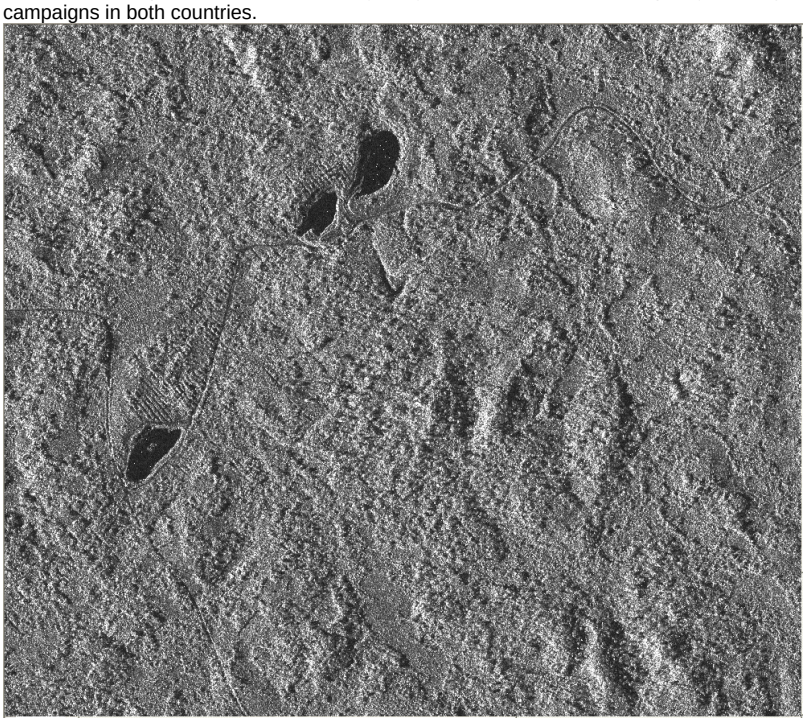
# TerraSAR-X & TanDEM-X contribution to REDD+ MRV

Success Story on the use of EO to assess deforestation

## Summary

About one fifth of all greenhouse gas emissions are caused by forest destruction with highest contribution from carbon-rich topical forests. REDD+, Reducing Emissions from Deforestation and Forest Degradation, aims to significantly reduce these emissions and enhance forest carbon stock by performance based payments. Proof of emissions reductions requires a special system of monitoring, reporting and verification (MRV) for large, inaccessible areas at requested observation frequency, independent from local interests as well as from external “handicaps” like cloud covers.

Both the Indonesian and Ghanaian pilot projects have shown the invaluable benefits and efficiency of the TerraSAR-X and TanDEM-X space-borne radar missions in the field of tropical forest monitoring for REDD+. The use of these highly accurate technologies has been proven in the field and won the recognition of local authorities and project partners. The developed services will help develop innovative approaches and methods for national MRV implementation. Additionally, they have led to successful capacity building campaigns in both countries.



## Project Background

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The ongoing destruction and degradation of tropical forests through expanding agriculture, new infrastructure and fire caused by anthropogenic intervention contributes between 10-20% of global greenhouse gas emissions. REDD + (Reducing Emissions from Deforestation and Forest Degradation) is an initiative within the Framework Convention on Climate Change (UNFCCC) to reduce emissions from deforestation and forest degradation. The carbon bound in forests is hereby assigned a monetary value. The developing countries will be refunded if they avoid emissions resulting from activities destructing the forest or degrading the biodiversity and quality of forests. In order to determine the compensation payments (incentives) and to monitor the reduction commitments of the countries concerned, current and accurate information on the carbon stock and its changes over time for large, tropical forest areas are required.

# Issues & Needs

Proof of savings of emissions relative to a reference time point (baseline) has to be provided within the framework of concepts defined for REDD + for monitoring carbon storage in the forest. The current solution is to use available archives of optical high to medium resolution satellite data for mapping of the recent and historical status of forests.
However, this faces two problems: First of all the temporal inconsistency of coverage as well as data gaps in tropical regions. Secondly, the mapping of forest degradation requires very high resolution data and sensitivity to changes in forest structure or biomass. Frequent cloud cover in the forest zone of Ghana and Mawas peat swamp forests in Kalimantan make the use of optical imagery difficult in terms of availability and applicability for deforestation and forest degradation mapping on an annual basis.

# Solution

TerraSAR-X and TanDEM-X radar imagery offer the capability to penetrate clouds on the one hand and very high resolution (3m) on the other, important factors when mapping complex land use patterns and forest degradation in tropical countries.

The TanDEM-X mission[1] will acquire Earth's entire land surface several times during its three-year mission. Thus providing an ideal data source for homogeneous and globally consistent, high resolution land cover surveys as a baseline for land use change and forest monitoring.

Up-to date TerraSAR-X imagery acquired in 3 m resolution StripMap mode under the same geometry can be directly compared to TanDEM-X global reference datasets and prove that even small scale selective logging activities, which indicate forest degradation, can be detected.

The use of information derived from single pass interferometry significantly improves the mapping capabilities and this enables to focus on forest changes. The combination of both, TanDEM-X based classification and TanDEM-X versus TerraSAR-X change detection, makes use of the unique characteristics of both missions, providing a powerful tool for the monitoring of tropical forests.

TanDEM-X and TerraSAR-X exhibit a unique geo-localization accuracy which is a prerequisite when combining remote sensing data with small scale forest field plots extending a few meters. The combination of remote sensing derived stratification with field plots on the other hand makes quantitative assessments on carbon stock change reliable and affordable.

1 The aim of the TanDEM-X mission is to acquire the data basis for the global Digital Elevation Model (DEM), WorldDEM™.

# Results & Perspectives

Methodology implementation and validation of TanDEM-X reference mapping was performed together with SarVision in Kalimantan, Indonesia. The chosen study site is located in a peat swamp forest which is characterized by drainage from the Mega Rice project which has led to increased fire vulnerability. Emissions from peat swamp forests equal about one quarter of the overall emissions from deforestation and degradation.

The pilot study shows that the TanDEM-X data is very useful to produce accurate land cover mapping, compliant with the 6 land cover categories mandatory for REDD+ MRV as specified by IPCC, and proved to be as accurate as conventional optical mapping results. Beyond basic classes it provides information on canopy cover and forest structure both related to forest biomass. Validation of quantitative forest characteristics with LIDAR measurements showed a good agreement with forest height and canopy cover.

Ghana was chosen as a second pilot case performed within the framework of public private partnership between GIZ[1] and Astrium GEO. The goal of the pilot is to test the applicability of methods for the national REDD+ MRV development process including capacity building of relevant institutions involved in later MRV execution.

Forest destruction in Ghana is largely a process of progressive degradation driven by a mix of forces from within and particularly from outside the forest sector. Therefore, the emphasis was laid on the forest change assessment to demonstrate the potential for forest degradation mapping with TerraSAR-X.

Test sites have been distributed in the different eco-zones of Ghana, from the tropical moist South to the semi-arid North.

TerraSAR-X based change detection results confirmed a high level of forest changes in the main forest zone of Ghana. The found cases of deforestation and degradation are representative in terms of drivers such as legal and illegal gold mining, palm oil production and selective logging within forest reserves. The pilot proved that small scale scattered changes can also be detected in TerraSAR-X StripMap mode (3 m) but most reliably in very high resolution SpotLight mode with 1m resolution. Detected changes were validated during a field trip with Ghanaian trainees including staff from the forestry commission.

(1) German Agency for international cooperation

## Indonesia, KALIMANTAN

This pilot stands to contribute to the conservation of Bornean orangutans, the endangered apes that live only in Asia, by providing current information on the status of their forest habitats. By mapping and monitoring tropical forests using remote sensing data from the TanDEM-X mission, it can assess the status of tropical forests and detect forest degradation and loss. Using space-borne SAR data allows accessing remote areas within Borneo's swamp forests in a timely manner and the assessment of the status of forests over large areas after, for example, fire events. This project will also strengthen local capacity: field work will be performed in collaboration with BOS-Mawas staff and local field assistants so the project will contribute to the training and transfer of field knowledge for Indonesians.

## Africa, GHANA

Given the level of forest degradation in Ghana in combination with the complexity of land use patterns and the dynamic nature of drivers of deforestation, it is proposed to use very high resolution imagery from TanDEM-X for reference mapping and TerraSAR-X for the subsequent monitoring of deforestation and forest degradation.
The proposed resolution offers better identification of features, change boundaries, drivers of change, and maps areas of forest degradation more accurately, than would be achieved with high resolution imagery such as Landsat.
The image to image change detection approach using TanDEM-X global archive as reference gives information on forest degradation at an early stage and therefore allows mitigation actions. Training on the job and verification of methodology was performed by Ghanaian users and led to recommendations of technology to the forestry commission of Ghana for REDD+ MRV implementation. Further validation and detailed cost benefit analysis will be performed in REDD pilot sites.

# Related Info

**EO service: Assess Deforestation / Degradation / Forest types**

TerraSAR-X based change detection product & services (operational)

TanDEM-X global reference datasets to detect hot spot of forest destruction (in definition)

Prototype of TanDEM-X derived baseline map for carbon monitoring (in development)

### Customer

Indonesia, Kalimantan: Borneo Orang-utan Survival (BOS) Foundation

Africa, Ghana: Forestry Commission of Ghana and the Centre for Remote Sensing and Geographic Information Services at the University of Ghana (CERSGIS)