Forest and Beekeeping Division - Ministry of Natural Resources and Tourism
Food and Agriculture Organization of the United Nations
Ministry of Foreign Affairs, Finland
Finnish Forest Research Institute

Designing National Forest Monitoring and Assessment
An important data provider for Ecosystem Services

The National Forest Monitoring and Assessment (NAFORMA) is the first comprehensive and nationwide forest inventory for Tanzania. Over the last 30 years sub-national inventories for different parts of the country have been carried out. In 1996 a national land-use mapping survey was undertaken.

In addition to providing very useful data on sustainable forest management, NAFORMA is key for Tanzania's Reduced Emissions from Deforestation and Forest Degradation (REDD) initiative as it will provide important forest-based biomass data for feeding into a National Carbon Accounting System.

The NAFORMA methodology is based on a backbone of 'permanent sample sites' that are initially 'assessed' (surveyed) and then 'monitored' at regular intervals into the future. NAFORMA has been designed to provide robust data from the district level upwards. The NAFORMA methodology is divided into two components:

» A '**Biophysical**' component which:

- Provides information on the extent and condition of the forest and 'trees outside forests' (TOF) resources, and;

- Captures deforestation and forest degradation though re-measurements.

» A '**Socio-economic**' component which:

- Provides knowledge about the human factors that affect changing forest conditions in a country – driving forces for forest change;

- Potential REDD+ linkages (ecosystem services).

Both components when put together are a powerful tool in assessing the effectiveness of forest and other related policies such as land use planning.

The objective of the survey design process has been to develop a methodology for NAFORMA that results in an accurate, repeatable, time- and cost-efficient survey. Attaining an indicative understanding of the overall distribution of forest resources in Tanzania has been key to planning the survey. Knowing where the trees are, how many there are likely to be and how difficult it is to get to them helps in designing a survey that is accurate (the more trees, the more measurement), repeatable (for monitoring), and time- and cost- efficient (good logistics planning).

'Input' data has been used iteratively to model design solutions such that the survey:

» achieves efficiency and accuracy/precision;

» provides reliable information at national & district level;

» improves the Food and Agriculture Organisation (FAO) National Forest Monitoring and Assessment (NFMA) methodology;

» uses multi-source input data.

This poster provides an overview of the innovative methodology developed to address complex design considerations in the planning of the bio-physical component of NAFORMA. The methodology has been developed by the Forest and Beekeeping Division in collaboration with the Finnish Forest Research Institute, Sokoine University of Agriculture and FAO.
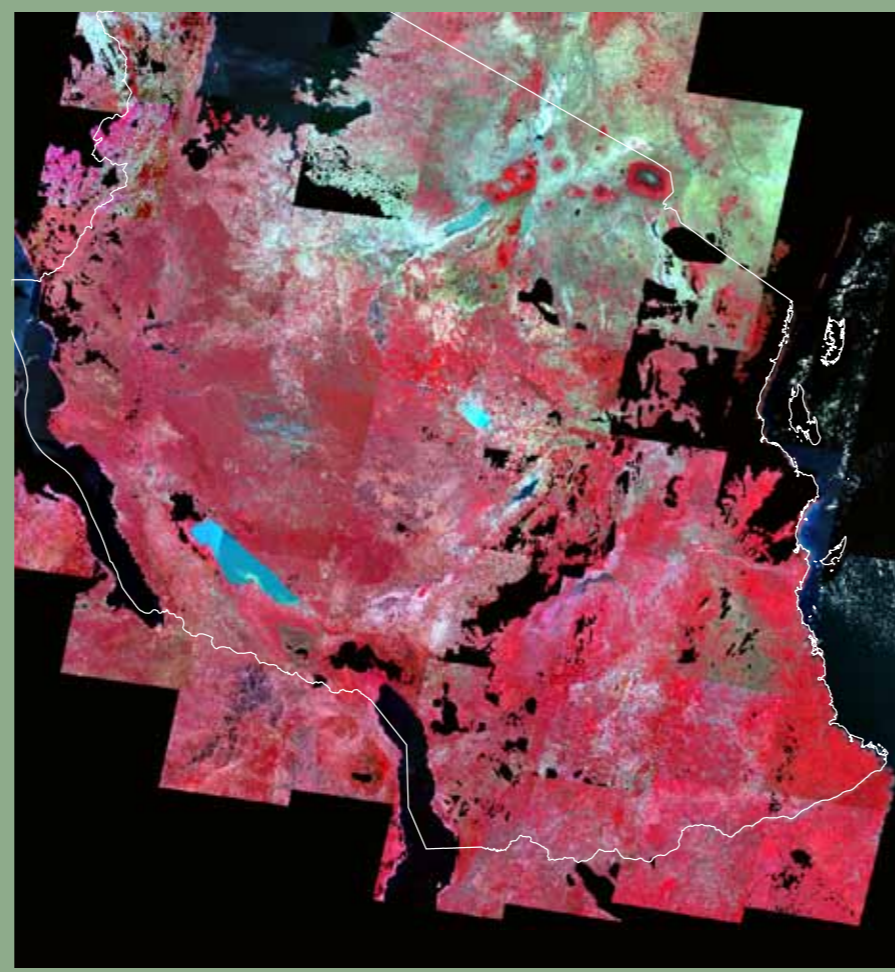
Landsat Mosaic Image

Reflectance at top of the atmosphere

Based on the GLS 2000 (Global Land Survey) data set from USGS

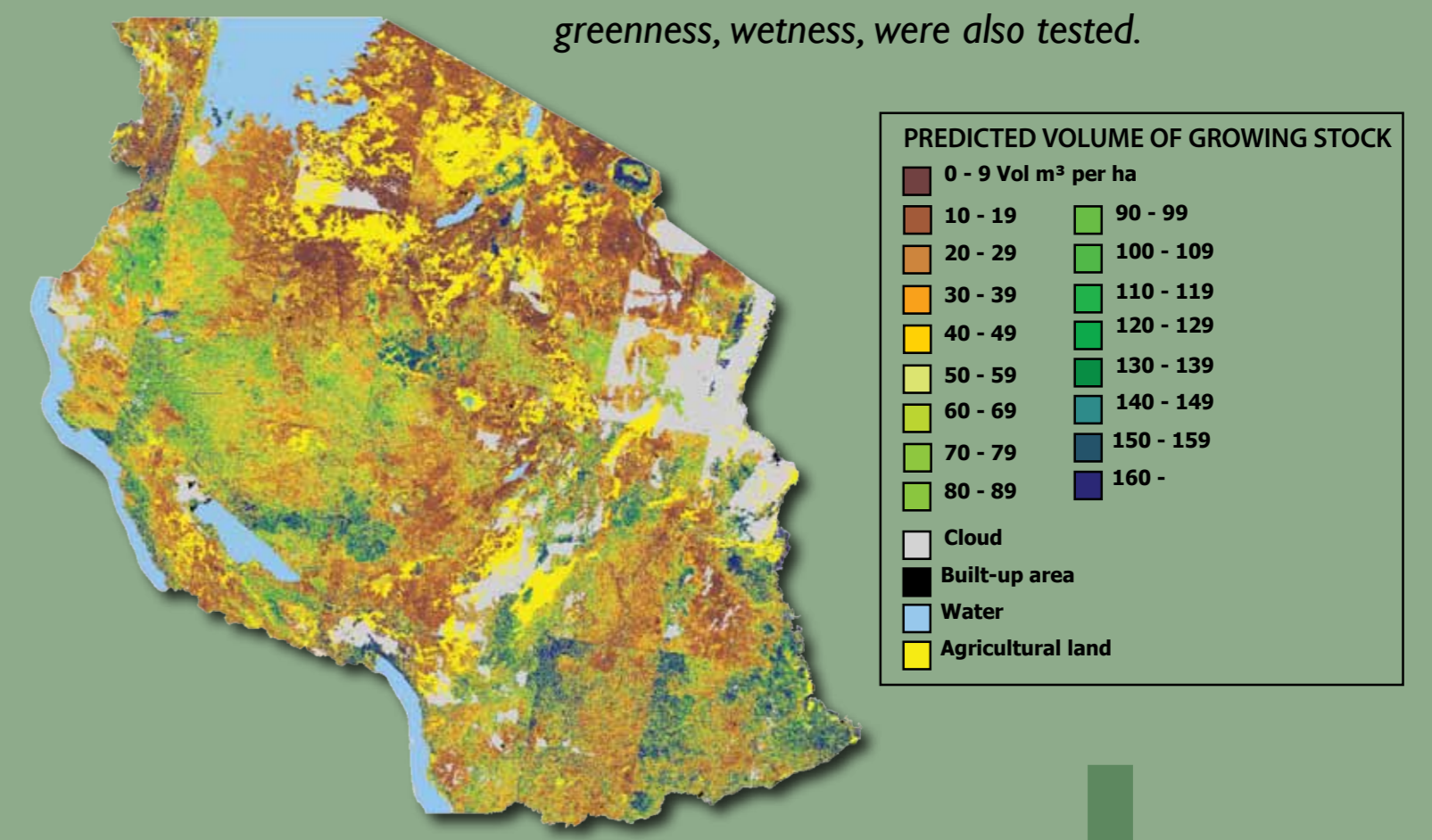22-05-2002   19-12-2000   21-07-2000
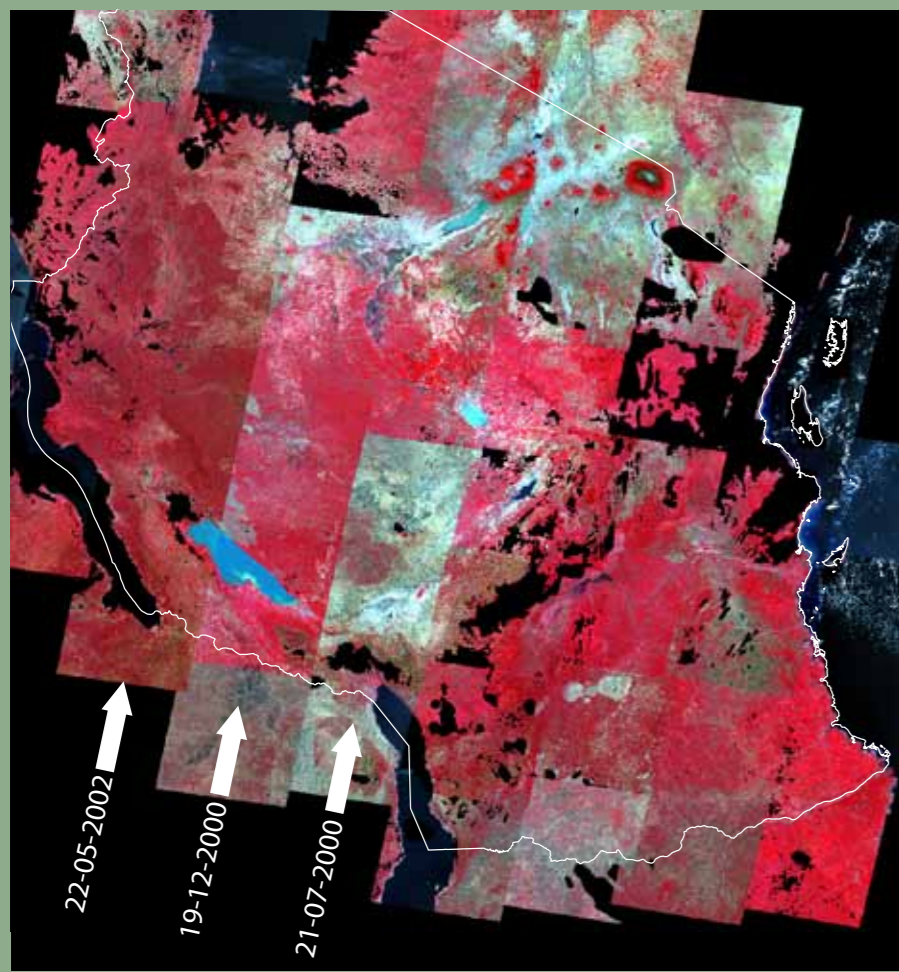
Corrected Landsat Mosaic Image

MODIS Aqua Composite used to compute surface reflectance from the original image data
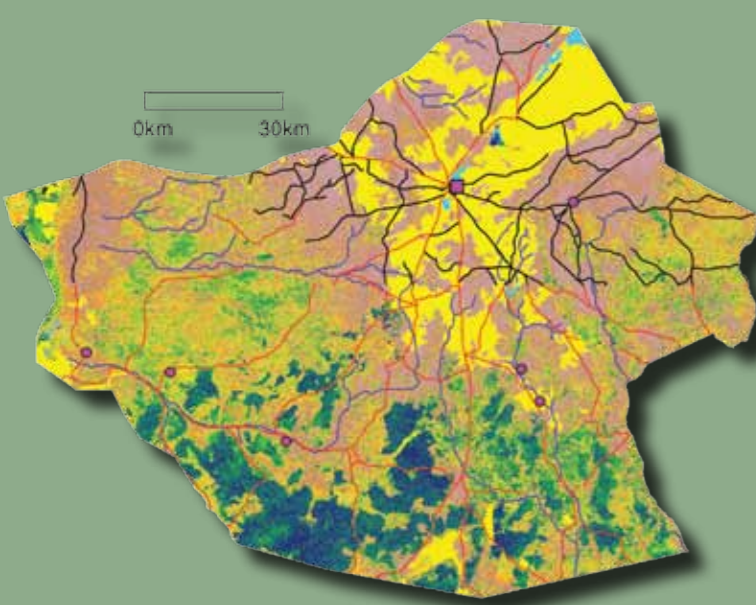

Predicted Growing Stock

A non-linear volume model was used to predict the size and distribution of growing stock (trees) using robust non-linear estimation, parameters estimated with Finnish data, top of atmosphere Landsat TM data with atmosphere correction. The model explained 75 % of the volume variation. Other variables, such as brightness, greenness, wetness, were also tested.

PREDICTED VOLUME OF GROWING STOCK

0 - 9 Vol m³ per ha	
10 - 19	90 - 99
20 - 29	100 - 109
30 - 39	110 - 119
40 - 49	120 - 129
50 - 59	130 - 139
60 - 69	140 - 149
70 - 79	150 - 159
80 - 89	160 -
Cloud	
Built-up area	
Water	
Agricultural land	

## Distance and time planning

0km   30km

The most time efficient work plan for the sample clusters is resolved in relation to the existence of roads, foot paths and topography (not shown). Multiple solutions can be modeled and generated to provide cost and time estimates.

0km   30km   Singida

DISTANCE FROM ROAD (KM)

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 15

— Driveable Road
— Footpath
— River
• Sample cluster

Sampling solutions for the survey

One of many potential sampling solutions for Tanzania, based on stratification and optimal allocation of the field plot clusters using the volume predictions and assessed measurement time, is shown below. Clustering and optimal allocation substantially increases the accuracy and efficiency of the inventory.


0km   300km
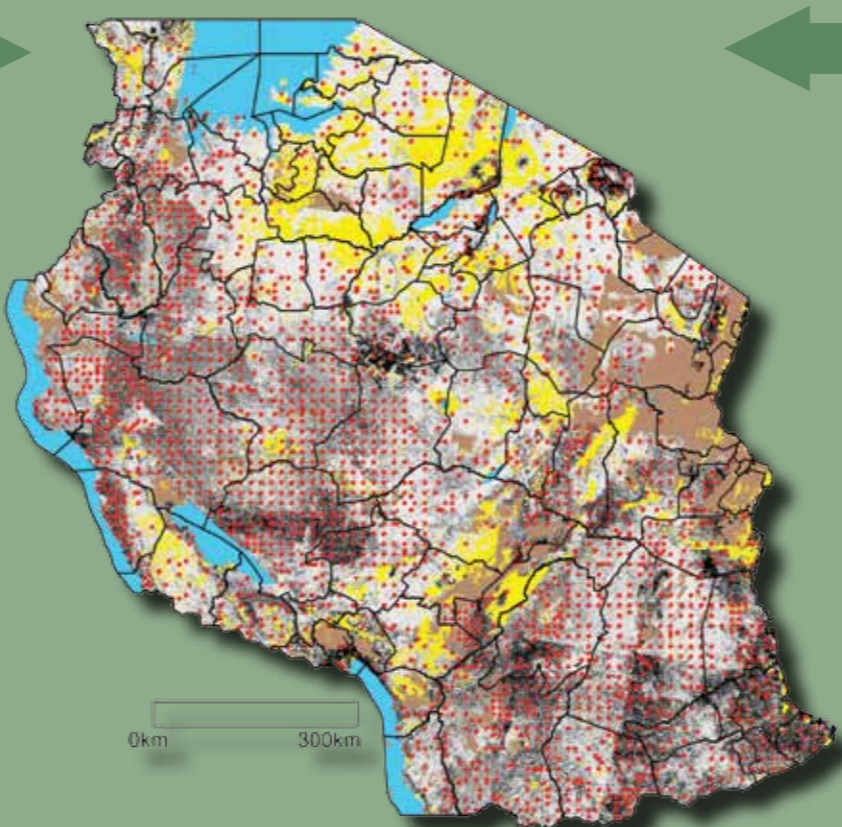
Clumped /stratified sampling

The predicted growing stock density is then used as the basis upon which to vary the distance between sample plot clusters. Several sampling designs are tested to find the most optimal in terms of the accuracy and costs. A model is run many times to generate the optimal placement of the clusters for the whole country which provides the sampling pattern with the smallest predicted error with the given costs. Each field plot cluster has ten sample plots. Each sample plot consists of four concentric circles, designed in such a way as to capture as much variability in the plot while minimising the measuring effort required.

Species name and dbh of all measured trees will be recorded in each plot in the following manner:

1. Within a 2m radius: all trees with dbh > 0cm will be recorded;

2. Within a 5m radius: all trees with dbh >5cm will be recorded;

3. Within a 10m radius: all trees with dbh >10cm will be recorded;

4. Within a 15m radius: all trees with dbh >20cm will be recorded.

250-400 m

10–45 km
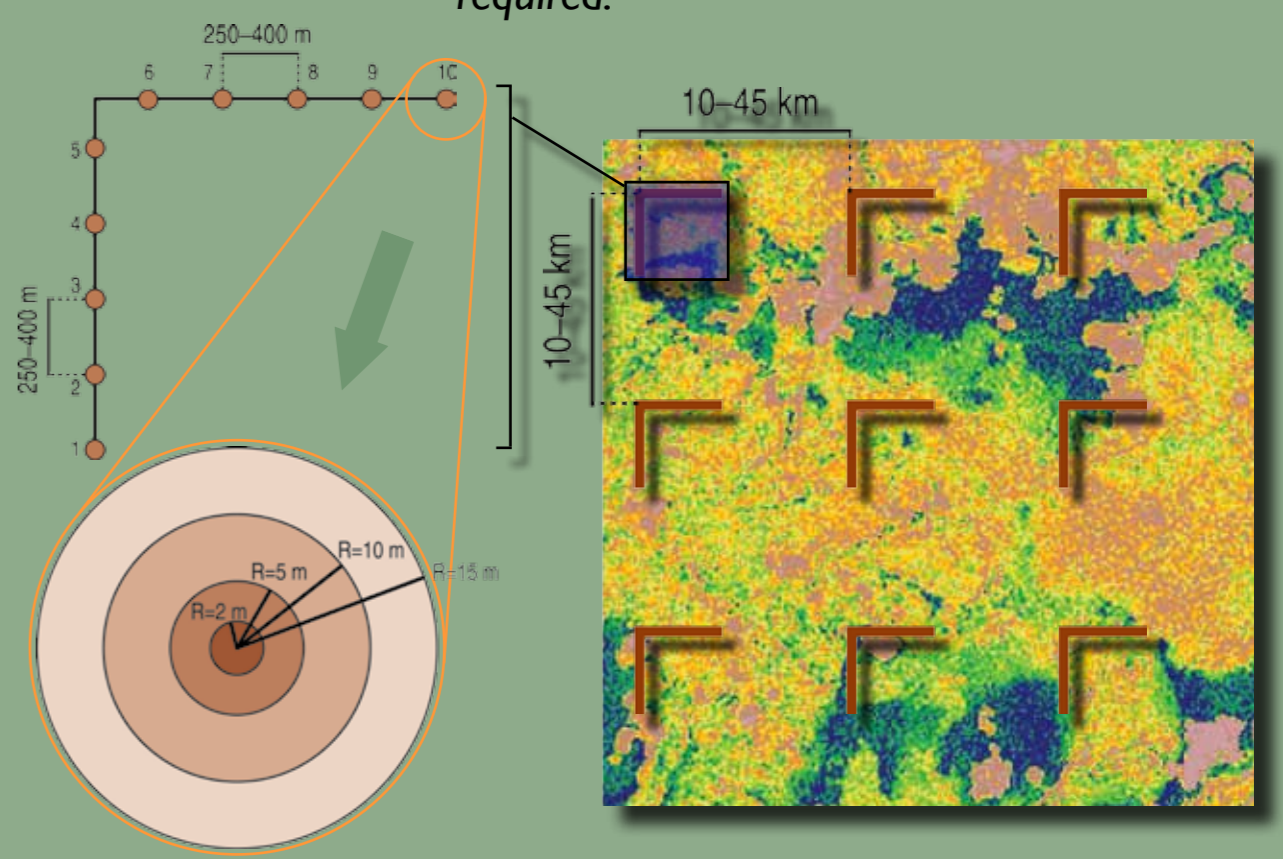
About National Forest Monitoring and Assessment (NAFORMA)

NAFORMA is a multi-source forest inventory where the results are supported by both field measurements on the ground and remote sensing data, aimed at capturing accurate and timely information on the state and extent of the forest and trees outside forest (TOF) resources of Tanzania. This is done through mapping the current and historical extent of the forest and TOF resources, and by establishing a system of permanent sample sites throughout the country. The method will enable monitoring through regular re-measurements in support of forest resources management, including Reduced Emissions from Deforestation and Forest Degradation (REDD). NAFORMA will introduce a policy-relevant, holistic and integrated approach to National Forest Assessment that addresses domestic needs for information as well as international reporting requirements.

NAFORMA has the following specific objectives:

I. Establish a broad consensus at the national level on the process and approach to NAFORMA in Tanzania, taking into account national users information requirements for planning and sustainable management of the forestry resources and the country's obligation of reporting to the international processes.

II. Strengthen the capability of the FBD to collect, analyze, update and manage the needed information on forests and trees under NAFOBEDA.

III. Develop a national database/dataset on forests and trees compatible with NAFOBEDA and other forestry related information systems.

IV. Prepare national maps of forests and land uses based on harmonized, classification and forest related definitions, with compatible storage and retrieval under NAFOBEDA.

V. Undertake a national assessment of the forest and trees outside forest resources with the aim to create an information base according to national (NAFOBEDA) and international requirements and to set up a long term monitoring system of the resources

VI. Define a long term monitoring program of the forestry resources, design specific and management oriented inventory in priority areas and formulate projects

The following three main actors were actively involved in compiling the Project Document in 2007 and subsequently signing the Project Agreement in 2008:

» The Government of Finland as the donor has committed approximately US$ 3 million to the project over a three year period.

» The Government of the United Republic of Tanzania as a counterpart has committed approximately US$ 800,000 for the same three year period and provides the organizational setting and office facilities for NAFORMA.

» FAO provides the logistical framework and technical support for timely management of experts and procurements.

The new national and international reporting requirements have necessitated further adaptation of the sampling design and inventory methodology. During the period August – December 2009 the sampling design and methodology were developed further to meet these requirements through collaboration between the Finnish Forest Research Institute, local experts and NAFORMA.

For more information contact:

National Project Coordinator
Mr Nurdin Chamuya,
Principal Forestry Officer,
Ministry of Natural resources and Tourism,
Forestry and Beekeeping Division,
P.O. Box 426,
Dar es Salaam, Tanzania

Tel: +255 759 348 934
Email: nuruchamuya@yahoo.com

Chief Technical Advisor
Mr Soren Dalsgaard,
FAO-Tanzania,
P.O. Box 2,
Dar es Salaam,
Tanzania

Tel: +255 759 228 182
Email: Soren.dalsgaard@fao.org