoning Argentina by the usage of climate and soil data to evaluate the potential of mono-cultivation production and potato double-cultivation considering different ecological crop areas. In different agro-ecological zoning and environments Neamattollahi *et al*. [11] for wheat, sugar beet and corn and Conijn *et al*. [4] for energy crops conducted two studies.

This study was carried out to assess the ecological sources potential in Ramsar basin according to systematic analysis for agricultural activities. Through doing it not only will assign the agronomic capacities of the area sources, but also we can specify the quantities of congenial areas in croplands. Considering such a comprehensive viewpoint we will be able to better program and manage cultivation activities in the study areas.

Corresponding Author: Hasan Zabihi, Department of Geoinformation, Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia. 81310 Johor Bahru, Johor, Malaysia.

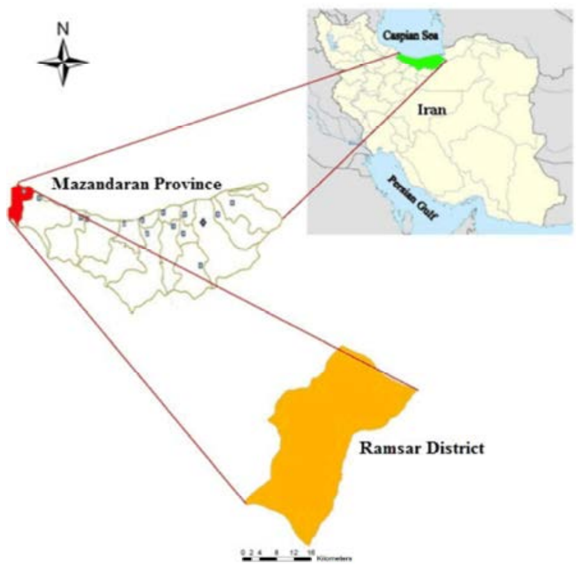

Fig. 1: The location of study area

On the cusp of the second decade of the 21st century it is evident that recent developments in the geotechnologies of Geographic Information Science (GIS) and remote sensing have had a substantial impact on ecological research, providing spatial data and associated information to enable the further understanding of ecological systems [7].

Study Area: The region investigated in this study is located in the northern part of Iran. It is about 250 km north of the capital of Iran. Ramsar region is situated in the west part of Mazandaran province, borders The Caspian Sea to the north and The Alborz Mountains range to the south. The population is approximately 70,000 at the end of 2010 census (statistical center of Iran, 2010). This region is one of the most important citrus production areas in Iran. In the study area, there were approximately 6600 hectares of citrus orchards as well (agricultural organization of Ramsar, 2010). The geographic coordinates of the study area are located between latitudes 36°32'00˝ to 36°59'11˝ N and longitudes 50°20'30˝ to 50°47'12˝ E. The total study area covers approximately 729.7 km^2. The altitude of Ramsar County starts at a height of -20 meters near The Caspian Sea to 3620 meters above sea level. A map of the study area is shown in Fig 1.

MATERIALS AND METHODS

For modeling the ecological potential approach of the agronomic zone; the following basic data, including digital topographical maps at 1:50,000 scale, land cover map, meteorological stations, annual mean rainfall in the area, GPS (GARMIN model), ground control points (GCP) and ArcGIS 10.1 were used to obtain agro-ecological zoning in the region. A list of datasets was given in Table 1.

Evaluating the ecological potential of the croplands in the area was done through following systematical analysis. In short the used general method is as follows:

- Recognizing and digitizing all the needed ecological resources
- Processing the stable and unstable ecological resources data
- Comparing the extracted agricultural and ecological potentials through using present lands.
- Editing and correcting the levels, transferring the images from geographical form to UTM coordinate system, changing the maps to resources, preparing topology in the ArcGIS 10.1 and analyzing DEM map, slope and aspect.

First, the bands were cut in accordance with the studied territory then there were performed the geometrical and radiometric correction of the bands. The next step was made the colorful complex of bands 431 and NDVI as indices and hydrothermal (RGB, a colorful mixture coming from some mineral materials). The above mentioned maps were generated through visual method or overlapping each of the maps coming from color band mixing or the other indices; furthermore, we used landuse maps, land cover and field survey. The digital terrain model (DTM) and digital rainfall model (DRM) were provided through 30 years statistical data (from 1980-2010) which collected inside and around the study area [12].

After providing the ecological resources layers, the existent information in database was processed; then, all the recorded quality data in terms of descriptive information were classified into two ecological groups. According to FAO 2007, despite continuous utilization of agricultural lands in the past decades, the process of land suitability has caused much more destruction. During resource accumulation and interpretation processing, the processed layers of the stable ecological resources were mixed in double method including slope, aspect and land cover, canopy and altitude layers. With respect to the variety of the layers and the related data in this stage, the maps generated from overlapping of different layers could be separated into smaller parts.

Table 1: list of datasets used in the study

Type of data	Description	Source
Land use map	Scale 1:50,000	2012,Mazandaran agricultural administration
Land cover map	Scale 1:50,000	2012, Ramsar agricultural organization
Meteorological statistics	Rainfall and temperature from 16 stations during 30 years	2013, Ramsar meteorological administration
Digital elevation model (DEM)	Derived from 1:50,000-scale topographic map at 80m resolution	2012, Geological survey of Iran
Slope	Generated from a 80m resolution DEM	2012, Geological survey of Iran

RESULTS

Rainfall range and slope are two negative factors which have a directly impact on farmland. It needs to create a climatograph diagram as a representation of climate parameters of the monthly average temperature and precipitation. It is a quick view of a climate condition. Fig 2 shows climatograph diagram of study area.

Based on the Fig 2, the lowest amounts of rainfall are in summer (in particular; in June, July and August) and spring season. In fact, in summer season, citrus plants need more water due to high temperature and evapotransportation phenomenon. It is clearly significant the length between rainfall and temperatures in the middle of the graph i.e. Jun, Jul and Aug months (Fig 2). In summers, based on Fig 2, water deficiency is inevitable. Rainfall surfaces were generated from isohyets (rainfall counters) by regression techniques. Moreover, distributions of rainfall pattern are not suitable within 12 month in study area. In other words, high rainfall basically falls in October, November and December. Amount of rainfall as heavy rainfall are not appropriate for citrus crop production, while, frequency of the rainfall is essential in the study area for farmland. Twenty three meteorological stations were used to create isohytes map. The isohyets map and slop gradient are displayed in Fig. 3.

The regression method cover the whole area in terms of annual mean rainfall based on DEM. Indeed, rainfall decreases as altitude increases. According to Fig 3, the highest rainfall areas are situated near The Caspian Sea in flat areas. Basically, highland areas in southern of Ramsar (light blue color in Fig 3) are unsuitable areas for agricultural activities because of limited rainfall pattern. In Fig 3, it is clearly seemed that many areas are in water restrictions. It means that, this is a negative environmental potential for plants. By increasing altitude, the amount of rainfall decreased as well (a negative correlation).

Rainfall pattern is one of the main negative factors on agricultural production especially the frequency of it in drought stress in hot seasons (critical month) [13-15]. In this section, the seasonal rainfall amount (mm) and percentage of Ramsar synoptic station is shown in Fig 4 and Table 4. Indeed, the distributions of rainfall are not equal in all seasons. Thereby, the rainfall seasonal distribution is shown in Fig 5. The lowest amounts of rainfall are in summer and spring season (end of March to August). In reality, in summer season, plants need more water due to high temperature and evapotransportation phenomenon. The mean rainfall, seasonal and percentage are shown in Table 2 and 3 respectively.

Topology: The vector data model often includes information about the data topology which describes the relative position (spatial relation) of objects to each other. The regions near The Caspian Sea (The green contour line) are favorable areas for agricultural activities. Fig 6, shows the topology of the study area. In northern regions based on low altitude, rainfall and favorable temperatures are demonstrated suitable regions for farmland. In general, by overlying different data sets (Table 1) the final map is shown for farmland (irrigated and rainfed) in Fig 7.

Basically, temperature decreases with increasing altitude. In other words, topology is a critical component of both the hydrological and geomorphological classifications. Different elevations have different temperatures and their situations. Its temperature is obviously related to latitude and altitude with a vertical declining rate of temperature about 0.6 °C /100 m. In the study area, the elevation gently increases in the southern area. In this study, the average temperature is 17°C in Ramsar meteorological station with an altitude of 100m falling to 0.4°C in southern regions.

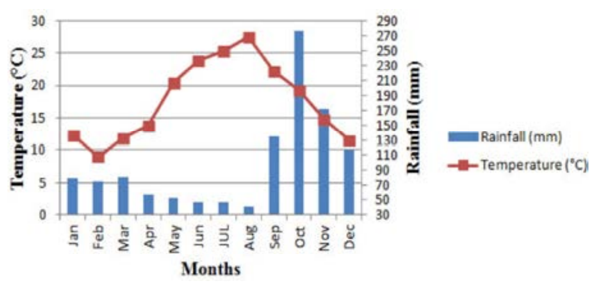

Fig. 2: Climatograph of the study area (30 years period)

Table 2: The mean rainfall (30 years period) of study area (Ramsar synoptic station statistics)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Rainfall (mm)	79.1	75.3	80.4	56.4	51.8	46.6	46.5	41.7	134.6	276.3	172.3	115.9

Table 3: The seasonal rainfall amount (mm) and percentage of the case study (Synoptic station of Ramsar, 1980- 2010)

Month	Autumn	%	Winter	%	Spring	%	Summer	%	Total
Volume (mm)	577.9	49	238	20	150.5	13	226	18	1192.4

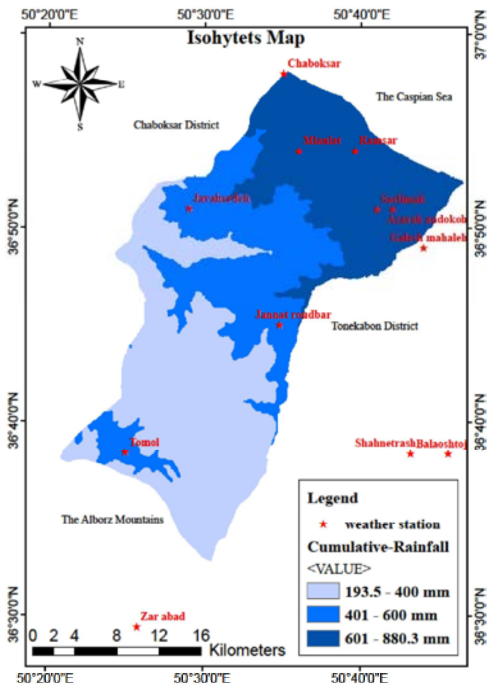

Fig. 3: Isohyets map

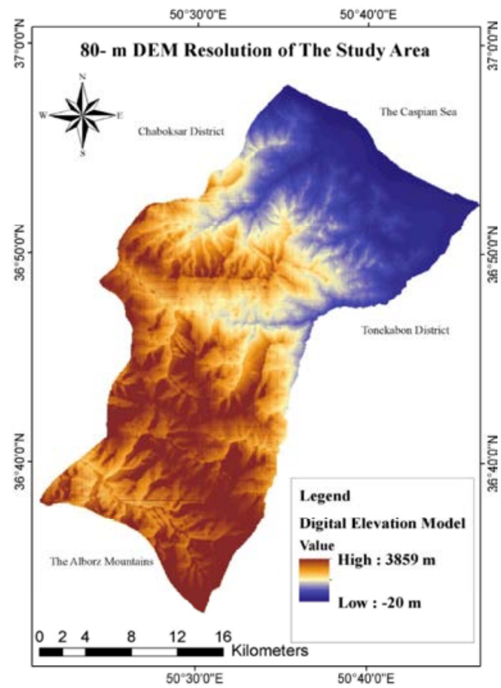

Fig. 5: Topology map of study area

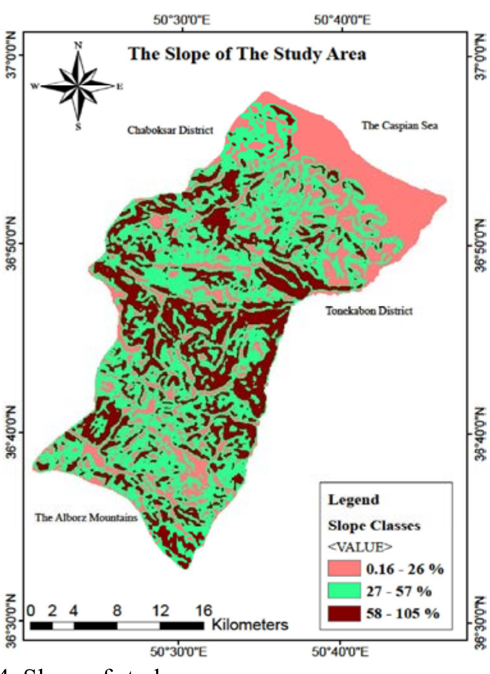

Fig. 4: Slope of study area

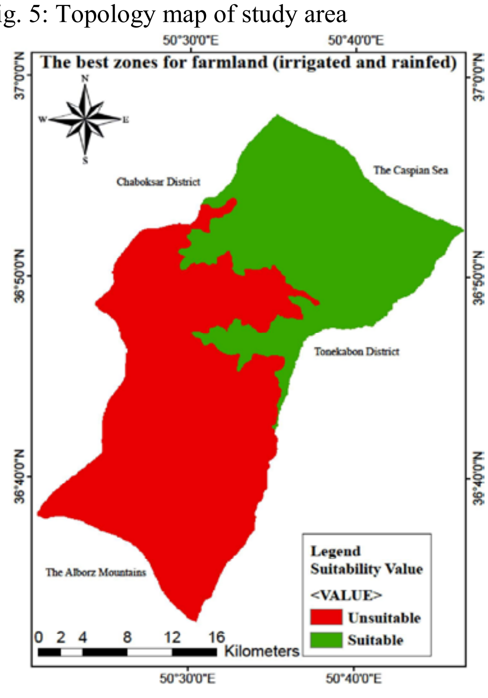

Fig. 6: Two classified zones for farmland

DISCUSSION

The study area is categorized into two levels as ecological potential. Modeling the ecological potential is based on simultaneous and suitable environmental characteristics which are the criteria of land utilization. Precipitation, humidity and temperature can be regarded as the most important climatic factors to grow and produce suitable plants. The results demonstrate that the annual rainfall less than 400 mm for rainfed farming can be a limiting factor. Thereby, the amount of precipitation limits the suitable crop production while, it does not stop the crops' growth. Furthermore, waters' quantity could be indicative in aquiculture, but not a good criterion to assess rainfed farming efficiency. In other words, out of this range the vital activities will be declined. In addition, crop production would be deceased by irrigation lower than tolerable threshold (green color in Fig. 7). In summer, the most important issue of water supply needed by the plant. According to Fig. 5 in summer and spring seasons, water stress in plants due to high reduced severely disrupts physiological processes of photosynthesis and finally drying and death of plants. In study area the annual temperature is considered for rainfed and irrigated farming (faryab); however, it cannot be a limiting factor for all kinds of plants in study area.

In addition, the sensitivity among different kinds of plants to day-length before reproductive stage of plants by environmental optic stimulus to complete its crop life cycle; it could come up with some unfavorable situations such as late cold weather in a season that for sure it subsides severely the crop yield. This implies that air temperature is the main driver of development in study area but water deficits modify the effect of temperature as well. Moreover, rainfall and temperature have a strong potential for producing in terms of agro-ecological zoning. Consequently, Rainfall and temperature impact on the farming systems and determine landuse / land cover and environmental planning.

CONCLUSION

The results show that elevation, slope, temperature and rainfall characteristics can be considered as the most stable element in various types of ecosystems which is essential in providing water and nutrition for plants. The approaches could be claimed that the study area is suitable for high quality efficiency; however, it would be a limiting factor as well.

Slope condition is one of the essential characteristics in soil erosion; furthermore, it is an important indicator factor in crop decisions making. According to this analysis, 70% of crop lands have a steep of over 26%. Therefore, not only this factor can be a limiting one, but also it would be affected on the other soil properties including: soil texture, depth, production, soil erosion.

In addition, the results demonstrate that the high slop would be significantly reduced soil indices like carbon organic and nitrogen percents. Air temperature, soil properties, slope, aspect, drainage and rainfall could be significant constraints resources farmland (rainfed and irrigated). Finally, to identify the type of exploitation must be evaluated all the ecological and economical-social resources' potentials.

REFERENCES

1. Caldiz, D.O., F.G. Gaspari and P.C. Haverkort, 2001. Agro-ecological zoning and potential yield of single or double cropping of potato in Argentina. Agricultural and Forest Meteorology, 109: 311-320.
2. Chen, L., I. Messing and S. Zhang, 2003. Land use evaluation and scenario analysis towards sustainable planning on the loess plateau in China-case study in small catchment, Catena, 54: 303-316.
3. Chetri, M. and C.R. Gurung, 2004. Vegetation Composition, Species Performance and its Relationship among the Livestock and Wildlife in the Grassland of Upper Mustang, Nepal. Yak Production in Central Asian Highlands. In: Proceedings of the Fourth International Yak Congress, Chengdu, China.
4. Jing, Q.S., J.G. Conijn, R.E.E. Jongschaap and P.S. Bindraban, 2012. Modeling the productivity of energy crops in different agro-ecological environments, Biomass and Bio Energy, 46: 618-633.
5. Kravchenko, A.N. and D.G. Bullock, 2002. Spatial variability of soybean quality data as a function of field topography: I. Spatial data analysis. Crop Science, 42(3): 804-815.
6. Fotheringham, A.S. and J.P. Wilson, 2007. Geographic Information Science: an introduction. In: Wilson, J.P. Fotheringham, S.A. (Eds.), Handbook of Geographic Information Science. Blackwell, Oxford, pp: 1-10.
7. Rundell, P.W., E.A. Graham, M.F. Allen, J.C. Fisher and T.C. Harmon, 2009. Environmental sensor networks in ecological research. New Phytologist, 182: 589-607.

8. Stol, W.G., H.J. De Koning, P.L. Kooman, A.J. Haverkort, H. Van Keulen and F.W.T. Penning de Vries, 1991. Agro-ecological characterization for potato production, CABO-DLO Report 155, Wageningen, the Netherlands, pp: 53.
9. Van Keulen, H. and W. Stol, 1995. Agro-ecological zonation for potato production. In: Haverkort, A.J. MacKerron, D.K.L. (Eds.), Potato Ecology and Modeling of Crops Under Conditions Limiting Growth. Kluwer Academic Publishers, Dordrecht, pp: 357-372.
10. FAO, 2007. Land evaluation towards a revised framework, Food and Agriculture Organization of the United Nations, Rome, Italy.
11. Neamatollahi, E., M. Bannayan, M.R. Jahansuz, P. Struik and A. Farid, 2012. Agro-ecological zoning for wheat (Triticum aestivum), sugar beet (Beta vulgaris) and corn (Zea mays) on the Mashhad plain, Khorasan Razavi province, The Egyptian Journal of Remote Sensing and Space Sciences, 15: 99-112.
12. Legesse, D. and T. Ayenew, 2006. Effect of improper water and land resource utilization on the central Main Ethiopian Rift lakes. Quaternary International, 148: 8-18.
14. Adimassu, Z., A. Kessler and L. Stroosnijder, 2014. Farmers' strategies to perceived trends of rainfall and crop productivity in the Central Rift Valley of Ethiopia, Environmental Development, 11: 123-14.
15. Ngetich, K.F., M. Mucheru-Muna, J.N. Mugwe, C.A. Shisanya, J. Diels and D.N. Mugendi, 2014. Length of growing season, rainfall temporal distribution, onset and cessation dates in the Kenyan highland. Agricultural and Forest Meteorology, 188: 24-32.