Trans. Inst. Indian Geographers
Vol. 11, No. 2, July 1989

PROBLEMS AND PERSPECTIVES IN AGROCLIMATOLOGICAL STUDIES IN SEMI-ARID TROPICS

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ABSTRACT: The paper focusses attention on the contribution of agricultural climatology and the need for greater involvement of agricultural geographers in research relating to climo-edaphic parameter of tropical agriculture. The review of the work done sofar brings into relief the hiatus in the studies relating to rainfall, soil moisture, agroclimatic classification, agroecological zones, and crop-yield analysis.

Introduction:

Agricultural production in semi-arid tropics (SAT) is hampered by the undependable weather. The low productivity of land and instability in crop prodcction have been the characteristic features of the semi-arid tropics. Inspite of the revolution in agricultural technology, the problem of low and unstable food production in vast dry farming tracts still remained unchanged. The gap between the demand for food and its production is widening with ever increase in population. Hence, a massive effort is needed for maximizing the food production by developing suitable technology for resource development and resource management. Despite the significant progress made by the researchers in crop production and crop protection, no significant achievement is made in exploiting the natural resources for optimum returns. In tropical agriculture, there still remain a number of areas which urgently require the attention of Agricultural Geographers.

Agriculture under rainfed conditions, starting from tillage to harvesting, is virtually linked with weather. A good knowledge of weather and climate goes a long way in the choice of a crop, sowing and developing a cropping pattern suitable to a place. Therefore, quantification and characterisation of environmental variables in semi-arid tropics is essential for the development of suitable technology.

2. Rainfall studies:

In SAT the value of rainfall in crop production to a large extent depends upon its even distribution and variability. Analysis of the distribution variability of rainfall in space and time is appropriate in the study of agricultural climatology of a region. These studies enable one to identify the different rainfall zones which will be useful both to regional planners and agriculture scientists. In any rainfall study, the average value should always be accompanied by the measure of variability. Also, in any analysis of variability of rainfall, the time period considered is important. Expressions of annual, seasonal or even monthly mean rainfall along its variability do not give any short period indication of moisture availability to plants. It is advisable to study the patterns of spatial and temporal variation in fortnightly or preferably weekly rainfall (Reddy and Rao 1987; Seksena, et al 1979) of semi-arid tropics, for assessing the agricultural potential. Information on probabilities of rainfall is more important than mean or median values. Knowledge of minimum probable rainfall with fairly high reliability will be extremely useful for the decision maker in crop selection, time of sowing and in the adjustment of seed rate. In arid and semi-arid climates, the short period rainfall distribution will be usually skewed towards lower values. For estimating rainfall reliabilities, gamma probabilities have been found to be a good fit (Mooley 1974). The shortest period rainfall probability maps with fairly high reliability are very very useful for screening crop varieties. Information on the probabilities for occurring dry spells and wet spells of different durations (Victor and Sastry, 1979; Raman and Krishnan, 1960), occurrence of droughts of different durations and intensities (Rao and Baliga, 1972; Subrahmanyam and Sastry, 1972; Biswas and Nayar 1984) and the distribution of rainy days (Rao 1984) is also useful for estimating the Agricultural potential of an area.

3. Soil moisture:

Since the peak period of rainfall in SAT is not known to coicide with high evaporation periods during the crop growing season moisture stored in soil becomes important for the plant. Thus measurement and estimation of soil moisture becomes an integral part of the agroclimatic survey of an area. Though various instrumental techniques like gravimetric method, resistance block method, tensiometers and neutral scattering meters are available, limited by practical difficulties, high cost, need for skilled labour and non-availability of repair facilities, they have not become popular. Alternatively, climatological water budgeting techniques (Thornthwaite 1948) has been widely used for estimating soil moisture. This technique is very simple and straight forward. It was developed primarily to determine the irrigation water requirements. With the advent of high speed computers climatological techniques have been refined. The most significant and widely used among all the computer based methods is the new versatile budget method (Baier and Robertson 1966). In the versatile budget, the soil profile is subdivided into six zones of varying plant availabe soil moisture capacities. Further, the method also considers the moisture in soil simultaneously withdrawn from different zones by roots depending upon the potential evapotranspiration, rooting pattern, soil moisture release characteristics and available water in each of the six zones. Based on many computations for various locations, it was found that soil moisture can be estimated with considerable precision from climatological data.

4. Agroclimatological classifications:

The spatial variation in soil types, topography, elevation and climate set limits to the agricultural productivity in different areas. Identification and delineation of agroclimatic regions which have more or less similar soil climatic conditions for crop production purpose is an essential prerequisite for developing suitable regional plans for optimum development of agriculture in SAT. Several methods have been proposed for classifying climates. Many of these classification schemes (de Mortonne 1926, Koppen 1936, Thornthwaite 1948, Troll 1965) seriously restrict their use for agricultural applications and some of them are very complex with large number of subgroups (Papadakis, 1966, 1975). On the other hand, there are several other schemes which give more emphasis on solar radiation and temperature. These are useful for classifying the areas situated beyond tropics (Popiv 1948; Budyko, 1956; Seliaminov, 1957). For semi-arid tropics where moisture is the limiting factor for agriculture, classification schemes based on moisture availability indices are more appropriate. In one of the classification schemes which is widely used in tropics (Hargreaves 1971, 1975) the moisture availability index (MAI) has been defined by comparing the rainfall expected at 75 per cent probability level with the estimated potential evapotranspiration. On the basis of the value of MAI, the climate of a place is classified into very arid and arid or into different moisture deficient classes. A modified form of the above index was adopted (Sarkar and Biswas 1980) for the assessment of crop potential of dry farming tracts of India. A similar index comparing rainfall with different amounts of potential evapotranspiration was employed by FAO. (Cocheme and Franquin 1967) for its agroclimatological survey of semi-arid areas in west Africa. Water balance approach has also been employed by some researches for the above purpose. From field experiments (Baier and Robertson 1966) it was found that the ratio of actual evapotranspiration to potential evapotranspiration can be used as an indicator of soil moisture availability. It was used for the survey of agricultural potential in north china (Yao 1969, 1974).

As stated earlier, water availability to plant growth and development is the single most crucial factor for optimisation of crop production in SAT. No particular moisture availability index is universally applicable. While selecting any particular classification schmes, one should evaluate the suitability of the scheme by comparing the information generated with the actual field data.

5. Agroecological zones:

In semi-arid tropics agriculture is complicated by erratic rainfall and ecological variability. Simple climatological analysis alone cannot provide sufficient information to determine the crops suitable to a place. It has been found that climatological analysis coupled with local ecological information helps in selection of agricultural technology suitable to a region. Therefore, highest priority will have to be given for identification and delineation of agroecological zones in SAT. F.A.O(1976) initiated the work on agroecological zones project with a view to preparing the production potentials of land resources in different countries. In Kenya agroecological zones were delineated (Relph and Horst 1982) based on probability of meeting the temperatures and water requirement of important crops. In this study, the yield expectation for leading crops is about 60 to 80% in the main ecological zone and lower yield expectation levels in marginal zones. The main zones are subdivided depending upon length of growing periods. Information on soil fertility, type, texture, depth, drainage, slope and salinity pertaining to each of the subzones is also provided.

6. Crop yield analysis:

Studies on the influence of weather parameters on crop development and yield are far from satisfactory. Research in this direction has to be intensified since it provides the necessary basis for statistical comparisons. Usually multivariate analysis is used to find relationships (Thomson 1969, 1970, Williams and Robertson 1964, IARS, 1977) between monthly or preferably weekly meteorological variables like rainfall, potential evapotranspiration, temperature during different growth stages and final yield of a crop. These models differ from region to region and from crop to crop. As such, similar models have to be developed for each agroclimatic zone in SAT. The information thus generated may be used as the basis for calculating the economic viability of the production of a crop.

Notwithstanding the fact that many advances have been made in the development of techniques useful for agro-ecological survey, lot more remains to be done. As pointed out earlier, no empirical or semi empirical indices should be employed blindly without checking their applicability to a region. If the existing indices are not suitable to the local conditions, appropriate modifications should be incorporated in developing the indices suitable to that place. Any violation of this principle could seriously affect the agricultural economy of a region. Finally, attention must be focussed on surveying and evaluation of the climatological and land resources of the semi-arid tropics at the meso level preferably taking taluk as an unit for which a regional agroclimatological atlas is a must. The atlas should give information on median rainfall values for short periods, number of rainy days, rainfall expected with fairly high probability, maximum and minimum temperatures, relative humidity, length of crop growing season, distribution of moist and humid periods, expected weather hazards, landuse and cropping pattern in different rainfall zones.

All this effort requires intensive study and preparation.

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