

Agro-ecological approach

to combat climate change impact

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The Observer Research Foundation report (2023) states that, "India, an emerging economy, ranks first among all G20 members in terms of overall climate performance, owing to its significantly low per capita contributions to carbon and GHG emissions; very limited share in legacy emissions relative to its population needs; least rate of per capita energy use; and significant efforts towards, not only preserving, but also expanding its climate-regulating land cover by 6% compared its 1992 levels. India has also done well in climate policy initiatives and limiting the unbridled expansion of climate-altering land cover." Such reports are generated with the help of: (a) baseline data from different systematically categorized regions/zones, (b) studies on how climatic aberrations affect agriculture, and (c) how such regions/zones respond to, and offset the effects of climate change.

Keywords: Agro-ecological region, Climate change, Sustainable agriculture

INDIA is characterized by heterogeneous landforms, climatic conditions and soil types. Combinations of these factors dictate the length of growing period and choice of crops. These factors have therefore contributed to the delineation of the entire country into relatively homogeneous regions, with a view to guide policy makers in formulating strategies to combat climate change and minimize its impact on agricultural production in the country through better understanding of soil, climate and crop interaction at different scales of planning. This led to the division of India into agroclimatic zones (Planning commission) and agro-ecological zones (ICAR-NBSS&LUP). Incidentally, the first agro-ecological region (AER) map of India was published in 1992. This article discusses the evolution of agro-ecological zonation, how the AER boundaries have changed over the years, and how India is improving its understandings of the operative parameters that are impacting our livelihood.

Agro-ecological zonation in India

India's dependence on monsoon for agriculture and hence food security is well known. Further, the adaptability to monsoon behaviour is often limited by typically smaller land holdings of resource-poor farmers making them highly vulnerable. Developing climate-resilient agriculture in the country is a formidable challenge to planners, technocrats and researchers alike. The target of producing about 455 million tonnes

of food grains in 2050 from the present level of about 323 million tonnes (Ministry of Agriculture 2023) is a frightful challenge for the country. Achieving this level of production is essential to nourish the estimated population of 1.6 billion in 2050. By then, the per capita land holding will go down to an abysmally low 0.087 ha, posing a serious concern. In 2050, cropland available for production may be reduced by 20% due to land degradation, urban expansion and conversion of cropland to non-food production.

To arrest land degradation and promote sustainable agriculture with multiple crops of high productivity, National Policy on Agriculture (NPA) recommended agro-ecological region-based agriculture planning. Several attempts have been made to classify the land area into climatic regions. FAO (1983) has given the concept of agro-climatic zones and agro-ecological regions. An agro-climatic zone is defined as a land unit that is uniform with respect to climate and length of growing period (LGP). It is suitable for a certain range of crops and cultivars. An agro-ecological region (AER) is characterized by distinct ecological responses to macro-climate as expressed in terms of vegetation, soils, fauna and aquatic systems. Therefore, an agro-ecological region is the land unit on the earth's surface carved out of the agro-climatic region by superimposing climate on landforms and soils, which are the modifiers of climate and LGP.

The first agro-ecological region map of the country was based on physiography, bio-climate and soils. Later, another agro-ecological region map of the country with similar parameters was prepared. Thus began the era of agro-ecological zoning in India. However, these maps suffered from several limitations due to excessive generalization. Areas of different physiographic divisions, temperature regimes and soils were placed in the same zone. Subramaniam (1983) divided the country into 29 agro-ecological zones based on the dominant soil groups (FAO/UNESCO 1974), however, adequate weightage was not given to the two very important parameters namely, physiography and bio-climate. In the absence of such important variables, the application of agro-ecological zones did not have practical relevance.

The Planning Commission divided the country into 15 broad agro-climatic zones based on physiography and climate (VII Plan 1985-90). The emphasis was on the development of resources and their optimum utilization in a sustainable manner within the framework of resource constraints and potentials. The State Agricultural Universities were advised to divide each zone/state into subzones, under the National Agricultural Research Project (NARP). Accordingly, the country was divided into 127 sub-zones, based on rainfall, existing cropping patterns and administrative units. Thus, the agro-climatic zones have a greater degree of commonality in the relevant basic features of soils, topography, climate, and water resources. However, in the climatic zonation of the country, neither adequate consideration was given to the soils and environmental conditions nor any uniform criteria adopted across the country. The use of the state as a unit for the subdivisions resulted in the placement of many divisions having the same agro-climatic characteristics in different states.

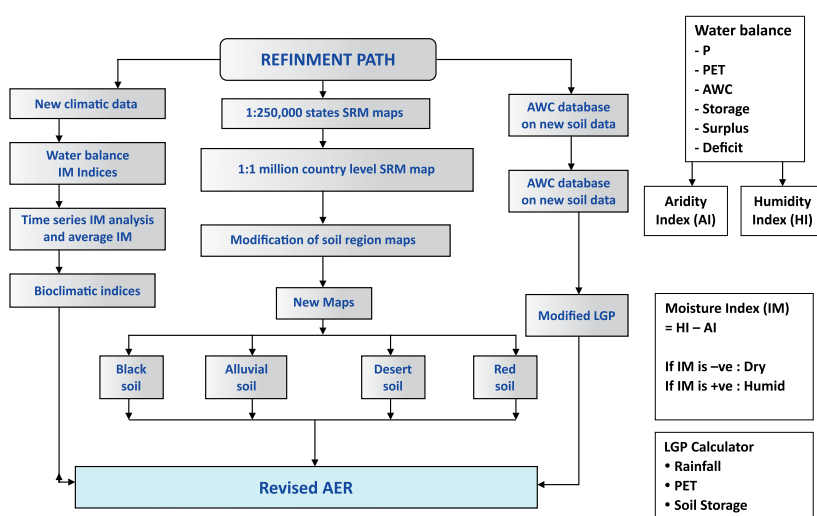
The agro-climatic regional planning approach was intended to take an integrated view of the agricultural economy concerning resource base and linkages with other sectors for future agricultural development. However, adequate weightage was not given to the natural resources that have to be protected from misuse, abuse and underuse. Therefore, the approach of the agro-ecological region was considered based on climatic conditions, length of growing period (LGP), landforms, and soils (NBSS&LUP 1992). The major advantage of LGP-based criteria is that it is a better indicator of moisture availability in soils as compare to the total rainfall. Crop planning, based on total rainfall, may be erroneous because the availability of moisture for crops is different on sandy and clayey soils with similar precipitation. Further, the use of Thornthwaites' moisture indices-based bioclimatic class portrays the average annual weather conditions of the zone. Within an agro-climatic region, several agro-ecoregions may result depending on soil-scape, LGP, and other environmental conditions, including flora and fauna.

Some agro-ecoregions with comparable broad climatic types are defined to represent agro-ecosystems. On the other hand, agro-ecoregions have been subdivided into different agro-ecological sub-regions by narrowing down the criteria of some parameters like LGP and bio-climate, and by introducing a few additional soil parameters such as texture, depth, and mineralogy. Therefore, agro-ecological region map is more precise and practical in developing future action plan invoicing crop diversification; transfer of on-farm research results, and agricultural technology to other analogous areas for optimizing land use.

The concept of agro-ecological region (AER) also helps to address agriculturally potential areas suitable for particular genotypes so that optimum production potential of a crop and cropping sequence could be attained. It is further useful in delineating agro-ecologically comparable resource regions for generating and transferring agro-technology to meet the country's ever-increasing food, fodder and fiber needs.

Revision of AER map of India

The revision of existing AER map of India was necessitated by the increased data availability. The continued efforts to enrich soil information through soil survey and acquisition of meteorological data through increased number of weather stations improved our understanding of soil-scape and their interaction with weather parameters. The revision was done in two steps. In the first step, a soil resource map of a 1:1 million scale was generalized in terms of red, black, alluvial and sandy soil regions. In the second step, LGP and bioclimate map were revised. Finally, bio-climate and LGP maps were superimposed on a generalized soil map for developing a revised agro-ecological region map of the country. In the AER map of 1992, a soil map of coarser resolution (1:7 M) was used. With the completion of soil resource mapping of the country on a 1:1 m scale (NBSS&LUP 2002), a refined soil map on finer resolution (1:250000) was published. The information on climatic parameters also changed geometrically since 1992. Therefore, the AER map of the country was re-delineated.



Methodology used for revising agro-ecological regions

Comparison of 1992 and 2015 AER maps: Impressions of changing climate

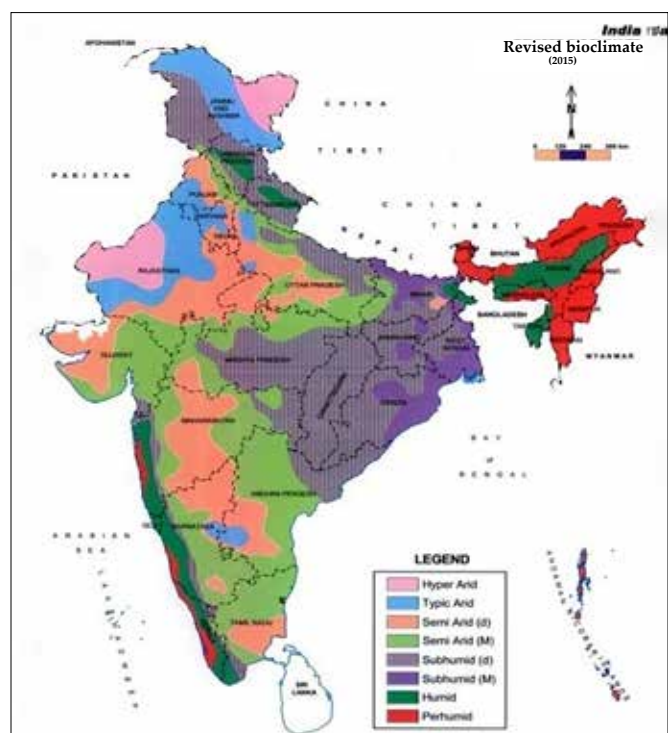
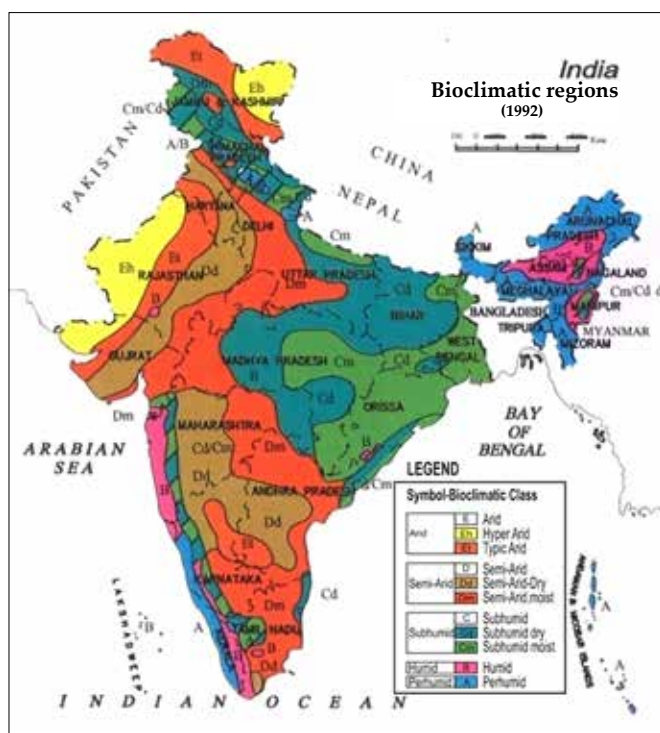
The present AER map divides the country into 20 agro-ecological regions. The first three regions (AER 1 to 3) cover arid ecosystems. In the year 1992, agro-ecological units 4 to 8 were assigned to cover the semi-arid ecosystem, whereas agro-ecological units 4 to 9 represent the semi-arid ecosystem in the revised edition of AER. In the year 1992, agro-ecological units 9 to 13 represented sub-humid agro-ecosystem, whereas agro-ecological units 10 to 15 represent this region in the AER map of 2015. Agro-ecological units 14 to 17 were defined per humid agro-ecosystem in the year 1992, whereas in the revised AER map, agro-ecological units 16 to 18 cover this region. Agro-ecological unit 20 represented exclusively island agro-ecosystem in 1992, whereas in the revised edition, island agroecosystem is merged with the coastal agro-ecological units 19 and 20. Agro-ecological units 18 and 19 in the earlier map exclusively represented coastal agroecosystem. In the revised edition, the east and west coast of India are covered under agro-ecological units 19 and 20 respectively. The revised map of AER with a finer resolution dataset sharpens the extent and area of different ecosystems prevailing in the country. The areas under arid and semi-arid agro-ecosystems are revised from 53.2 to 45.0 and 116.4 to 145.3 million hectares respectively.

Change in the area of arid agro-ecosystem is attributed to the development of water resources through irrigation projects, whereas scarcity of water to raise the second crop in the rainfed areas of Uttar Pradesh, Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh, and Telangana is discernible from the area under delineated semi-arid agro-ecosystem. Similarly, the scarcity of water for raising the second crop in the states of Jharkhand,

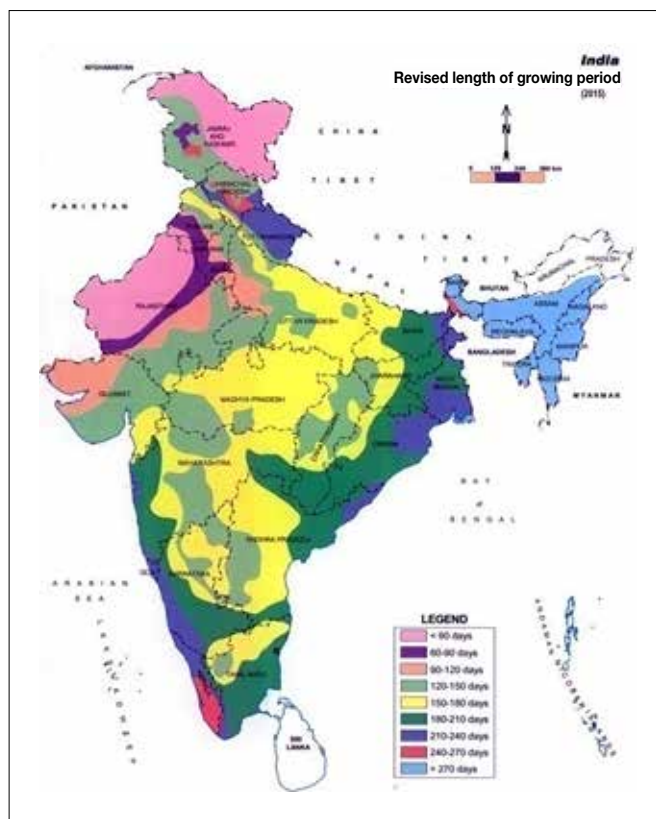
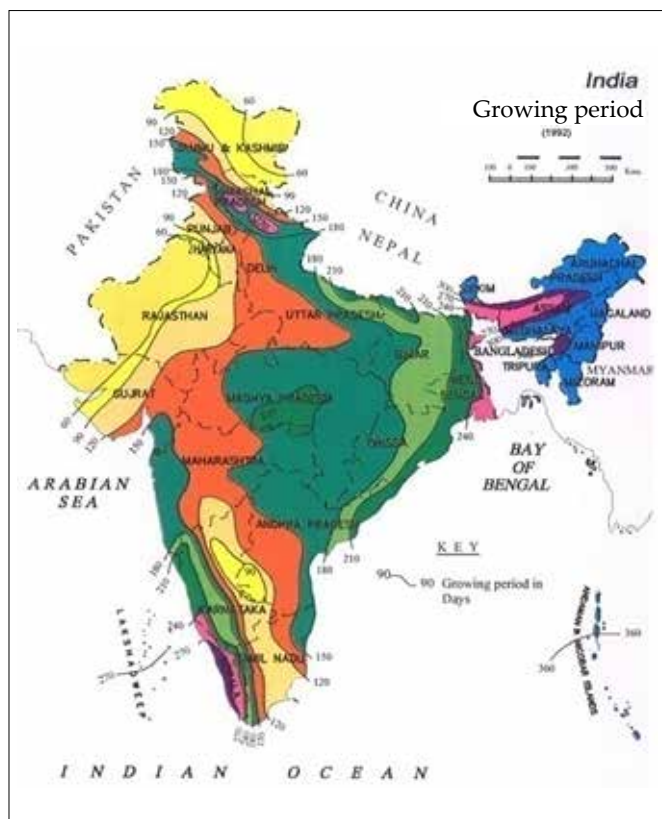


Agro-ecological map of India

Odisha, Bihar, Chhattisgarh and Maharashtra could be observed from the revision of extent and area in the sub-humid agro-ecosystem category from 105.7 to 89.6 million hectares. The changes have also been made in the extent and area of humid, per humid ecosystem



Bio-climate maps (1992 and 2015) of India



Length of growing period maps (1992 and 2015) of India

from 32.4 to 28.5 million hectares. On comparing the bio-climate type, a component of AER maps of 1992 and 2015, it is noted that, the area under hyper-arid category changed from 9.9 mha (3.0% of TGA) to 6.6 mha (2.0% of TGA) and the area under sub-humid moist category changed from 72.4 mha, (22.0 % of TGA) to 13.2 mha (4.0% of TGA). The revision also estimated an increase in the area under the semi-arid moist category from 78.9 mha (24.0% TGA) to 98.6 (30.0% of TGA) and sub-humid dry 42.8 mha, (13.0 % of TGA) to 78.9 mha (24.0% of TGA). Similarly, the area under the humid and per-humid categories is revised from 32.9 and 52.6 mha to 16.5 and 39.5 mha, respectively. The semi-arid (dry) areas have been modified from 26.3 mha to 49.4 mha.

Shift in the area and extent of bio-climate type and the LGP classes may be ascribed partly to the climatic aberrations, particularly in the pattern and the amount of rainfall in recent years. These have been noted from the increasing incidence of dry spells, late-onset and early withdrawal of monsoon, and cyclones of varying intensities. Shifts in the extent and area of bio-climate and LGP are also partially attributed to the development of irrigation facilities under the state-run watershed development programme and irrigation projects. The extent and severity of land degradation such as salinity, sodicity, nutrient depletion, multi-nutrient deficiency, and acidity may be the other reasons for the shift in AER parameters.

Similarly, on comparison of revised map of LGP classes of 2015 (another component of AER) with that of 1992, it is observed that the area under LGP <60 days is

revised from 16.5 to 29.6 mha and the area under LGP class of 60–90 days belonging to the western Rajasthan, arid part of Gujarat and Ladakh region of Jammu and Kashmir is modified from 16.4 to 9.9 mha. The area under LGP class of 120–150, 150–180 and 180–210 days belonging to the states of Maharashtra, Madhya Pradesh, Uttar Pradesh, Telangana and Karnataka is also revised. The area under LGP class of 210–240 covering the Western Ghats of Kerala, Karnataka, Maharashtra and Uttarakhand state is revised from 6.6 to 26.3 mha. The area in LGP class of 240–270 and >270 days encompassing the western part of Assam and the eastern part of West Bengal is also altered from 9.9 to 6.6 mha and from 13.2 to 23.0 mha, respectively.

SUMMARY

Owing to the revision, the AER map is now closer to the ground reality as compared to the previous one. It is expected that the map would be more useful in defining crop-specific zones and in undertaking alternate land use planning in the changing scenario of demography and climate. It has greater relevance and practical utility in developing future action plans involving crop diversification, upscaling of on-farm research results, extension of agricultural technologies and overcoming challenges of sustainable land use to maintain food security under climate change scenario.

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