Frequently Asked Questions (FAQ)

What is GAEZ about?

The term GAEZ refers to the Agro-Ecological Zones system, developed by the Food and Agriculture Organization of the United Nations (FAO) in collaboration with the International Institute for Applied Systems Analysis (IIASA). The approach enables rational land-use planning on the basis of an inventory of land resources and an evaluation of their biophysical limitations and potentials for crop production. The GAEZ programs utilize the land resources inventory to assess all feasible 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 basic for the supply of water, energy, nutrients and physical support to plants.

What does GAEZ 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 potential and attainable crop yields as well as expected 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 a reference climate (average of period 1961-1990), individual historical years of 1901 to 2009 (climate data for individual years for the period 1960-2000 are uploaded in GAEZ v3.0 Data Portal) and future climate based on the published outputs of various global and regional climate models combined with IPCC scenarios. Hence, the GAEZ results consistently quantify impacts on land productivity of historical climate variability as well as of potential future climate change.

Does GAEZ accounts for socio-economic conditions?

Socioeconomic needs of rapidly increasing and wealthier populations are the main driving force in the allocation of land resources to various kinds of uses, with food production as the primary land use. Heavy 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. GAEZ uses socioeconomic information for defining the input-output relationships under which individual crops are assumed to be grown. Such 'packages' are referred as land utilization types. Their evaluation results in a database of viable land use options.

What questions can be answered by GAEZ?

GAEZ can assist to answer a number of questions including:

- Will there be sufficient land for agricultural production to meet the food and fibre requirements of future populations?
- Will there be sufficient renewable water resources for irrigated agricultural?
- What is the potential benefit (contribution to combatting local food insecurity) of widespread application water conservation techniques in semi-arid and arid areas for agricultural production?
- What and where are main soil, terrain and climate related constraints to agricultural production? If at all possible, how can these constraints be overcome?
- How much cultivated and pasture land is required for ruminant livestock grazing and feeding monogastric livestock?
- Will global warming affect agricultural potentials? Where will climate change affect agricultural production potentials? And by how much?
- Where do significant yield and production gaps occur, what is nature of these gaps and how can they be overcome?
- What can conservation agriculture in combination with precision farming contribute to food security and food diversification?
- Considering human and livestock food feed and fibre requirements is there room for bio-energy feedstocks without affecting bio-diversity, nature conservation by avoiding the use of highly biodiversity areas, protected areas and forested areas?

Apart from assessments related to agricultural production potentials, what else can GAEZ do?

Beyond the traditional use of GAEZ for mapping and quantifying crop production potentials; there are several recent applications where GAEZ or outputs from GAEZ analysis have been used for environmental and economic assessments.

- **GAEZ and potentials of fodder and grassland**: Among the total of 280 land utilization types implemented in GAEZ, there are 14 types concerned with fodder and grass production (six types of silage maize, 2 types of alfalfa, and six generic types of grasses and pasture legumes). The methodology also includes crop coefficients for quantifying crop residues (e.g., straw) and by-products (e.g., bran from cereals or cakes from processing of oilseeds) potentially available for animal feeding. Together these can provide comprehensive information to assessments of livestock potentials as well as of regional biomass potentials from crop and grassland sources for energy uses.
- **GAEZ and land evaluation for forestry**: With an increased emphasis on multiple use forestry, agro-forestry, on forest as renewable energy source, and on the role of forests in global CO2 balances, the scope of quantitative land evaluation for forestry is widening. (A GAEZ companion model has been developed for assessing of productivity of boreal and temperate forest tree species; model expansion with tropical tree species LUTs is foreseen).
- **GAEZ** employs flexible sequential downscaling procedures, based on iterative rebalancing method. These procedures are used to estimate spatial distributions from aggregate agricultural statistics and to produce 5 arc-minute resolution global inventories of actual harvested area, yield and production for major crops/commodities.

- **GAEZ** provides estimates of apparent yield and production gaps. These have been estimated by comparing potential attainable yields and production and actual yields and production derived from downscaling of statistics of main food and fibre crops. The 'yield gap analysis' provides at 5 arc-minute resolution locations with apparent yield and production gaps for major crops/commodities.
- **GAEZ linkage to economic modelling**: The GAEZ land productivity assessment conducted at IIASA provides a multifaceted environmental characterization of land with regard to agricultural uses. Key objectives for its development included the compilation of geographically explicit information that could be embedded within an economic model, to provide a biophysical basis for the estimation of spatially explicit agricultural production relations, and to allow consistent linkage to the modelling of the water sector, in particular the demand for irrigation water. Agricultural production in this economic model is co-determined by the biophysical potential of land, and by the level of factor inputs (*in terms of nutrients and power*). Potential output is based on results generated by the GAEZ model. The rationale behind this specification is that the observed actual crop output level represents a certain fraction of the biophysical potential.
- **GAEZ and Land Resources Information Management System**: LRIMS is an ArcGIS extension developed by FAO based on the GAEZ methodology for application at national and regional level. In addition FAO has developed a suite of tools to assist with the implementation of the GAEZ methodology, crop growth, crop yield forecasting such as AgroMetShell, CROPWAT, AQUACROP as well as other in-house tools.

Who are the users of GAEZ outputs?

The GAEZ provides comprehensive information relevant for decision-making. It is 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 analysis and promoting an enhanced level of resource literacy. National and sub-national applications of GAEZ may provide important components of land use planning. The evaluation of performance of alternative land utilization types facilitates land use planners and decision makers with options in dealing with utilization of land resources

What are the GAEZ limitations?

The GAEZ results are based on 30 arc-minutes latitude/longitude world climate data set for individual years and 10 arc-minutes for 1961-90 average climate, 30 arc-seconds soils data contained in the Harmonized World Soil Database (HWSD), 30 arc-seconds Global Land Cover Characteristics Database, and a 3 arc-seconds SRTM elevation data set. While representing the most recent global data compilations, the quality and reliability of these data sets are known to be uneven across regions. Reliability of the information contained in the database is variable: the parts of the database that still make use of the Soil Map of the World such as North America, Australia, West Africa and South Asia are considered less reliable, while most of the areas covered by SOTER databases are considered to have the highest reliability (Central and Southern Africa, Latin America and the Caribbean, Central and Eastern Europe). Further expansion and update of the HWSD is foreseen for the near future, notably with the excellent databases held in the USA, Canada, and

Australia. The land cover data used for GAEZ is derived from six data sets: GLC2000 land cover classifications (JRC 2006), IFPRI's agricultural extent database, the Global Forest Resources Assessment FRA2000 and FRA2005, the Digital Global Map of Irrigated Areas (vs 4.01), the IUCN-WCMC protected areas inventory (2009) and a spatial population density inventory for year 2000 which is based on LandscanTM (2003) Global Population Database calibrated to UN year 2000 population data. New higher resolution land cover and ancillary datasets will be used for land cover share estimations updates.

Socioeconomic needs of rapidly increasing and wealthier populations are the main driving force in the allocation of land resources to various kinds of uses, and socioeconomic considerations are crucial for rational planning of sustainable agricultural development. So far, in GAEZ, the use of socioeconomic information is limited spatial distribution of population spatial distribution of ruminant livestock and accessibility. Further socio-economic criteria are used in defining modes of production and the quantification of "input–output packages." The latter are referred to as LUTs, which are accounting for the socioeconomic context of production decisions and conditions.

Also 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, no doubt, benefit from additional verification and data. 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/reliability of the basic data and the scale of the study. While various modes have been pursued for "ground-truthing" and verifying results of the GAEZ suitability analysis, there is a need for further validation of results and underlying databases.

How reliable are GAEZ potential and actual yield and production estimates?

Potential yield and production

Various modes have been pursued for "ground-truthing" and verifying results of the GAEZ suitability analysis. Apart from consulting expert knowledge and agricultural research institutes, results have been systematically compared with research data and agricultural statistics. In particular the following activities have been conducted intensively by IIASA and staff of FAO's Economic and Social Department and its Agricultural Department.

• Confirmation of estimated potential crop distribution and yields against quantitative and qualitative occurrence of these crops in national and subnational agricultural statistics.

• Comparison of limits of AEZ potential crop distribution with limits to actual distribution of agricultural land (e.g., by comparison with spatial land use/land cover databases and crop distribution maps).

Various modules in GAEZ are from well tested origin such as (i) the estimation of crop water stress and related yield losses (CROPWAT), (ii) the robust biomass and yield calculation procedures (Kassam 1977) which have been applied tested and scrutinized in case studies in more than twenty countries and (iii) the agro-edaphic suitability procedures and results have benefitted of extensive verification with documented expert knowledge, resulting from numerous sub-national, national, regional and global AEZ assessments over the past three decades.

It should, however, be understood that in the light of improved knowledge, any part of the GAEZ suitability procedures and the model parameters will be scrutinized and may be subject to updating

by FAO and IIASA. Also, the model and model parameters are expected to benefit from refinement as a result of follow-up applications.

Actual yield and production

The reliability of the downscaled actual harvested areas, yields and production depends on quality of employed national and subnational statistics, the accuracy of the location of cultivated land and reliability of data to estimate crop distribution (the prior). Tests in China and Brazil by comparing downscaled results based on statistics available on national level, with detailed sub-national statistics on county and micro region level revealed strong correlations between downscaled national statistics and county/micro-region level statistics of harvested areas, yields and crop production.

What differences can be expected when comparing GAEZ pixel counts and official statistics?

It is known to be differences between GAEZ derived statistics and official FAOSTAT, CountrySTAT and national estimates when comparing area statistics at the country and territory, regional and global levels. Statistics generated by GAEZ are dependent upon pixel counting methodology. This methodology is normally biased when compared to the official estimates. Counting pixels and multiplying by the area of each pixel will result in biased area estimates and should be considered raw numbers needing bias correction. In addition area and territory definitions used in the Global Administrative Unit Level (GAUL) do not always match with the country definitions. This is known to add additional bias on the estimates. Official estimates at the national and regional level are available at FAOSTAT http://faostat.fao.org

How are the statistics tables created?

Statistics table are generated automatically generated by the system and provides aggregations over the pixel data according to the options selected. There are two types of tables for statistics. One table is used when the selected data consist of continuous grid cell values. The table includes the total area in each geographic unit of non-zero values of the selected output.

Map statistics over all non zero values including:

- sum - sum of all values
- min - minimum value of all values
- max - maximum value of all values
- range - values range
- mean - average value (NODATA pixels are not used in calculation)
- standard deviation (NODATA pixels are not used in calculation)

A second type of statistics table is used when the raster represent discrete data. The table provides aggregated table statistics indicating area coverage for each class. Area totals for each geographic unit and the percentage of each geographic unit in the total area selected are provided for reference as well.

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

The methodology used to derive the statistical data from the thematic raster datasets is limited by certain inaccuracies associated with the quality of the source data, as well as definitions used to describe the administrative units. The pixel count methodology even though internally consistent

and robust, has its own limitation such as the assignment of the share of the pixel to the unit. At the current version up to 4 levels of share (based on the spatial location of the 30 arc-second pixel inside the 5 arc-minute pixel are assigned to each administrative unit. Formally recognized disputed territories are not included to any other country at national level assessments. However, there are considered to the regions as defined by GAEZ regionalization. The results are considered to be representative for national, regional, continental and global assessments and for limited number of countries and territories at the first sub-national level only. It is generally not recommended to calculate statistics at finer administrative levels with this version of the database.