Frequently Asked Questions
Global Agro-Ecological Zoning version 4

Version 2.0 (November 2022)

1. What is AEZ about?

The term AEZ refers to the Agro-Ecological Zones system and methodology. The approach enables rational land-use planning on the basis of an inventory of land resources and a spatially detailed evaluation of their biophysical limitations and potentials for crop production. The AEZ programs utilize the land resources inventory to assess a wide range of agricultural land-use options and to quantify expected production of cropping activities relevant in a particular agro-ecological context, for specified management conditions and levels of inputs. The characterization of land resources includes all relevant components of climate, soils and landform, which are essential for the supply of water, energy, nutrients and physical support to plants.

2. What does GAEZ v4 provide?

GAEZ provides a standardized framework for the characterization of climate, soil and terrain conditions relevant to agricultural production. It identifies crop-specific limitations of climate, soil and terrain resources in a consistent and empirically founded way. It systematically computes spatial and temporal data on maximum attainable crop yields, determines best performing crop types and crop calendars, and estimates sustainable agricultural production potentials at different specified levels of inputs and management conditions. The GAEZ computations were completed for a range of climatic conditions, including historical reference periods (average of period 1961-1990, 1971-2000 and 1981-2010), and a selection of future climate simulations using recent IPCC AR5 Earth System Model (ESM) outputs for four Representative Concentration Pathways (RCPs). Hence, the GAEZ results consistently quantify impacts on land productivity of historical climate conditions as well as of potential future climate change.

3. Who are the users of GAEZ outputs?

The GAEZ mapped and tabulated outputs provide comprehensive information relevant for planning and decision-making. The results are of particular interest to national and international organizations dealing with aspects of agriculture, land and water resources, food security, agricultural development and policies, or with climate variability and climate change. GAEZ outputs and procedures can be beneficially applied for teaching and research, enabling comparative regional analyses and promoting an enhanced level of resource literacy.

4. What are the different themes available on GAEZ v4?

The GAEZ v4 Data Portal provide access to many of the outputs generated by GAEZ. It includes more than 150 variables organized hierarchically by six main themes and 25 sub-themes. The six main themes in GAEZ v4 include: (1) Land and Water Resources, (2) Agro-climatic Resources, (3) Agro-climatic Potential Yield, (4) Suitability and Attainable Yield, (5) Actual Yields and Production, and (6) Yield and Production Gaps.

5. What's new in GAEZ v4 in comparison with GAEZ v3?

The current Global AEZ (GAEZ v4) provides a further update of data and extension of the methodology compared to the release of GAEZ v3 (Fischer *et al*., 2012). The GAEZ v4 update includes 2010 baseline data (compared to a baseline of 2000 in v3) comprising statistical data of 2009-2011 and up-to-date spatial representations of land cover, protected areas and areas of high biodiversity value as well as climatic conditions using a time series of historical data of 1961-2010 and a selection of future climate simulations derived from recent IPCC AR5 Earth System Model (ESM) outputs for four Representative Concentration Pathways (RCPs), which have been used instead of the SRES-based climate scenarios assessed in GAEZ v3.

6. What is the difference between Theme 3 (Agro-climatic Potential Yield) and Theme 4 (Suitability and Attainable Yield)?

Theme 3, Agro-climatic Potential Yield, provides crop-wise information about potential biomass and yield and related crop cycle attributes, calculated using an eco-physiological crop growth model and spatially detailed climate characteristics (radiation, temperature and precipitation) during different crop development stages. Growth cycle attributes include the day of crop emergence (i.e., start of crop cycle), duration of crop cycle from emergence to full maturity, crop-specific actual evapotranspiration, accumulated temperature sums and water deficits/net irrigation requirements during the crop growth cycle. Results account for temperature limitations and moisture constraints that are affecting crop growth and development and include yield reducing effects due to pests, diseases and weeds as well as climate related workability constraints. Note that possible reductions due to site-specific soil and terrain conditions are not taken into account in the agro-climatic potential yield estimates of Theme 3.

Theme 4, Suitability and Attainable Yield, presents results of the final step in the GAEZ crop suitability and productivity assessment, combining agro-climatic potential yields with the results of soil/terrain evaluation. GAEZ determines for each grid cell of the resource inventory the respective make-up of land units in terms of soil types and slope classes and applies yield reduction factors due to the constraints induced by soil limitations and prevailing terrain-slope conditions.

7. Where to find the list of data available in the GAEZ v4 Data Portal?

The complete list of themes, sub-themes and variables available through the GAEZ v4 Data Portal is provided in of the GAEZ v4 Users's Guide and in a separate Excel file that can be downloaded from the Supporting Documentation webpage of the GAEZ v4 Data Portal.

8. How to download information from the GAEZ v4 Data Portal?

Users can access and download the data through the Data Access webpage of the GAEZ v4 Data Portal, or by clicking directly on the buttons "Access the Data" from the GAEZ Themes webpage.

The GAEZ v4 datasets have been published as ArcGIS Image Services, dynamic web services that allow for visualization, analysis and extraction of raster-based datasets. For each thematic area a corresponding Image Service URL is provided. Each image available through these Image Services includes an attribute that gives an URL where the original .TIF file can be downloaded.

To download single raster dataset, use the Data Viewer to filter down to an image of interest and then select a pixel on the map - the popup window will provide a download link to the raw .TIF file for that image.

Alternately, to download a selection of rasters of the same theme, use the attribute table widget of the Data Viewer. To activate the tool click on the "Open in Full Screen" button on the upper right corner of the map display, proceed with the selection using the filters and then select the option "Export all as CSV" in the Attribute Table widget. The attribute table lists all the rasters and display attribute columns, including the download URLs. The URLs can be used with the command *curl* in a .bat file to automatically download in batch a series of rasters (e.g. *curl –k* [URL of the GAEZ raster layer] *–o* [output directory]).

In addition, for some selected themes, it is possible to download all the rasters included in the theme by clicking the corresponding link of the table published on the Data Access webpage of the GAEZ v4 Data Portal.

9. Where to find examples on how to use the GAEZ v4 data?

A number of global analyses as well as case studies for different countries have been produced using the AEZ system and data. Examples are available and can be downloaded from the Supporting Documentation webpage.

10. What are the different climate models and which RCP to be selected when searching for data projection?

IPCC AR5 climate model outputs for four Representative Concentration Pathways (RCPs) are used to characterize a range of possible future climate distortions included in the agro-

climatic resources inventory and crop potential assessments for the 2020's (period 2011-2040), the 2050's (period 2041-2070) and the 2080's (period 2070-2099).

RCPs define dynamic greenhouse gas concentrations trajectories developed for the climate modelling community as a basis for long-term and near-term modelling experiments adopted by the IPCC for its fifth Assessment Report (AR5). The four RCPs used in GAEZ v4 together span the range of year 2100 radiative forcing values found in the open literature. The four RCPs – RCP2.6, RCP4.5, RCP6, and RCP8.5 – are named after a possible level of radiative forcing values in the year 2100 (2.6, 4.5, 6.0, and 8.5 W/m^2, respectively). Development of RCPs has been completed by an international team of scientists and these pathways are documented in a special issue of Climatic Change (van Vuuren *et al.*, 2011). Climate model simulations based on the four RCPs were undertaken as part of the Coupled Model Intercomparison Project Phase 5 (CMIP5) (Taylor, Stouffer and Meehl, undated).

GAEZ v4 applies data which were bias-corrected and downscaled to 0.5 degree in the Intersectoral Impact Model Intercomparison Project (ISI-MIP) (Hempel et al., 2013). ISI-MIP data at half-degree resolution of five climate models (GFDL-ESM2M, HadGEM2-ES, IPSL-CM5A-LR, MIROC-ESM-CHEM, NorESM1-M) and for four RCPs (RCP 2.6, 4.5, 6.0 and 8.5) - totaling 20 combinations of respectively RCPs and climate models.

11. Does GAEZ account for socio-economic conditions?

Socioeconomic needs are the main driving force in the allocation of land resources to various kinds of uses, with food production as the primary land use. Population pressure and the related increased competition by different types of land users have emphasized the need for more effective land-use planning and policies. Rational and sustainable land use is an issue of great concern for preserving the land resources for the benefit of present and future populations. Land use is largely conditioned by environmental factors such as climate, topography, bio-diversity and soil characteristics, and determined by demographic, socioeconomic, institutional and political factors, such as education, poverty, land tenure systems, markets, and agricultural policies. Global AEZ makes only partial use of socioeconomic information which is limited to the specification of modes and purpose of agricultural production, the quantification of levels of inputs and management, the reliance on current land use information and protected areas, the inclusion of agricultural prices and the consideration of population numbers and distribution..

12. Do the GAEZ estimates account for production sustainability?

The environmental sustainability of cropping is accounted for in AEZ. Sustainable agricultural production of land is concerned with preventing erosion of topsoil and decline of fertility. Usually this is achieved by combining special crop management and soil conservation measures. In the short term, cultivation of steep slopes might lead to yield reductions due to loss of applied fertilizer and fertile topsoil. In the long term, this will result in losses of land productivity due to truncation of the soil profile and consequently reduction of natural soil fertility and of available soil moisture. Therefore, in the Global AEZ model steep slopes are

declared unsuitable by setting slope limits depending on rainfall intensity and land utilization type. Furthermore, many soils, in their natural state, in particular in the tropics, cannot be continuously cultivated without undergoing degradation. A decrease in crop yields and a deterioration of soil structure mark such degradation of nutrient status and other physical, chemical and biological attributes. Under traditional low input farming systems, this deterioration is kept in check by alternating some years of cultivation with periods of fallow. In Global AEZ, therefore, depending on climate and soil conditions, crop type grown, and inputs applied, appropriate fallow factors are imposed to ensure maintenance of soil fertility.

13. How robust are the Global AEZ results?

Various modes have been pursued for 'ground-truthing' and verifying results of the Global AEZ suitability analysis. Apart from consulting expert knowledge and agricultural research institutes, results have been compared with available research data and agricultural statistics. Where more detailed and compatible resource inventories are available from regional and national studies, these have been used for comparison. Nevertheless, global data sets used as inputs to AEZ are known to be of uneven quality and reliability. Hence, the results obtained from this Global AEZ study should be treated in a conservative manner at appropriate aggregation levels, which are commensurate with the resolution of basic data and the scale of the study.

14. Which crops are considered in GAEZ v4?

Suitability and potential yield are provided for some 53 crops and were generated by assessing more than 300 crop/LUTs (see Appendix 4-1, Table A4-1.2 and Table A4-1.3 of the GAEZ v4 Model Documentation). Most crops in GAEZ v4 are represented by several different Land Utilization Types (LUTs), where a LUT comprises technical specifications for crop production within a given socioeconomic setting. Attributes specific to each LUT include crop information such as crop parameters (crop growth cycle duration, harvest index, maximum leaf area index, maximum rate of photosynthesis, etc.), cultivation practices and input requirements, and utilization of main produce, crop residues and by-products. For each LUT, the GAEZ procedures are applied in all land separately for rain-fed and irrigated conditions.

The GAEZ crop list is fairly comprehensive for cereals (11 crops comprising of 108 LUTs), roots and tubers (5 crops based on 19 LUTs), sugar cops (2 crops and 8 LUTs), pulses (6 crops comprising of 35 LUTs) and major oil crops (6 crops comprising of 28 LUTs). The coverage is less complete for the wide range of existing annual and perennial fruits and the large variety of vegetables.

Results of downscaling statistical area, production and yield include all reported crop production of respectively 1999-2001 and 2009-2011 and are available in terms of 26 crops or crop groups (see Table A4-1.4 of the GAEZ v4 Model Documentation).

15. What are the Crop Summary Tables about?

GAEZ information stored for 5 arc-minute grid cells contains distributions resulting from the separate sub-grid evaluations of the respective make-up of land units in terms of 30 arc-seconds soil types and slope classes. Crop summary tables make full use of all sub-grid data and provide standardized information for each crop by administrative units (country or sub-national units for some major countries, and by sub-continental and continental regional aggregations) and by broad hydro-regions. The comprehensive tables are organized by land cover class, protection/exclusion class and AEZ class and summarize by suitability class the suitable extents, attainable production and yields, various constraint factors (due to thermal regime, moisture deficits, agro-climatic constraints due to pest, disease and workability limitations, and due to soil/terrain limitations) and aggregate simulated water deficits (rain-fed conditions) respectively net irrigation requirements (irrigated conditions).

Crop summary tables are provided for 53 crops, separately for rain-fed and irrigated conditions, and for historical and future climate scenarios. For 12 major countries, summary statistic were prepared also at sub-national level. Those countries have been selected based on their ranking in terms of three criteria: (i) total country area, (ii) total cropland area, and (iii) average size of sub-national administrative units.

16. What are the limitations on the creation of statistics tables?

The computation of statistical data from the 5 arc-minutes thematic raster datasets is limited by certain inaccuracies associated with the resolution of the source data and the raster representation of administrative units. The attribution and aggregation of grid cells, even though internally consistent and robust, has some limitations such as the method of assigning a pixel to different units. The current version applies shares of up to 4 different units (based on the occurrence of 30 arc-second pixel within a 5 arc-minute grid cell) to assign results to different administrative units. Results of grid cells from formally recognized disputed territories are not included in national level accounts but are contained in the regional totals as defined by various GAEZ regionalizations. The GAEZ v4 results are considered to be representative for national, regional, continental and global assessments as well as for a limited number of countries and territories at the first sub-national level. It is generally not recommended to calculate statistics at finer administrative levels with this version of the database.

17. Which legend render should be used when visualizing a map in the Data Viewer?

To visualize the layer with the correct symbology, a set of corresponding renderer is available through the drop-down list of the Renderer/Palette panel in the Data Viewer. The recommended Renderer is also listed in the pop-up window that is shown by clicking on the map. Each raster provides guidance on which renderer is appropriate for the data.

The complete set of symbologies to adopt for the correct visualization of the GAEZ data can be downloaded from the Supporting Documentation webpage, see also the User's Guide for details on this.

18. Where to find the description of each layer?

In the Data Viewer, a description of the layer can be found in the pop-up window that appears when the user clicks on the map after filtering the data. The pop-up window shows the names of the file, sub-theme and variable selected and information for the map layer displayed on each of the dimension variables filtered. It gives also a brief description, information about the data unit, the recommended renderer and the pixel value at the selected location.

19. How to look for a specific dataset?

From the Supporting Documentation webpage is possible to download the complete list of themes, sub-themes and variables provided in the GAEZ v4 Data Portal.

Also, the Attribute Table widget in the Data Viewer assists the user in filtering the data within a specific theme using different expressions (see the User's Guide for details on the use of this specific tool).

20. How should the GAEZ v4 data be cited?

The recommended citation for the GAEZ v4 Data should be: FAO and IIASA. Global Agro Ecological Zones version 4 (GAEZ v4). [Date accessed and/or downloaded]Accessed DATE. URL: http://www.fao.org/gaez/

21. What are known limitations in GAEZ v4?

Many spatial datasets used in GAEZ v4 have been updated and improved in resolution and accuracy compared with previous GAEZ v3. The GAEZ results make use of 5 arc-minutes latitude/longitude climate data based on historical half-degree world climate data sets and various Earth System model future climate projections, 30 arc-seconds data for soils and soil attributes from the Harmonized World Soil Database (HWSD v1.21), land cover shares of the GLC-Share v1.1 Database, 30 arc-second representations of protected areas, key biodiversity areas and wetlands, and 3 arc-seconds digital elevation and terrain slopes data sets. While representing the most recent global data compilations at the time when GAEZ v4 computations were performed, the quality and reliability of these data sets are known to be uneven across regions. The quality of the world soil map, in particular, is reason for concern. Accurate and detailed soil information is crucial for reliable GAEZ estimates and a major update and further refinement of soil information would be desirable and seems possible if international partners would be willing to cooperate and provide best available soil data of their regions..

Land degradation in its multiple aspects, including crucial elements such as soil degradation (soil erosion, contamination, compaction, nutrient depletion, and biodiversity loss), vegetation

degradation, and water resources decline in quality and quantity, are not or only partially taken into account. They obviously influence sustainable yield and production capacities and a more thorough treatment of these factors would be desirable.

Global AEZ makes only partial use of socioeconomic information which is limited to the specification of modes and purpose of agricultural production, the quantification of levels of inputs and management, the reliance on current land use information and protected areas, the inclusion of agricultural prices and the consideration of population numbers and distribution.

The agronomic data, such as the data on environmental requirements for some crops, contain generalizations necessary for global applications. In particular, assumptions on occurrence and severity of some agro-climate related constraints to crop production would benefit from additional verification and data.

Land has many important functions. GAEZ outputs emphasize the suitability of land for crop production. The need to plan for more and better food supplies, from less resources and with less environmental impacts, will have to continue with high priority in the next decades. Current GAEZ respects land marked by protection/exclusion status or with recognized biodiversity value by using an 'exclusion' layer compiled from up-to-date and reliable international datasets. Integration of supplementary modules to quantify additional ecosystem services within the GAEZ framework would be desirable.

For the above reasons, the results obtained from this GAEZ study should be treated in a conservative manner at appropriate aggregation levels, which are commensurate with the resolution of the basic data and the global scale of the study. While various modes have been pursued for "ground-truthing" and verifying results of the GAEZ suitability analysis with available statistical data and research data in a number of national studies, there is nonetheless a need for further validation of results and underlying databases.