



Ecocrop Model Approach for Agro-Climatic Sugarcane Crop Suitability in Bhogawati River Basin of Kolhapur District, Maharashtra, India

V. S. Pawar-Patil* and S. P. Mali²

*¹Department of Geography, New College, Kolhapur, 416012

²Department of Geography and Research Center, Parvatibai Chowgule College of Arts and Science, Margaon, Goa

Corresponding Author: vickypawarpatil@gmail.com

Abstract:

Agriculture is the backbone of Indian economy and as the population explosion is concern, there is high demand of food to from increasing population. Hence, there is need of high agricultural production for both cash crops and food crops to from available land by using modern agricultural practices. India is one of the leading sugarcane grown nations in the world having about 4.60 million hectare of area with 289.6 million metric tons of sugarcane production. Maharashtra is one of the major sugar producing state of India. The aim of present research is to develop Ecocrop module in DIVA-GIS which is being used to predict the adjustment of a particular crop considering the temperature and rainfall thresholds over geographic region. Model computes suitability index for temperature and precipitation differently and finally with the integration of both obtain final suitability rating. In view of that to assess sugarcane cash crop site suitability in Bhogawati river basin using Ecocrop model is main objective of present research work. The Sugarcane crop site suitability index has been analyzed, in which marginal, suitable, very suitable and excellent suitability sites were obtained in Bhogawati river basin. The result stated that, the majority of the area which is about 839 Sq.km has comes under excellent type of agro-climatic suitability for sugarcane cultivation. Geo-spatial technology is playing a crucial role for giving accurate information for Eco-crop modeling and agricultural planning of the region.

Keywords: Agriculture, Crop suitability, DIVA-GIS, Ecocrop model, Sugarcane crop

1.0 Introduction:

India is profoundly agrarian country; Indian agriculture has long history dating back ten thousand years. Agriculture is continues to be life supporting activity in our country and prosperity of rural economy is intimately attached with agriculture and allied activities, hence agriculture sector is a decisive sector of Indian economy. Sugarcane is one of the important cash crops cultivated in India since Vedic period. Botanically, Sugarcane belongs to the Andropogonae tribe of the family Gramineae, order Glumiflorae, class Monocotyledoneae, subdivision Angiospermae, and division Embryophitasiphonogama. The subtribe of sugarcane is 'Sacharae' and the genus is 'Sacchrum' the word derived from the Sanskrit' language

"Sarkara" means 'White Sugar'. It reminds that the plant has been reached to Mediterranean from Indian subcontinent. 'Saccharum' is having five important species viz. *Saccharum officinarum*, *S. Sinense*, *S. Barberi* etc. are common (Director of Sugarcane Development, GOI, 2013).

Sugarcane producing countries in the world are situated between 36.7⁰N and 31⁰S latitudes of the equator. Worldwide sugarcane has covered an area of about 20.42 million hectare with total production of about 1333 million tons (FAO, 2003). India is the second largest sugarcane grown country in the world having about 4.60 million hectare of area with 289.6 million metric tons of sugarcane production. Maharashtra is one of the largest sugars producing state of India which was having yielded of about 80

t/ha (Thakkar, 2013). In India sugar is a Rs. 30,000/- crore industry, the second largest in the country in the agro processing sector, next only to textiles, and represents the principle livelihood of the 35 million farmers (ICRISAT-WWF Project, 2009). Especially western Maharashtra is dominant in sugarcane production which covers Satara, Sangali, Kolhapur, Pune, Ahemadnagar, Solapur and Nashik districts of Maharashtra. Kolhapur district is one of the leading districts in sugarcane cultivation in western Maharashtra, where fertile soil, monsoon type of hot and sub humid climate, irrigation development supports to enhance the sugarcane cultivation.

The international centre for tropical agriculture association with biodiversity international and the international potato centre have developed the ecocrop model. The ecocrop model uses FAO's Ecocrop database of the environmental requirements of a long list of plant species, which can be used to identify possible crops to grow in a particular environment (Hijmans, et al., 2012) Mapping and spatial analysis of agro ecological suitability zonation of particular crop can be done with this model in DIVA-GIS. The computer programme, DIVA-GIS was developed at the International Potato Centre (CIP) in collaboration with the International Plant Genetic Resource Institute (IPGRI), and with support from the System – wide Genetic Resource Programme (SGRP), (Hijmans, et al., 2003). Ecocrop module in DIVA-GIS is being used to predict the adjustment of a particular crop considering the temperature and rainfall thresholds over geographic region. Model computes suitability index for temperature and precipitation differently and finally with the integration of both obtain final suitability rating. The major objective of the research is to evaluate the

sugarcane cash crop site suitability in Bhogawati river basin using Ecocrop model.

2.0 Study Area:

Bhogawati river basin of Kolhapur district of western Maharashtra (India) has been selected as a study area for present research work. The Bhogawati river basin lies between $16^{\circ} 18' 42''$ N to $16^{\circ} 44' 33''$ N latitudes and $73^{\circ} 49' 31''$ E to $74^{\circ} 12'$ E longitudes having an area of about 1128.28 Km². Bhogawati river rises in the Sahydri (Western Ghats) a few miles away from phonda pass and after a northerly course of about 25 miles is joined by Tulasi near the historical village of Bid (Gazetteers of Kolhapur District). The river is having three main tributaries named as Tulasi, Kumbhi, Dhamani all are confluence on the left bank of the Bhogawati river. Radhanagari reservoir has been constructed on this river in 1957 in order to facilitate irrigation development in the lower reaches of the watershed and also hydro-electricity generation. The river Bhogawati is one of the major tributary of river Panchganga in a Mega Krishna basin. Deccan volcanic and Basaltic of upper cretaceous to lower Eocene age topography is predominant in this region. The general slope of the region decrease from west to east direction and region receives rain from south-west monsoon having average annual rainfall of about 4800 mm and temperature ranges between 10°C to 40°C (Pisal, et al., 2013). Dentritic and sub dentritic type of drainage pattern is observed there and well fertile black soil supports to grow and enhance sugarcane crop in this region.

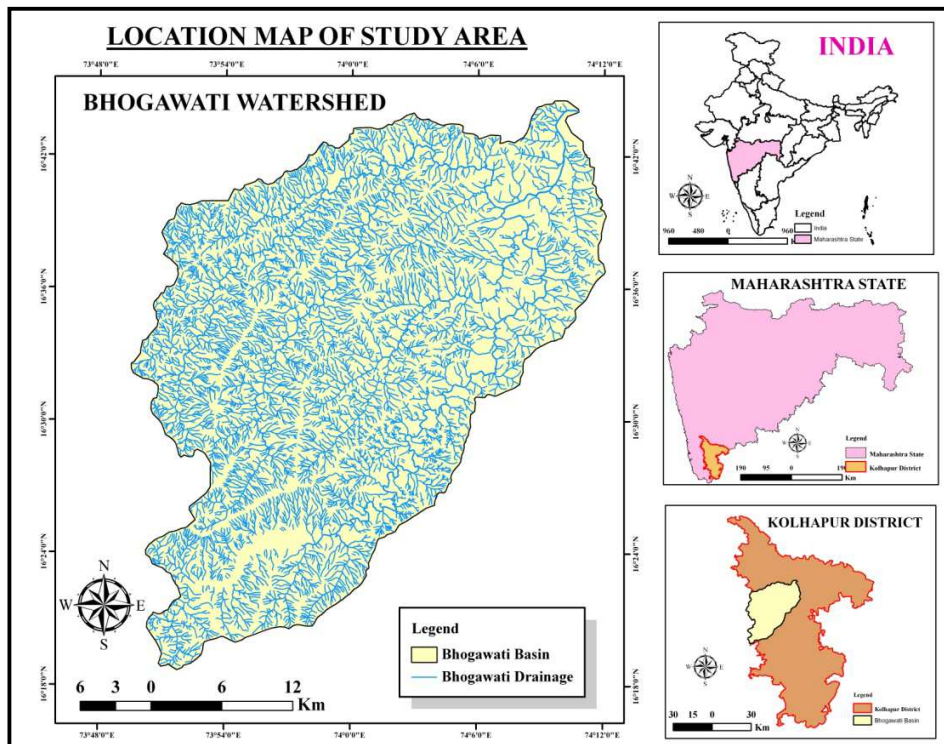


Figure 1: Location Map of Study Area

3.0 Data base and Methods:

Eco-crop model is based on FAO's ecocrop database and mainly it required temperature and precipitation data of the region. In view of that, WorldClim2-5 minute gridded database of the temperature and precipitation were used in GIS environment. Cartosat Dem of 30 meter spatial resolution was used in order to delineate Bhogawati watershed and sub watersheds. SOI Toposheets (47 H/13, 14, L/1, 2) were employed to cross verify the watershed area. FAO's threshold values of growing period, maximum and minimum temperature and rainfall for sugarcane were taken in to account in Eco-crop model.

At the outset, Cartosat DEM of 30 meter spatial resolution data was imported in ArcGis 9.3 version software and reprojects the same. The reprojected DEM data was imported in Arc SWAT extension and outlet has given in the same software which is being used to delineate major watershed and sub watersheds in the Bhogawati basin. The delineated watersheds were overlaid on georeferenced and mosaicked toposheets of the study area. Following

chart (Fig. 2) showing the general methodology of the research.

The delineated Bhogawati watershed boundary layer was imported in DIVA-GIS environment. WorldClim (2-5m) gridded climatic data were downloaded and extracted in a particular folder which also imported in Ecocrop module. WorldClim is a global gridded dataset of monthly climatological means of maximum, minimum and mean temperature and total precipitation developed through thin plate spline interpolation of long term (1950-2000) weather station records (Ramirez et al. 2014).

In this model temperature parameters viz.

KTMP = Absolute temperature ($^{\circ}\text{C}$) that will kill the plant

TMIN = Minimum average temperature ($^{\circ}\text{C}$) at which the plant will grow

TOPMN = Minimum average temperature ($^{\circ}\text{C}$) at which the plant will grow optimally

TOPMX = Maximum average temperature ($^{\circ}\text{C}$) at which the plant will grow optimally

TMAX = Maximum average temperature ($^{\circ}\text{C}$) at which the plant will cease to grow

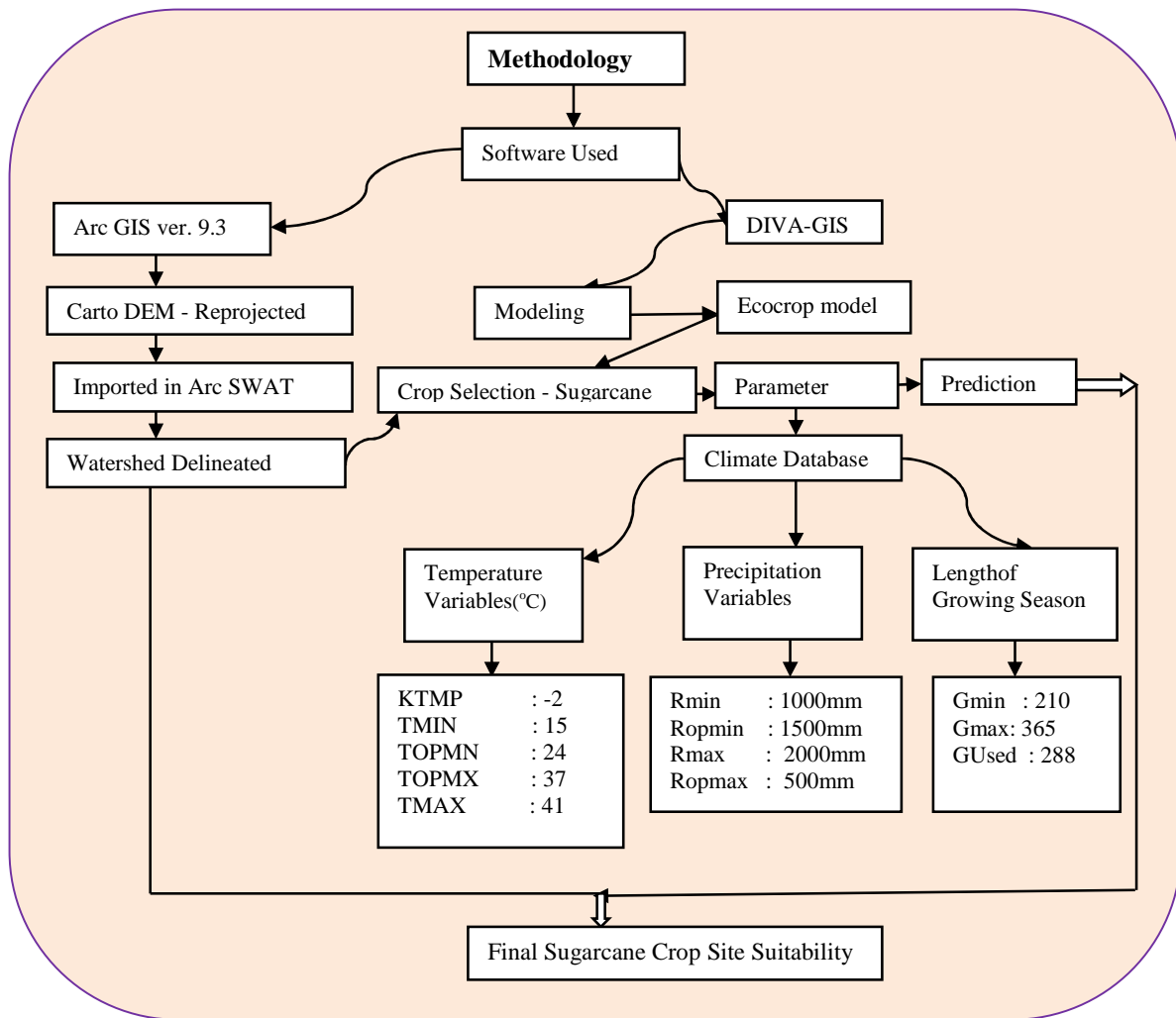


Figure 1: Flow Chart of Methodology

Precipitation parameters viz.

Rmin= Minimum rainfall (mm) during the growing season

Ropmin = Optimal minimum rainfall (mm) during the growing season

Ropmax= Optimal maximum rainfall (mm) during the growing season

Rmax= Maximum rainfall (mm) during the growing season

Which are being used to conduct temperature and precipitation suitability ratings. The growing period of a particular crop is defined in days between Gmin (Period of start of growth of a particular crop) and Gmax (Period of end of a growth of particular crop) (Hijmans, et al., 2012). The above mentioned FAO's thresholds of temperature and precipitation data is

already preset in Ecocrop module of DIVA-GIS and with the help of those researchers have got final site suitability map of sugarcane crop of Bhogawati basin. The same gridded map is converted into shape file format and imported in ArcGIS environment. The imported site suitability map were reclassified in ArcGIS environment and suitability area viz. Excellent, Very suitable, Suitable and Marginal suitable were calculated.

4.0 Result and Discussion:

The Sugarcane crop site suitability index has been analyzed, in which marginal, suitable, very suitable and excellent suitability sites were obtained in Bhogawati river basin. The majority of the area has come under excellent type of agro-climatic suitability for sugarcane cultivation i.e. 839 km² of area. Middle

and upper reaches of the basin is showing excellent and very suitable type of suitability for sugarcane. Very meager area is covered by marginal suitability i.e. 20.81 km² which covered extreme north-eastern part of the basin. Sub-basin level analysis revealed that main Bhogawati river basin is sheltered marginal, suitable, very suitable and excellent type of site suitability zones for sugarcane cultivation and

maximum area came under excellent (302.40 km²) and very suitable (99.46 km²) type of suitability. All other sub-basins are endowed with excellent and very suitable type of sugarcane crop site suitability.

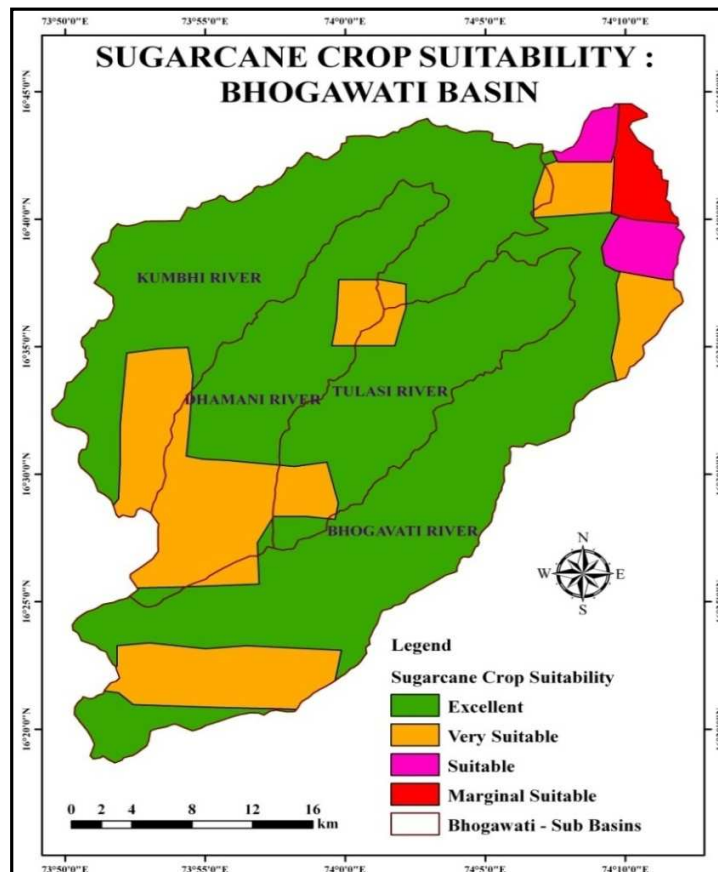


Fig. 3. Sugarcane Suitability Zone

Table 1: Sugarcane site suitability in Bhogawati river basin and sub-basins

Sr. No.	Suitability index	Whole River Basin	Bhogawati Basin	Tulasi Basin	Kumbhi Basin	Dhamani Basin
		(Area in Km ²)				
1	Marginal	20.8112	20.8112	--	--	
2	Suitable	27.8743	27.8743	--	--	
3	Very Suitable	240.2260	99.4617	19.2831	45.1376	76.3434
4	Excellent	839.3740	302.4080	145.0250	272.0420	119.8990
	Total	1128.2855	450.5552	164.3081	317.1796	196.2424

Source: Compiled and computed by researchers

5.0 Conclusion:

In recent years GIS has provided much-required spatial dimensions to natural resource management and planning (Sarkar, 2008). Specific crop site suitability analysis can be done easily in GIS environment. DIVA-GIS is open source software package endowed with Ecocrop module is proved best one to handle the climatic data base and satisfy FAO's thresholds of temperature, precipitation and growing seasons. Ecocrop model of DIVA-GIS is an universal model which can be used for the crops of any region by adjusting the required climatic parameters (Utpala, et al., 2008). Ecocrop model has been used to assess agro-climatic sugarcane crop site suitability in Bhogawati river basin. This model has pointed out only the greatest climatic potentiality of a success of particular crop in a defined region and final deduction requires in-depth study of other parameters viz. soil type, soil depth, soil organic matter content, chemical properties of soil, slope, aspect, availability of irrigation facilities as well as agro-economic and social status of the people in this region. The site suitability analysis will be helpful to optimize expense raise income level in a region and Ecocrop model can be employed from regional to global scale for assessing the climatic suitability of a particular crop.

References:

- 1) Sarkar Aditi (2008): Geo-spatial approach in soil and climatic data analysis for agro-climatic suitability assessment of major crops in rainfed agro-ecosystem (A case study of parts of Madhya Pradesh), Unpublished Thesis submitted to Andhra University for M. Tech. degree, IIRS, Dehradun.
- 2) Director of Sugarcane Development, GOI, (2013): Status paper on Sugarcane, Ministry of Agriculture (Dept. of Agriculture & Cooperation), Aliganj, Lucknow (UP).
- 3) Government of Maharashtra (2006) Gazetteer of Maharashtra- Kolhapur District, Directorate of Gov. Printing, Stationary and Publications, Bombay.
- 4) Hijmans, R. J., Guarino, L., Cruz, M., Rojas, E. (2001): Computer tools for spatial analysis of plant genetic resources data: 1. DIVA-GIS, plant Genetic Resources Newsletter, No. 127, 15-19.
- 5) Hijmans, R. J., Guarino, L., Mathur, P. (2012): DIVA-GIS manual, ver. 7.5.
- 6) H. Thakkar (2013): South Asian Network on Dams, Rivers and People, Sugarcane status report. Maharashtra.
- 7) ICRISAT-WWF Project (2009): Sustainable sugarcane initiatives-improving sugarcane in India, Training Manual, Andhra Pradesh, India.
- 8) Pisal, P.A., Yadav, A. S., Chavan, A. B.(2013): Morphometric analysis of Bhogawati river basin, Kolhapur district, Maharashtra, India., IOSR-Journal of Mechanical and Civil Engineering, 1-8, ISSN 2278-1684.
- 9) Ramirez, V. J, Fransisco Cuesta, Chritian Devenish et al., (2014): Using species distribution models for desiging conservation strategies of Tropical Andean diversity under climate change, Journal for Nature Conservation, G-Model JNC-25349.
- 10) Scheldemman X., Zonneveld, and M. V.,(2010): Training manual on spatial analysis of plant diversity and distribution, Biodiversity International, Rome, Italy, ISBN 978-92-9043-880-9.
- 11) Utpala, P., Jayarajan, K., Johny, A. K., V. A. Parthasarathy (2008) Identification of suitable areas and effect of climate on ginger- a GIS study, Journal of species and Aromatic Crops, Vol. 17 (2): 61-68.
- 12) FAO, 2003 <http://www.fao.org>