



## **GEOSS Ag 07 03 Discussion Paper**



**Global Earth Observation System of Systems  
Task on Global Agricultural Monitoring**

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## **ABOUT GEOSS**

The purpose of GEOSS is to achieve comprehensive, coordinated and sustained observations of the Earth system, in order to improve monitoring of the state of the Earth, increase understanding of Earth processes, and enhance prediction of the behavior of the Earth system. GEOSS will meet the need for timely, quality long-term global information as a basis for sound decision making in the field of food, water security, disasters and climate change. GEOSS will provide the overall conceptual and organizational framework to build towards integrated global Earth observations to meet user needs. GEOSS tasks include:

- Address the identified common user requirements
- Acquire observational data
- Process data into useful products
- Exchange, disseminate, and archive shared data, metadata and products; and
- Monitor performance against the defined requirements and intended benefits.

### **GEOSS TASK Ag 07 03**

There are nine Societal Benefit Areas (SBA) for international cooperation and collaboration. Agriculture is one of the Groups and aimed at improving food security through increased use of earth observation data. One of the main tasks under this SBA is Global Agricultural Monitoring (GEO Task AG 07-03). The purpose of this task is to support operational agricultural monitoring systems, enhancing the current capabilities in the areas of agricultural monitoring, famine early warning and food security. These include

- Global monitoring of agricultural production, facilitating reduction of risk and increased productivity at a range of scales.
- Timely and accurate national (sub-national) agricultural statistical reporting.
- Accurate forecasting of shortfalls in crop production and food supply.
- Effective early warning of famine, enabling a timely mobilization of an international response in food aid.
- Global mapping, monitoring and modeling of changes in agricultural type and distribution, in their social and ecological context (land-use changes).

## **Need**

Agriculture sustainability and food/nutritional security are the global concern to day. The reliable information on agricultural output is of paramount importance in the policy and decision-making exercise related to procurement, price stability, import/export, distribution etc. All crop-producing countries, therefore, have a critical need for accurate and up to date information. In many countries, there is no suitable infrastructure for the implementation of programs to monitor crop production. In some countries, gathering agricultural statistics is arbitrary and subjective. In some countries, these conventional methods for compiling crop statistics are time consuming and not available for timely decision. Many times the stakes in the absence of reliable information are quite high. Above all there is no uniformity of method, and often the results are not comparable across a region.

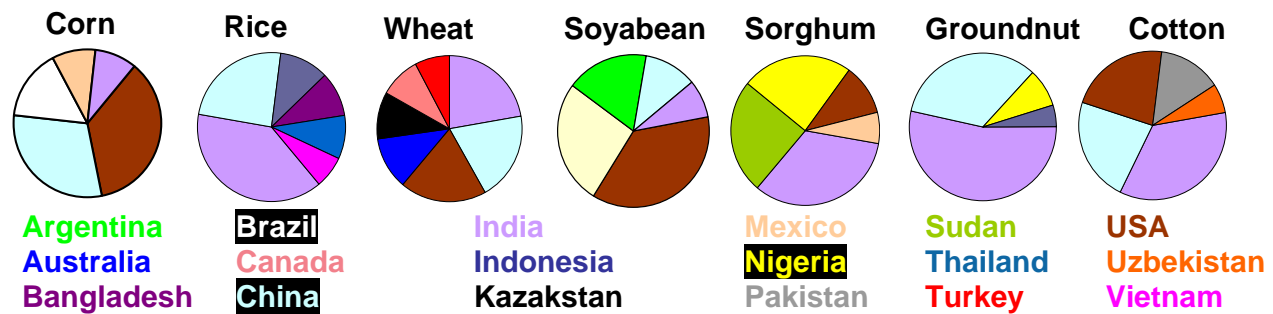
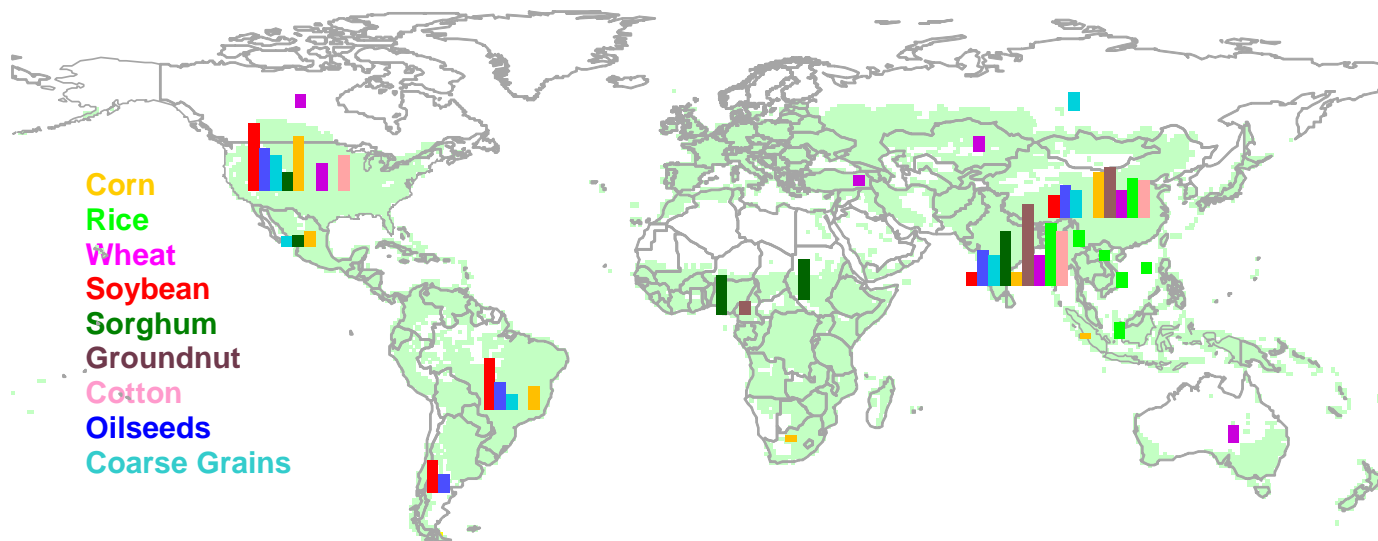
The location and extent of agricultural land is baseline information necessary for regional level assessments. This baseline information needs periodic updating to account for changes in agricultural land use. The need for spatially explicit data for large areas and its regular non-intermittent availability make remote sensing (RS) a highly viable option. Earth observations from sensors on board satellite platforms and in-situ ground based networks that provide direct information for monitoring agricultural system can provide timely information on crop production and yield in a standardized and regular fashion at national to international levels.

## **Global Cropping pattern**

In the global context, there are 6 major agricultural crop groups viz. cereals, oilseeds, pulses, fibers, sugar and tubers. Around 16 crops can be considered as significant viz: wheat, rice, maize, barley, *Sorghum*, millet, cotton, groundnut, rapeseed or canola, sunflower, soybeans, potato, cassava, sugarcane, sugar beet and pulses. Pulses are the most diverse category and include many types.

The most prevalent group of crops across the world is cereals. It is the dominant crop in all regions, except the Caribbean and central Africa, where, the dominant major crop is sugarcane and cassava, respectively. Among cereals, wheat is the dominant crop, occupying a little more than 20% of the total cultivated area in the world, followed by rice, maize and sorghum.

The distribution of these crops in the world varies according to the prevailing climate of the region. The major climate based agricultural regions can be described as Temperate, Tropical and sub-tropical regions.



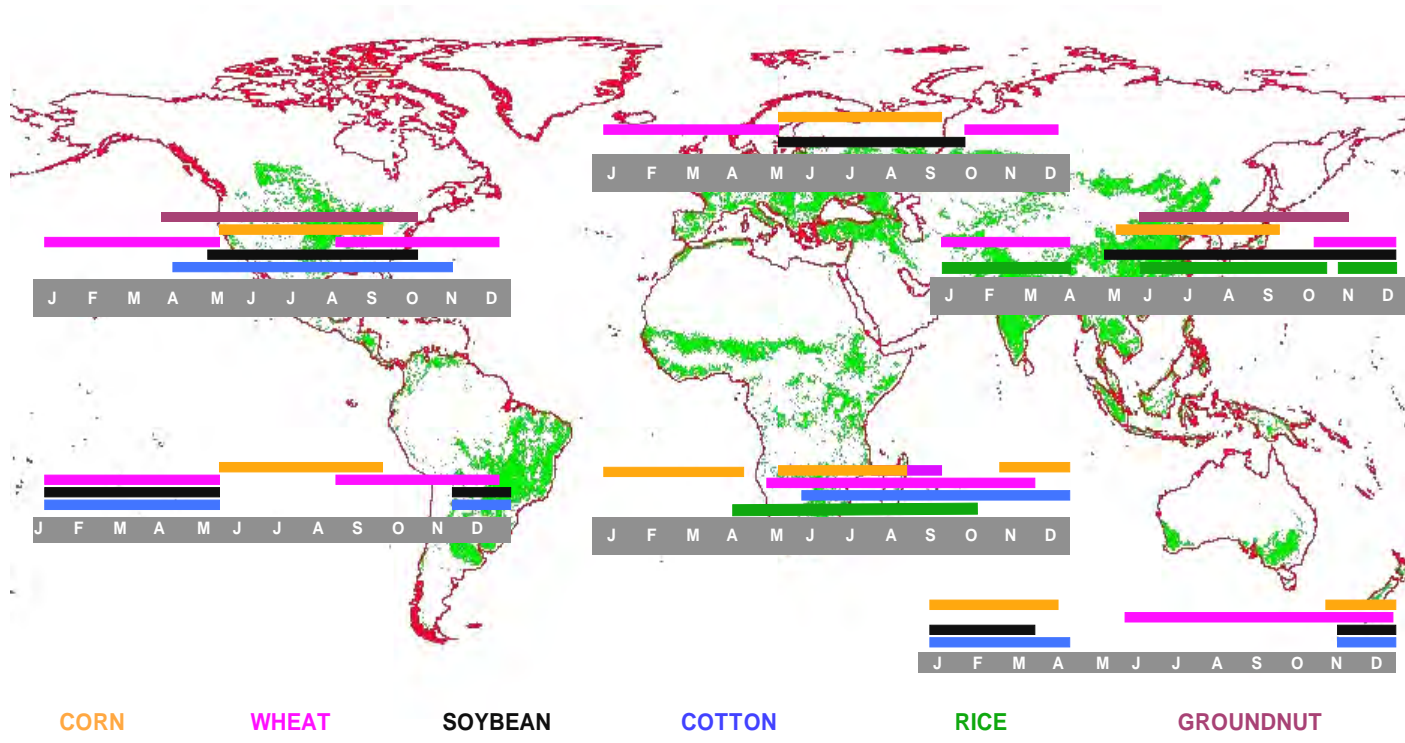
Contribution of different countries under relevant crops

## **Crop Calendar**

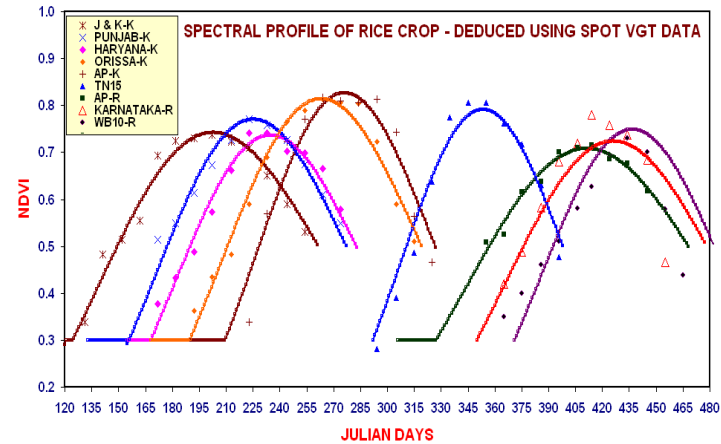
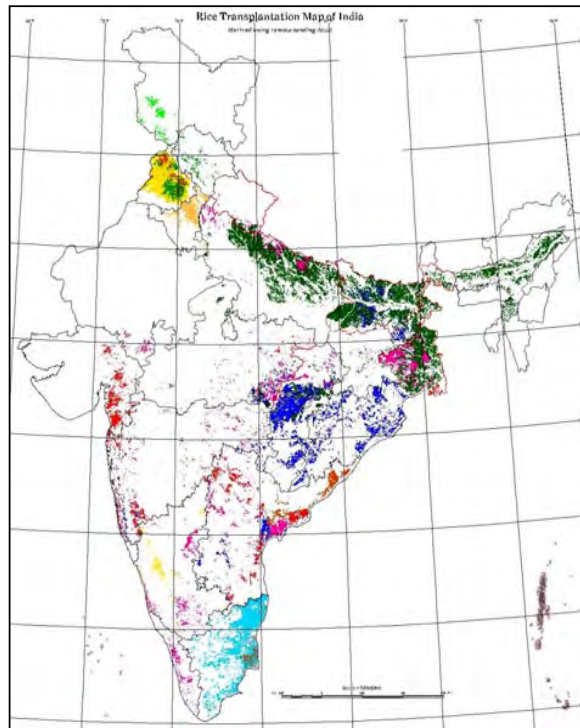
The growth calendar of the crops is controlled by climatic parameters; hence there is a wide variation in growth pattern of same crop across the continents/countries. Wheat is grown both in winter and spring season in temperate areas. Corn crop in temperate areas is sown in May-June and harvested by October-November, while in tropical areas it is sown in September-October and harvested by April-May. Cotton is sown in April-May and harvested in Sept-Oct. in parts of USA, and northern Brazil while in Southern Brazil, Argentina and Australia it is sown in October-November and harvested in April-May; in India, it is sown in June-July and harvested by November-December.

Soyabean is sown in April-May and harvested in August-September in temperate areas, while in tropical areas, it is sown in November-December and harvested in March-April, while in sub-tropical areas like India it is sown in June-July and harvested in September-October.

Rice is the dominant crop in Asian countries and is grown almost throughout the year, though the rainy season is the main season with a large diversity in crop varieties.



Crop calendar of major crops of the world – continent wise



Rice is the dominant crop in Asian countries with a large diversity of crop varieties (short, medium and long duration crops). Space based observations bring out this diversity of crop calendar very clearly as observed for the rainy season rice crop calendar in India that varies widely within the country.

**Wet season rice area in India and its growth calendar derived using temporal remote sensing data highlights the strength of space input in deriving spatial crop calendar.**

The distribution of these crops in the world varies according to the prevailing climate of the region. The major climate based agriculture can be described as in temperate, tropical and sub-tropical regions.

Temperate climatic region: This part of the globe comprises of Eurasia, Russia, China and USA. In this part, area under wheat cultivation occupies majority of the agriculture system followed by corn. Most of the region is sparsely populated with mechanized farming. This make the monitoring through remote sensing far simple compared to other climate regions.

Tropical climatic region: In countries of Africa, South America like Brazil, Argentina, Australia, winter wheat, soybean and corn are the major crops cultivated.

Sub-tropical climatic region: the Southeast Asian countries and the great Indian Sub-continent form the intensive cultivation region. Rice is the major crop cultivated throughout the year, though the monsoon period is the main season.

## **Field size and shape**

Field size is a very important aspect of agriculture. This is mainly controlled by topography, agroclimatic conditions, cropping pattern and land holding. In temperate countries, the average land holding varies from 7.5 hectares (ha) in Italy to 186 ha in USA. In tropical areas, the average land holdings vary from about 0.5 ha in Congo Basin, less than a hectare in African countries to about 65 ha in Brazil. In Sub-tropical area, the average land holdings vary from 0.9 ha in Nepal to 3.36 in Thailand. Satellite remote sensing based approach was used to take a number of sites over various continents and observe the field size. The results showed that the field size varied from 0.28 ha to more than 370 ha. Thus, there is an urgent requirement to study the field size and synthetic field size for different crops grown across the world, as that will provide vital information to define the requirement of sensors. Towards this, a sampling design has been made based on agricultural area distribution and concentration derived from satellite data. Even a three percent sample will amount to a number of sites for enumeration to arrive at a reasonably mean field size in different continents.



Kazakhstan

Field Size (Median) = 347.11 ha.



Saskatchewan-CANADA

Field Size (Median) = 63.38 ha.



India

Field Size (Median) < 1 ha

**Variation of field sizes measured from high resolution data (Courtesy: Google Earth™)**

Details of agriculture fraction based strata of the world at 15' X 15' grid level using square-root method

15'X15' Strata	Range (%)	No. of grids	Percent of grid	Avg	Std. Dev	CV
X	0	183879	61.4	0	0	
E	0-10	35344	11.8	4.1	2.9	70.73
D	10-30	26685	8.9	19.6	5.8	29.59
C	30-50	17466	5.8	40.1	5.8	14.46
B	50-75	16926	5.7	62.7	7.3	11.64
A	75-100	19124	6.4	89.1	7.3	8.19



Santa Cruz



South Africa

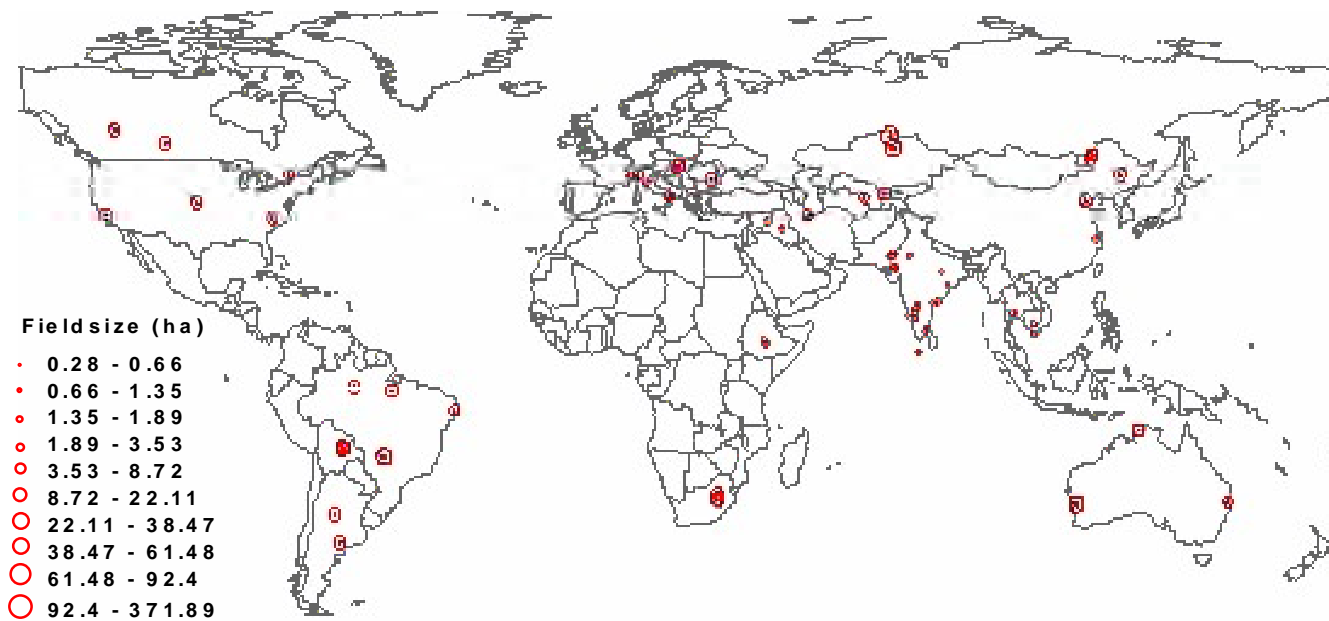


China



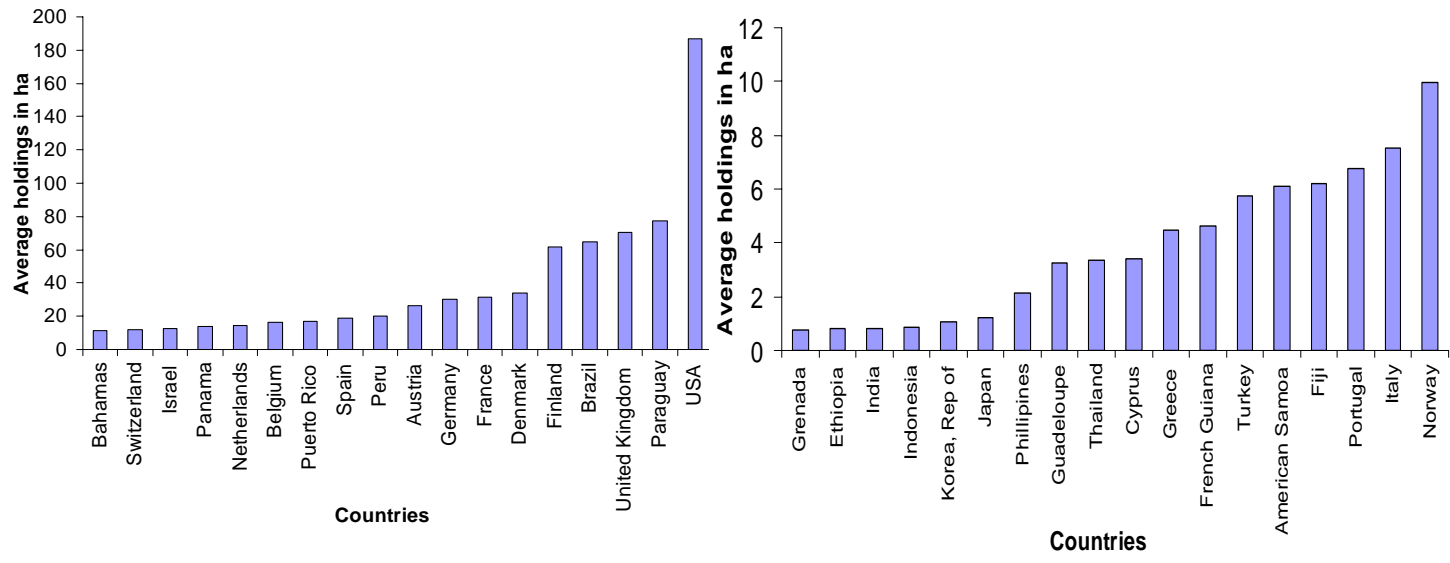
Ethiopia

Variations in field shapes in different parts of the world (*Courtesy: Google Earth™*)



**Average field sizes in different countries**

In addition to field size, the field dimensions, orientation etc. also show diversity across continents and countries. To some extent it is controlled by land types, for example, the rice lands have bunds and orientation across the drainage direction, while pivot sprinkler irrigation causes a circular pattern.



Average agricultural holdings of countries

## **Sampling Design for Global Scale Monitoring of Agriculture**

Global/continent level monitoring of agriculture requires proper sampling approach, taking into account the target crops, their concentration, vigor etc, which vary significantly across the globe. To start with the cultivated land may be taken as a criterion to observe the variability. Work carried out using the recent land cover derived using the 300 m resolution MERIS data shows the diversity of agriculture area distribution pattern in the world.

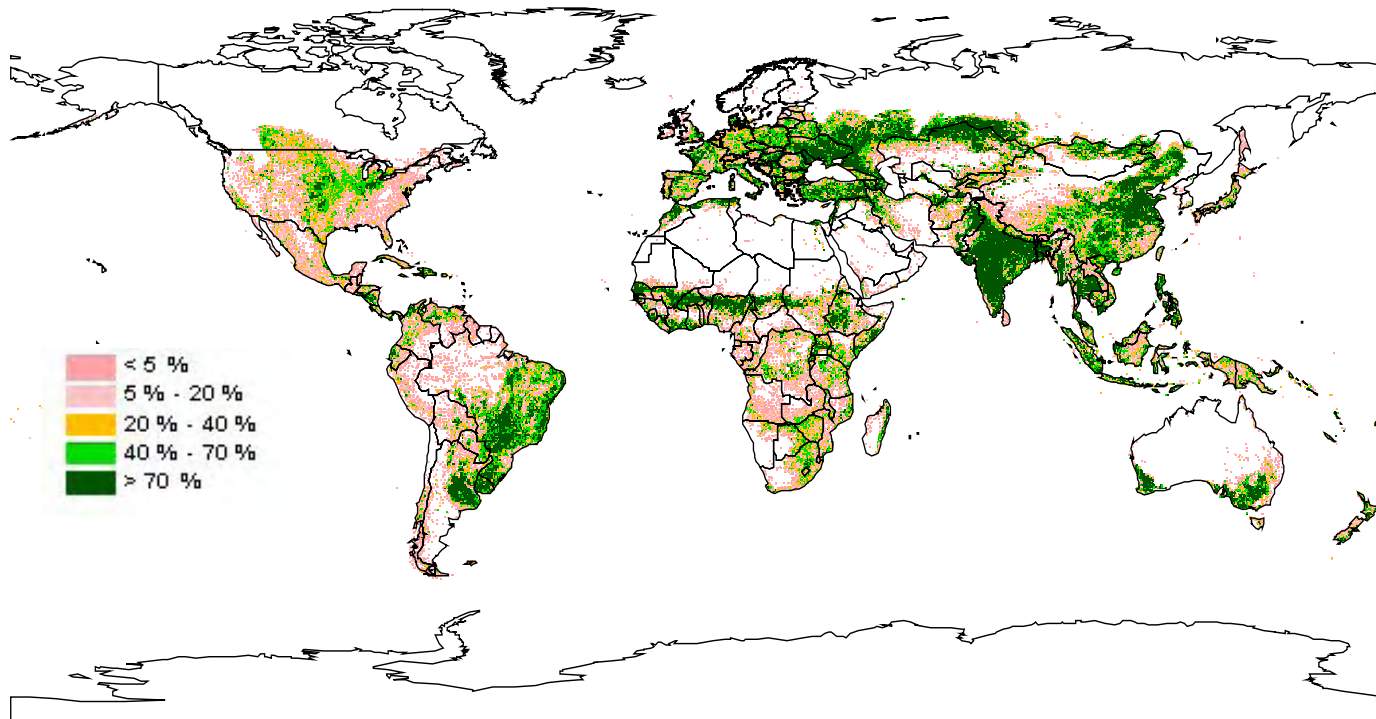
Under different scenario of grid size viz: (i) 5°X5° (ii) 1°X1° (iii) 30'X30' (iv) 15'X15' (v) 7.5'X7.5' and (vi) 5'X5' there is large variation in total agriculture grids and population under various category of per cent cover. It was noted that even further reducing the grid size from 15X15' there is not much change in the percent of agriculture grids. This indicates that for global scale monitoring, 15X15' size may be optimum which results around 115545 agriculture grids in total. Stratification of these grids based on percent agriculture, cumulative square-root of frequency method results in 4 strata that optimize the coefficient of variation viz.

(i) A: > 70 %   (ii) B: 40-70 %   (iii) C: 20-40 %   (iv) D: 5-20 %   (v) E: 0-5 %.

## **Monitoring Global Agriculture**

The location and extent of agricultural land is baseline information necessary for regional level assessments. This baseline information needs periodic updating to account for changes in agricultural land use. The need for spatially explicit data for large areas and its regular non-intermittent availability make remote sensing a highly viable option. Earth observations from sensors on board satellite platforms and in-situ ground based networks that provide direct information for monitoring agricultural system, can provide timely information on crop production and yield in a standardized and regular fashion at national to international levels.

Stratification of agricultural area into different categories holds a key in focusing our attention towards acquiring remote sensing data for agriculture monitoring. A sample stratification based on crop map for the world at 15'x15' grid level shows the variations in agriculture practices followed in the world.



**Stratified map based on crop area density for the world at 15' x 15' interval**



Image of the earth



Image Courtesy: ARCGlobe™ of ESRI

