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Application of mobile devices for community based forest monitoring

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Abstract: Tropical deforestation and forest degradation monitoring is one of the central elements for REDD+ implementation. Current schemes for monitoring are based on remote sensing and field measurements. Since monitoring is a periodic process of assessing the properties of forest stands with respect to some reference data, adopting the current schemes for implementing monitoring at national levels is a challenging task. Recently, the advancement in Information and Communications Technologies (ICT) and handheld devices has enabled local communities to monitor their forest in an efficient and cost effective way. In this paper we present a conceptual framework and process that aims to simplify the forest monitoring capacities of local communities in developing countries.

Keywords: REDD+; ICT; handheld devices; community based monitoring; forest change

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1. Introduction

The Inter-governmental Panel on Climate Change (IPCC) has identified that tropical forest degradation has a significant contribution to the increase of greenhouse gases in the atmosphere [1]. To address this issue, United Nations Framework Convention on Climate Change (UNFCCC) proposed the mechanism, Reduced Emissions from Deforestation and Forest Degradation in Developing Countries (REDD+), aims to reduce greenhouse gas emission, enhance the forest cover through the sustainable management of forests through local community by providing co-benefits and livelihood support [2-4].

National REDD+ activities should foster sub-national implementation and need to engage with national-level greenhouse-gas (GHG) monitoring and accounting activities to register carbon credits

and ensure contribution and verification to countrywide reduction targets. This activity requires reliable, up-to-date and credible national framework of measuring, reporting and verifying (MRV) forest carbon and its change stocks. MRV framework also supports policy-makers to involve local community groups and societies to carry out forest monitoring, in particular, if there is any prospect of payment and credits for environmental services.

A variety of practical experiences from developing countries, e.g. Nepal, Tanzania, Cameroon, India and Mexico have demonstrated that local communities can play an essential role in forest monitoring and management program [3, 5]. Moreover, if communities are involved in measuring the above-ground biomass carbon pool (which can be used in calculating the carbon stock changes) in the forests they manage, they may establish 'ownership' of any carbon savings, strengthen their stake in the REDD reward system and greatly increase transparency in the sub-/intra-national governance of REDD finances.

Handheld devices such as smart phones and personal digital assistant (PDA) devices may play an important role in the measurement and estimation of forest-related carbon emission at the community level mainly for two reasons. Firstly, it supports mobility supporting community participants to immediately record the measurement in the systems. Secondly, the implementation of the scheme becomes cost-effective and sustainable because of the cost of these devices. Simple measurements collected with handheld PDA and Global Positioning System (GPS) units, like tree density, diameter at breast height (DBH) and in particular forest changes and human activities affecting forest carbon are among the variables that can be rather efficiently monitored by communities [6]. Thus, while remote sensing techniques are the main tools used at the national level to detect deforestation, local level community data can be an important input to analysis of deforestation and degradation events. Community based monitoring (CBM) can help to complement remote sensing estimates and to signal new changes (even before the remote sensing data have been analysed). Important information provided by CBM could be location, time, area and type of the change events in the ground.

CBM can play a useful role when it comes to locally-driven change activities and causes of small scale forest degradation, for example, by subsidence fuel wood collection, charcoal extraction and grazing in the forest. The impacts of these activities are rarely captured accurately in national databases or from remote sensing [7]. In these cases, data acquired by communities is often essential, and can include reporting on incidence of change events, as well as ground measurements on carbon stock changes for tracking and reporting on local REDD+ implementation activities. There are many examples showing that communities can carry out such monitoring activities [3, 8, 9]. However, the success of these programs depends on socio-cultural aspects as well as the technical capabilities of the members of the community where it is to be implemented.

This paper proposes a conceptual framework and process that would allow local community to collect forest monitoring data independently and effectively. The data can be used for ground verification, forest carbon estimation and also for reducing the uncertainties of national forest inventories. It thus promotes the reliability of national MRV program. The paper is structured as follows: Section II describes the service platform architecture of community based monitoring. Section III presents the prototype implementation results and finally, Section IV gives concluding remarks.

2. Service Platform Architecture

Collecting and transmitting vital forest change signal is central part of the community based monitoring. The proposed system provides a complete end-to-end platform for local community to gather and deployed these measurements effectively. The general overview of functional architecture of the system is mentioned in Figure 2. The core elements of the system are: Data collection, data transmission, database management system, information processing and analysis and visualization. Further explanation is given as follows:

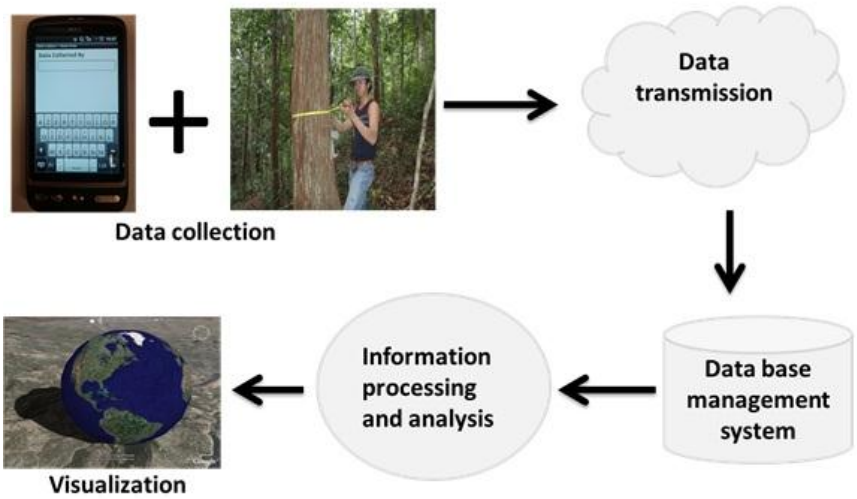

Figure 1: Service Platform Architecture for community based monitoring

Data collection component enables local community to acquire the data. Data is acquired through systematically designed form based on the monitoring activities and requirements of national REDD+ programmes. These forms contains optional input constraints, flow depending on previous answers, icon based user-friendly graphics and local language support. The form is deployed on handheld devices such as smart phone, tablet PC, personal digital assistants (PDA) devices with integration of GPS and camera. The details of the form and corresponding attributes are summarized in Table1:

Table 1: Forest monitoring form and attributes

Form type	Attribute
Forest inventory form	Geo-Location
	Date-Time
	DBH
	Height
	Species
	Photo
Signaling forest change	Geo-Location
	Date-Time
	Change Activity

	Photo graphs
	Descriptions
Training data for remote sensing	Geo-Location
	Date-Time
	Forest type
	Change Activity
	Descriptions

- *Forest inventory form:* This form contains measurement of forest inventory data such as Geo-location, Date-time, DBH, height, tree species and photographs.
- *Activity monitoring form:* This form allows the user on capturing forest activities such as small scale degradation, deforestation and reforestation. The form facilitates the user to store the location, photographs and description of the activity.
- *Training data for remote sensing:* This forms permits the user on capturing Geo-location, Date-time, Forest type, change activity, photographs and description

Handheld devices store the data asynchronously and transfer to the data servers over GPRS, Wi-Fi, or USB when connectivity permits. A suitable database management system is designed for the proper storage of acquired data. The local data, upon meeting all the national requirements, can be integrated into the national database. The aggregated data will be processed, analysed and feed into estimations on emissions and removals at the national level. The results can be reported (using the IPCC GPG) to an international body for carbon crediting and will be visualized though the Google Earth Engine [10], Google fusion tables and map forms.

3. Prototype Implementation

We implemented this architecture for a prototype in Horapark, Ede, The Netherlands. The suggested monitoring systems have adapted an intermittent communication. Therefore system is designed to work both online and offline. Users do not always access to an Internet connection. They can transmit there data in a local data base. Consequently, availability of internet permits to submit monitored information to remote server. That is why it is essential for monitoring applications to have a local and remote database. We used Open Data Kit (ODK) software for mobile side and Java 2 Enterprise Edition (J2EE) for java netbeans, PostgreSQL and QuantumGIS for server side. Typical screenshots of monitored location in Google earth and data attributes are presented in Figures 2 and 3.

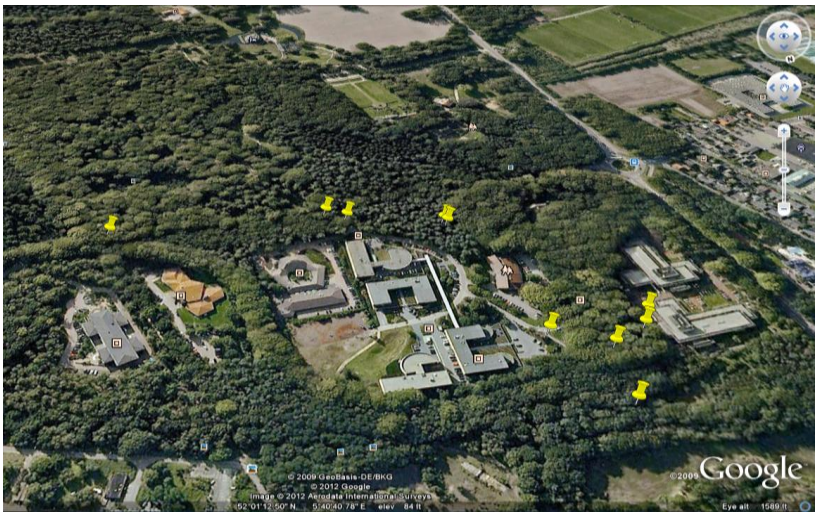

Figure 2: Monitored tree location

Data_Collected_By	Observation_Date	Tree_Location Latitude	Tree_Location Longitude	Tree_Location Altitude	Tree_Location Accuracy	Tree_Age	Photograp
Arun	Mon Feb 13 00:00:00 UTC 2012	52.02122927	5.67370355	57.0	32.0	2	
Arun	Mon Feb 13 00:00:00 UTC 2012	52.02136874	5.67385912	65.0	4.0	0	
Arun	Mon Feb 13 00:00:00 UTC 2012	52.02149749	5.67433655	69.0	6.0	2	

Figure 3: Monitored data attributes

4. Conclusions/Outlook

In this paper, we have presented application framework of handheld devices for community based monitoring to support national MRV requirements. This is a very promising field with exponentially increasing number of sensors and opportunities in the marketplace that has the potential to significantly change forest monitoring system and make it more efficient. Furthermore, it links the community to national MRV in the prospect of data demand, data supply, quality assurance, data management and report.

References and Notes

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