

Identification of suitable areas and effect of climate change on ginger - a GIS study.

Utpala Parthasarathy, K Jayarajan , A K Johny & V A Parthasarathy

Indian Institute of Spices Research,

Calicut, Kerala, India-673312

E.mail: utpala@spices.ne.t.in

Abstract

Secondary data of area, production and productivity of ginger have consistently shown an increasing trend during the last 3 decades. Increase in area is not always in proportion with the increase in production. Thirty years area and production curves of the important ginger growing states are compared with the Eco-crop suitability model which indicated that suitability has direct impact on production. Orissa, West Bengal, Mizoram and Kerala are very highly suitable while North western states like Gujarat, Rajasthan, Uttarpradesh, Madhya Pradesh are marginally suitable or unsuitable. North eastern and south western states are ideally highly suitable for ginger cultivation. Future prediction of Eco-crop model shows, if the temperature increase by 1.5 to 2°C, the suitability of Orissa and West Bengal will reduce drastically from high suitability to marginally suitable, indicating the effect of climate change.

Key words; Eco-crop model, ginger, productivity, suitability.

Introduction

Ginger requires a warm and humid climate and a heavy rainfall of 150-300cm a year or plenty of irrigation. The plant can be cultivated from almost sea level to an altitude of 1500m above sea level. It thrives well in sandy or clay loam soil with good drainage and humus content. Ginger is best grown in partial shade and can be cultivated as an intercrop in coconut, coffee and orange plantations. Planting is done in April/May during the onset monsoon.

Use of geographic information system (GIS) to assess land suitability of ginger for current and potential regions in Indian climate is the primary focus of the study. The assessment is based on spatial frequency distributions of

measurable environmental criteria derived from characteristics of climatic requirement of the crop.

Crop growth simulation models are research tools usually applied in assessing the relationship between crop productivity and environmental factors. They have been shown to be efficient in determining the response of crop plants to changes in weather and climate. Examples of such models include EPIC (Williams *et al.* 1989), CERES (Ritchie 1989) and GAPS (Butler and Riha 1989). In most of the cases these crop models have been developed in particular localities and they are not always applicable in other regions without modification. Therefore, when introducing such crop models into new regions, their applicability needs to be evaluated. The Eco Crop model of DIVA GIS

is an universal model which can be used for the crops of any region by adjusting the required climatic parameters. DIVA-GIS implement Ecocrop to predict the adaptation of a crop over geographic areas (Hijmans *et al.* 2005). According to FAO, Ecocrop can be used to assist in the identification of candidate species for defined environments. Similar models have been used extensively to evaluate the potential impact of climate change on shifts in the production and growing regions of various crops (Easterling *et al.*, 1993; Rosenzweig *et al.*, 1995; Tubiello *et al.*, 2000; Tubiello *et al.*, 2002).

In this study 30 years secondary data on area and production of ginger were compared with the suitability map of ginger ecocrop model, to understand the effect of land suitability on the production and productivity of the crop.

Material and methods:

Thirty years data of area and production of ginger were collected from the secondary sources (the record of spices board and statistics departments). With the help of MS Excel, graph for area, production and productivity were drawn.

Suitability map for ginger was drawn with the help of ecocrop model of DIVA GIS. In Ecocrop prediction model all the parameters like the growing period, the length of the growing season are kept same and only the maximum temperature (T max) increased by 2° C minimum temperature (T min) reduced by 1.5°C is defined as the average of Gmin and Gmax, expressed as number of months.

Result and discussion

The site suitability map (Utpala *et al.*, 2006) showed that Assam, Mizoram, Tripura, Western part of Meghalaya, West Bengal, Orrisa, Kerala and Western Ghat region of Karnataka and Maharastra have the highest suitability for ginger cultivation in India (Fig 1 and Table 1). The area under the crop has increased to 62,000 ha in 2003 compared to 17000 ha in 1950-51. Similarly production has

also increased from 15000 tons to 1, 86,000 tons over the same period (Datta *et al.*, 2003).

Assam: Ginger is a popular spice crop of Assam and some districts like N.C. Hills, Darrang and Cachar are having considerable area under cultivation and the total production in 2001-02 was 1,14408 MT, average productivity ranged between 4000-7000 kg/ha.

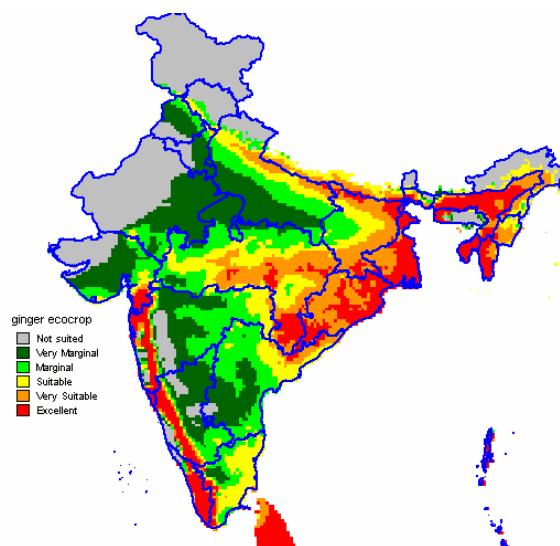


Fig.1. Ginger site suitability map for India (Utpala *et al.*, 2006)

A complete record for last thirty years of production and area under ginger cultivation of Assam is not available but Assam cultivates total five varieties out of which four are of high yielding and one local variety (Utpala *et al.*, 2006). Assam is very suitable and now produces more than 30% of the total ginger produced in India (Kalita and Baruah 2003). Recent statistics indicate that Assam has 18,180 ha under ginger cultivation with a production of 1, 23,990 tonnes and a productivity of 6,820 kg/ha.

Mizoram: The whole state of Mizoram has an excellent suitability for ginger and only three high yielding varieties, Maran, Thingpuri, and Thinggria are cultivated (Utpala *et al.*, 2006). The productivity level is high. Increase in area is less compared to the increase in productivity. The impact of intensive agriculture has been negligible during the past decades and Jhume cultivation is still in practice (John 2003) (Fig. 2 and 3).

Table 1. Suitability of different states for ginger cultivation

State	Excellent	Suitable	Marginal	Not suitable
Assam	**			
Arunachal Pradesh		**		
Andra Pradesh		*	**	
Bihar			**	
Karnataka	*(Western Ghats track)		**	
Kerala	**			
Madhya Pradesh		*	**	
Maharashtra	*(Western track)		**	
Manipur			**	
Meghalaya zone	*(Western part)			**Central
Orissa	**			
Tamil Nadu		**	*	
Tripura	**			
Uttar Pradesh			**	
West Bengal	**			

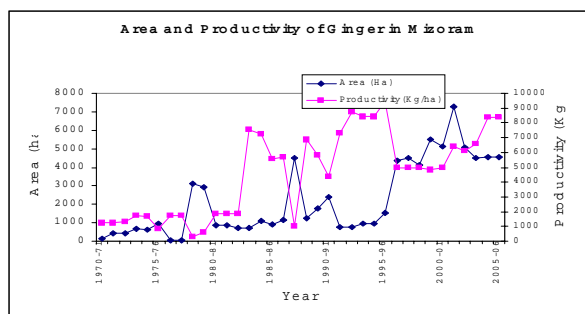


Fig.2. Area Productivity (1971-2006) curve of ginger for Mizoram

Meghalaya: ginger is one of the major cash crops. During the last 30 years, area went up but productivity was constant till 2004 in the range of 4500-6000kg/ha (Fig. 4).

It is interesting to note that from 2004 to 2005-06, the area has come down to 2000 ha but productivity went up to 10,000 kg/ha. The suitability map indicates that only West and South Garo hills districts are excellent for ginger cultivation, but eastern side of the Khasi hills and Jaintia hills are not suitable (Fig. 5).

Orissa: The suitability map shows that Orissa is very suitable for ginger cultivation. But the productivity level is very less (only 2000 kg/ha) (Fig. 6). Misra (2003) reported that ginger is cultivated by the tribal farmers, mostly economically backward. It is grown under rainfed conditions with their local varieties. This is the main reason for the low productivity of ginger in the state. As the suitability is high, with proper technology transfer, Orissa can become one of the highest ginger producing states in India (Fig. 7).

West Bengal: Ginger is cultivated in almost 18 districts sharing 12.15% in area and 7.6% in production of the country (Samanta and Nasar 2003). Bengal also has high suitability like Orissa. Though the area has increased in last 30 years from 2000 ha to 8000 ha, productivity level is below 2500kg/ha (Fig. 8). The reason may be that more than 95% ginger area is in hilly terrain and is covered by the cultivar Gorubathan, which is a high fibre variety. The lack of new improved varieties and want of adequate awareness about value added products and less demand in other states has led to poor attention

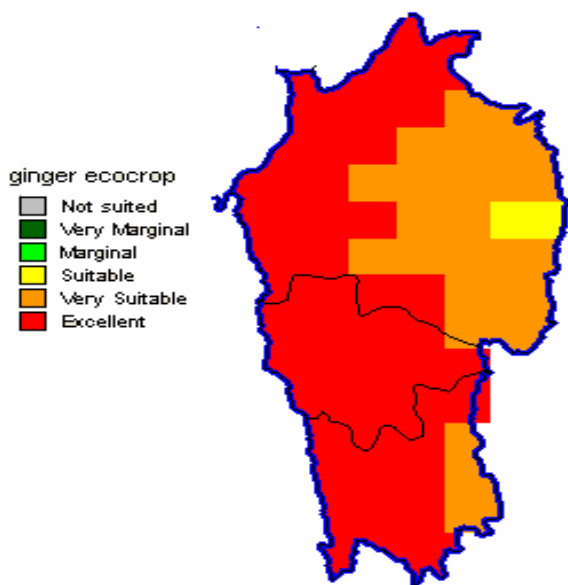


Fig.3. Site suitability map of ginger in Mizoram

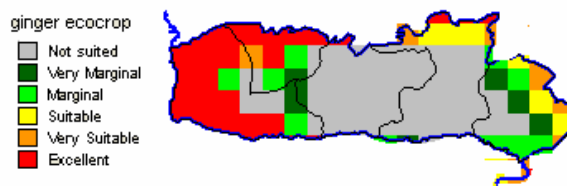


Fig.5. Site suitability map of ginger in Meghalaya

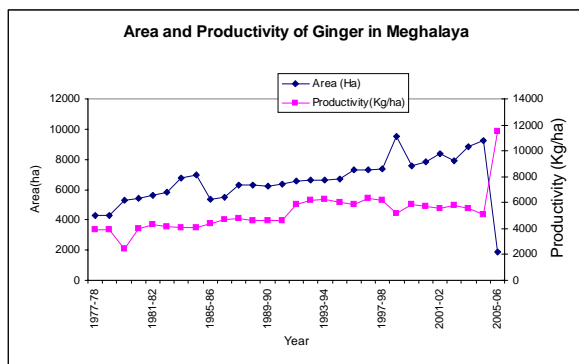


Fig. 4. Area Productivity(1971-2006) curve of ginger for Meghalaya

towards the crop. If adequate interest is given for the improvement, a very high return may be expected (Fig. 9).

Andhra Pradesh: Suitability map shows that A.P is not suitable for the cultivation of Ginger (Fig. 10). So in last 20 years though area has increased from 500 ha in 1970 to 3000 ha in 1990, again it has come down to 2000 ha in 2004-05 (Fig. 11). As the crop is not highly economical the area has decreased. The north eastern part of the state is suitable and most of the production restricted to those parts.

Tamil Nadu: The suitability of ginger in is marginal to suitable (Fig. 12). From the figure,

it can be inferred that from 1970 to 1990, productivity was 800-1000 kg per ha when area under cultivation was very high (around 2000ha) (Fig. 13). From 1991, the area has come down to 600- 800 ha and productivity level has gone high, up to 2000 to 3000kg/ha. The reason for high productivity is the cultivation in limited suitable area and the use of modern technology.

Kerala: Very suitable for ginger cultivation and all high yielding varieties are cultivated in recent years. The area and productivity curves (Fig. 14) show that in 1970, area was very high (12000 ha) and the productivity was 1800 kg/ha. But after 1990 area started falling and in 2000, it was very less (8000 ha) but productivity showed on increasing trend. Again during 2004-05, area rose to 11000 ha and the productivity reached 4500 kg/ha (Fig. 15). Kerala grows all high yielding varieties.

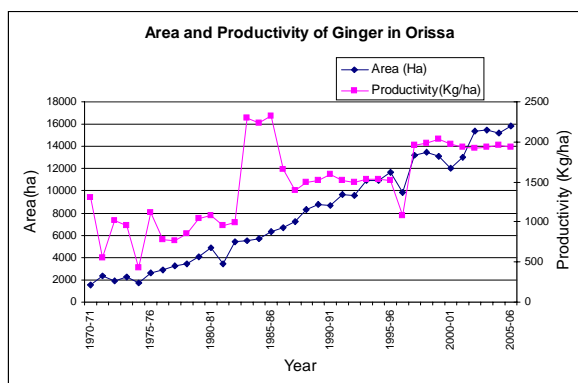


Fig 6. Area productivity (1971-2006) curve of ginger for Orissa

Out of nine varieties under cultivation, 5 are high yielding. The high suitability and use of modern technology resulted in very high productivity.

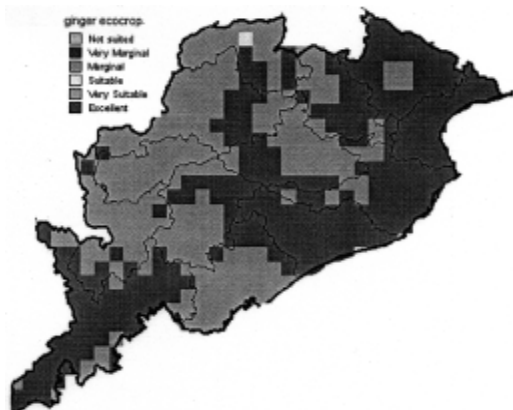


Fig.7. Site suitability map of ginger in Orissa

Karnataka: In case of Karnataka only certain parts in the Western Ghats range are very suitable for ginger (Fig. 16). Hence, though

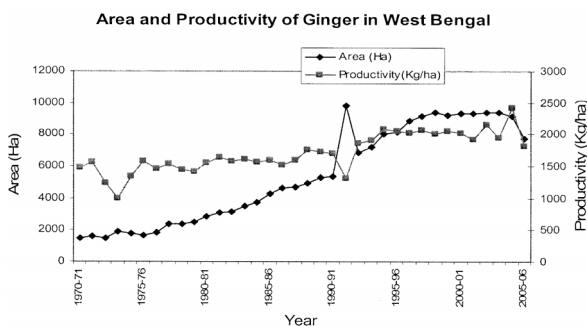


Fig. 8. Area productivity(1971-2006) curve of ginger for West Bengal

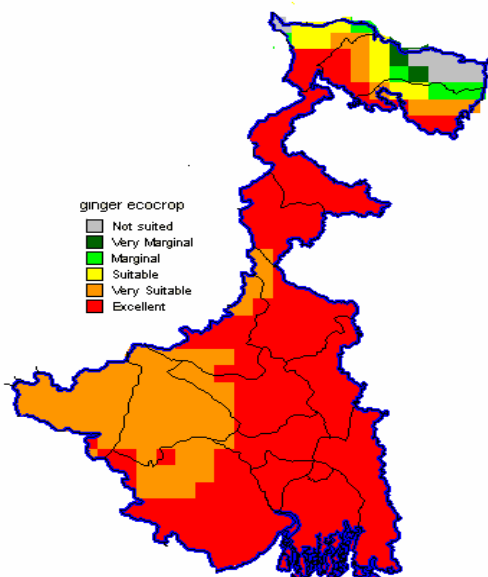


Fig.9. Site suitability map of ginger in West Bengal

area is increasing, productivity remained constant as the main production comes from these areas (Fig. 17).

The primary goal of crop simulation models is, that the researchers can use these results for predicting the crops for the regions. Satya and Shibasaki (1998) developed 'Spatial-EPIC' model to estimate the relationship between soil erosion and crop productivity.

Climate change is one of the important alert for present era. Several recent studies indicated that annual rainfall and diurnal temperature is in declining trend while maximum and minimum temperature is in warming trend. Piyasiri *et al* (2004) stated that in Sri Lanka, the reduction of mean annual rainfall during 1986-2001 has raised to 9% as compared to the period 1932-85 and

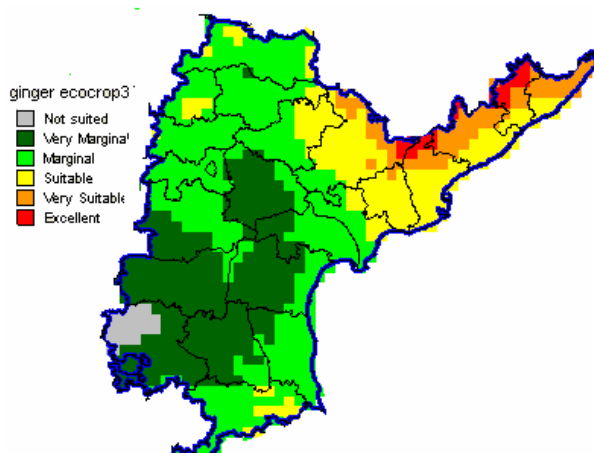


Fig 10. Site suitability map of ginger in Andhra Pradesh

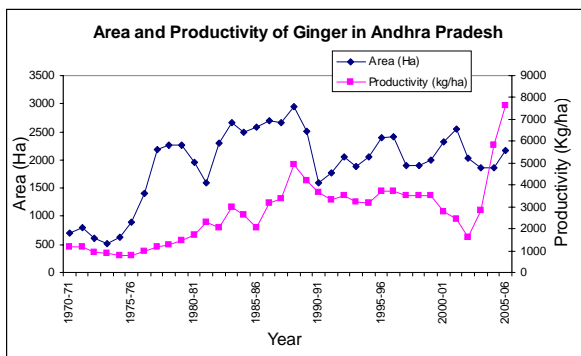


Fig 11. Area productivity (1971-2006) curve of ginger for Andhra Pradesh

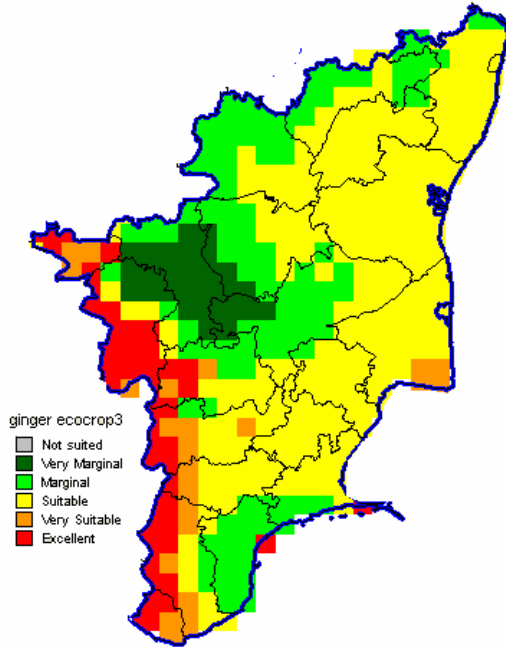


Fig.12. Site suitability map of ginger in Tamil Nadu

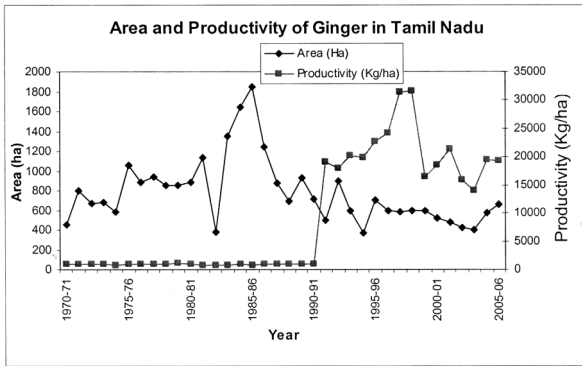


Fig. 13. Area and productivity (1971-2006) curve of ginger for Tamil Nadu

increase in temperature for the same period was 1.4 %. Here, the future prediction with Eco-crop model of DIVA GIS has done by raising the temperature 1.5°C to 2°C. The prediction map shows that the area under ginger is likely to shrink to less than half. The map shows that Orissa and West Bengal will become marginally suitable from the present condition of highly suitable one (Fig. 18).

Lane1 and Jarvis (2006) projected the future data for 2055 and predicted that climate change will cause shifts in areas suitable for cultivation of a wide range of crops.

Some studies indicate that overall, suitable areas will increase, but most affected by loss of area will generally be regions that are already struggling from the impacts of irregular and extreme climatic events. The application of GSI approach in precision farming would allow for optimizing the use of resources on a site-specific basis. There are many other factors which affect the production of a crop but the analyses of three decades data clearly indicate the suitability of climate as an important factor on the crop

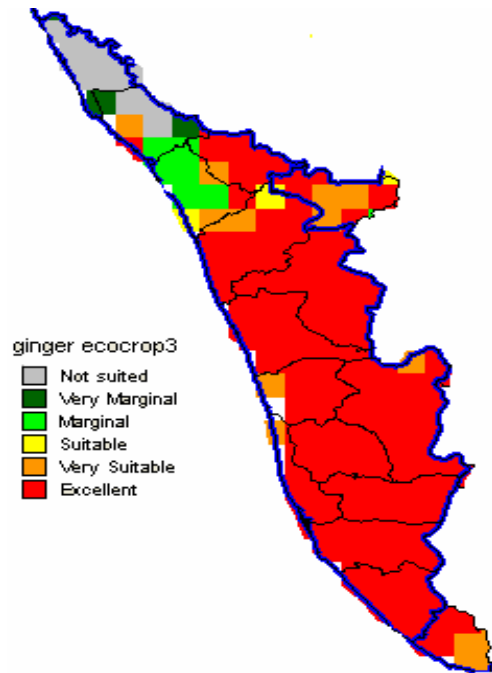


Fig.14. Site suitability map of Ginger in Kerala

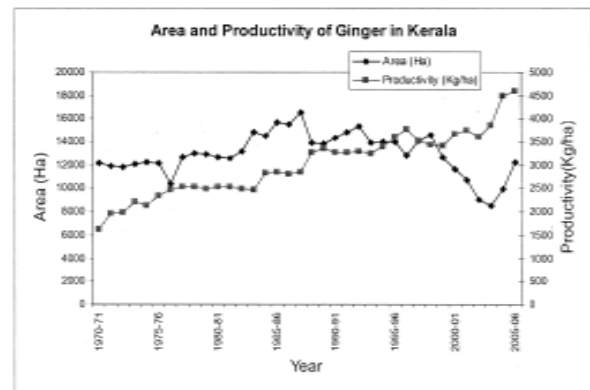


Fig. 15. Area and productivity (1971-2006) curve of ginger for Kerala

growth. By using GIS tools, rational approach can be made to cultivate suitable crops in suitable area.

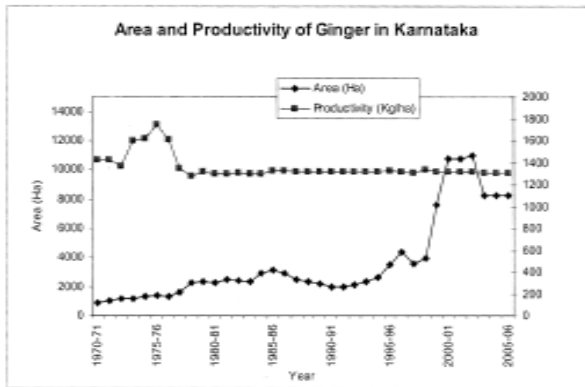


Fig. 16. Area and Productivity (1971-2006) curve of ginger for Karnataka.

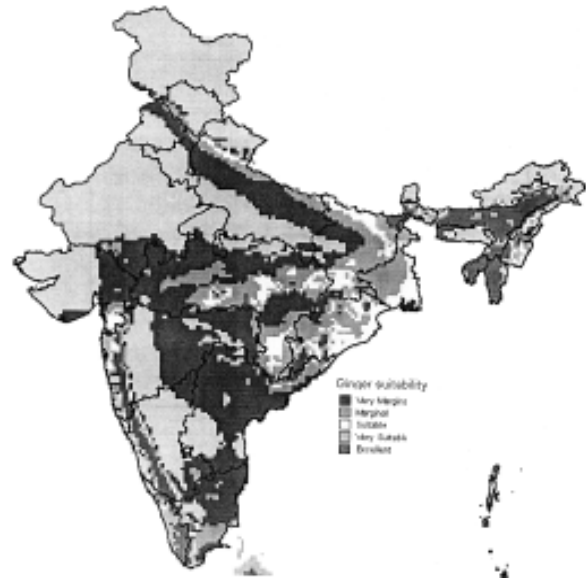


Fig. 18. Future of ginger suitability if temperature increases by -1.5°C to 2°C

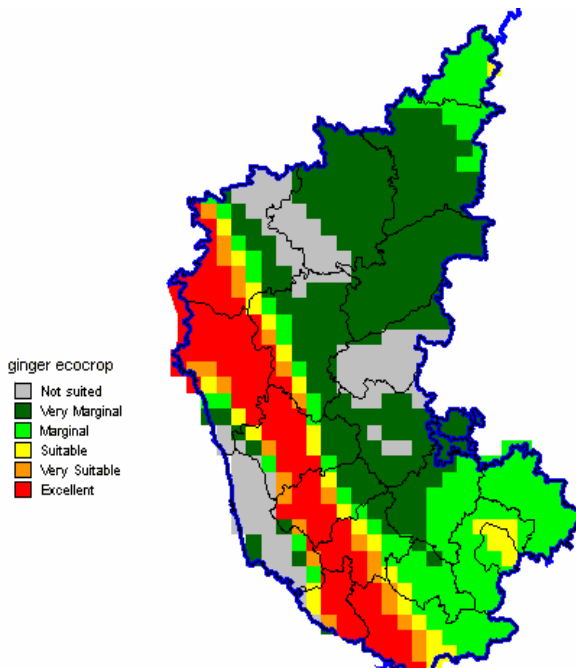


Fig.17. Site suitability map of ginger in Karnataka

References

Andrew R Solow, Richard F Adams, Kelly J Bryant, David M Legler, J O Brien, Bruce A. Mc Carl, William Nayda & Rodney Weiher 1989. The Value of Improved ENSO Prediction to U.S. Agriculture. Climatic change 39 (1) 47-60.

Butler I W & Riha S J (1989) GAPS: A general Purpose Formulation Model of the Soil - Plant - Atmosphere System Version 1.1 User's Manual, Department of Agronomy Cornell University, Ithaca New York.

Easterling W E, P R Crosson, N J Rosenberg, M S McKenny, L A Katz & K M Lemon 1993 Agricultural impacts of and responses to climate-change in the Missouri-Iowas- Nebraska-Kansas (MINK) region. Climatic Change 24: 23-61.

Hijmans R J, Guarino L, Cruz M, Jarvis A, O'Brien, R, Bussink C & Mathur P 2005 DIVA-GIS version 5.1. A geographic information system for the management and analysis of genetic resources data. Manual. International Potato Center and International Plant Genetic Resources Research Institute, Lima, Peru.

John Koshi 2003 Organic Agriculture and Possibilitied for Organic production of ginger in Mizoram. Indian Ginger Production and Utilization 9edt. H.P.Singh and Tamil Selvan. Niseema Printers, Cochin

Koshy John 2003. Organic Agriculture and possibilities for organic production of Ginger in Mizoram. (Ed.) H.P.Singh and M.Tamil Selvan.87-94.

- Kalita M M & Barooeh 2003 Status of production and utilization of ginger in Assam. Indian Ginger Production and utilization (Ed.) H.P.Singh and M.Tamil Selvan.186-189.
- Lane1 A & A Jarvis 2006 Changes in Climate will modify the Geography of Crop Suitability: Agricultural Biodiversity can help with Adaptation. An Open Access Journal published by ICRISAT '<http://www.icrisat.org/Journal/SpecialProject/sp2.pdf> '
- Misra U K 2003 Prospect for development of ginger cultivation in Orissa. (Ed.) H.P.Singh and M.Tamil Selvan.183-185.
- Ritchie J T 1989 Crop models and decision making: Scenario for the future. In A. Weiss (ed.) Climate and agriculture systems approaches to decision making. Proc. Am. Meteor. Soc. 106-117.
- Rosenzweig C, L H Allen Jr, L A Harper, S E Hollinger & J W Jones 1995 Climate change and Agriculture: Analysis of Potential International Impacts. ASA Special Publication Number 59, American Society of Agronomy Inc., Madison, WI.
- Samanta S K & Nasar S K T 2003 Status and prospect of ginger in West Bengal (Ed.) H.P.Singh and M.Tamil Selvan.198-201.
- Samar K, Datta, Gurdev Singh & Milind Chakarbarti 2003 Management of marketing and exports of ginger and its products with special reference to East Himalayan Region, Indian Ginger Production and Utilization 9edt.) H.P.Singh and Tamil Selvan. Niseema Printers, Cochin.
- Satya Priya Shibasaki, Ryosuke & Shiro Ochi 1998 Modeling Spatial Crop Production: A GIS approach, Proceedings of the 19th Asian Conference on Remote Sensing, 16-20 Nov, 1998 held at Manila. pp A-9-1 to A-9-6
- Tubiello F N, M Donatelli, C Rosenzweig & C O Stockle 2000 Effects of climate change and elevated CO₂ on cropping systems: model predictions at two Italian locations. European Journal of Agronomy 13: 179-189.
- Tubiello F N, M Donatelli, C Rosenzweig & C O Stockle 2002 Effects of climate change on US crop production: simulation results using two different GCM scenarios. Part 1: Wheat, potato, maize and citrus. Climate Research 20: 256-270.
- Utpala P, Johny A K, Parthasarathy V A, Jayarajan K & Madan M S 2006 Diversity of ginger cultivation in India- a GIS study. Journal of Spices and Aromatic Crops,15 (2) 93-99.