Expected properties of remote sensing applications for forest managers: lesson learnt from their experiences and expectations

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KEY WORDS: Cost reduction, Capacity building, Information sharing, Operational use of remote sensing

ABSTRACT: The forest/land managers at landscape level, such as in national parks or forest management units, who have their own hands for implementing management and/or law enforcement, also requires their own eyes to keep watching their lands. In spite of their expectations for long time, however, remote sensing has not been well implemented in the operational monitoring at this level. The lack of mutual understanding between the managers and the experts has been recognized for decades. We studied the experiences and expectations on remote sensing from the forest managers in Indonesia, consisting of forest/park managers and remote sensing researchers from national parks, logging companies, non-governmental organizations, universities, etc. Despite their experiences on remote sensing varied from nothing up to running expert facilities, all of them expected more effective utilization of the technology for their management practices. Majority of the participants identified that cost reduction, capacity building and information sharing were the most important issues for the dissemination. Remote sensing experts should cooperate with the managers, who will to utilize the technology by themselves, by providing appropriate technologies and helping their capacities building.

1. INTRODUCTION

Remote sensing (RS) has been assumed to contribute to forest and landscape managements since its initiation. There has been a huge amount of research and development on the technology, including sensors, processing and analyses. And the studies using RS have improved our understanding of the study sites. For the operational forest and landscape managements, or the tactical level of forest planning (Davis et al. 2001), however, RS has contributed not so much as expected yet (Wynne et al. 1997; Holmgren et al. 1998). Successful research methods cannot always be applied to the operational managements. It is recognized that there is a gap between the scientific and the operational uses of RS(Franklin 2001).

As a process of developing an operational RS framework in forest/land management, we invited some professional forest managers and RS experts to discuss about the experiences, expectations and constraints on RS in their management activities.

In this paper, we will present the summary of the discussion then discuss about required properties for a framework of operational satellite monitoring system for forest/land management.

2. THE FOCUS GROUP DISCUSSION

We held “Focus Group Discussion on the Operational Role of Remote Sensing in the Forest and Landscape Management” in CIFOR on 3rd October, 2007. The aim of the Discussion was to share among the managers and RS experts the experiences, expectations and constraints of RS in the practical managements. There were 27 participants arbitrary invited from 13 organizations, including National Parks, local governemnts, private companies, conservation non-governemtal organizations (NGO), and research institutions, all from Indonesia.

Prior to the Discussion, preliminary questionnaire was distributed to all the organizations so as to survey the spectrum of their experiences and expectations on RS. On the day, after presentations by some perticipants introducing their experiences, all the participants joined plenary and group discussions at which major expectations and constraints of the use of RS in forest management practices were discussed and prioritized. In the rest of this section we present exerpts from the questionnaire and discussion results.

2.1. Preliminary Questionnaire

We had sent a preliminary questionnaire to each of the 13 participated organizations prior to the discussion. The questionnaire consisted of two questions; Q1. “What are your experiences of remote sensing?” and Q2. ”What are your expectations to remote sensing?”

Among the 13 organizations, 7 had experiences in using RS (Group 1a), 5 had at least considered but not yet experienced well (Group 1b), and the remaining 1 were unknown but supposedly no experiences (Group 1c). No organizations in Groups 1a or 1b had experiences in regular/operational basis. Some forestry companies (both private and state-owned) classified themselves into Group 1b despite their abundant experimental experiences, apparently because they had not used RS in their regular activities. See Table 1 for the summary of the responses.

2.2. Plenary and Group Discussions

In the plenary discussion, major constraints for implementing RS in forest/land management were discussed by all the participants. Information sharing was an issue that drawn high attention of the participants. If information is widely shared among all concerning stakeholders, it should contribute to consistent forest/landscape planning throughout an area as well as cost reduction by avoiding duplicated investments on data and analyses. Participants identified by their experiences the causes that prevented from information sharing, including;

- Lack of communication among the players,
- Misunderstanding and/or over-expectations on RS
- Authorization and copyright that prohibit distributing results from the data source

Table 1 Summary of the responses to the preliminary questionnaire

Q1. What are your experiences of remote sensing?	Experiences	1a	Delineation (road, river, illegal logging, shifting cultivation, fire, high conservation value forest), LC/LU classification/ interpretation, LC/LU change, Assessment (erosion risk, habitat, land capability), Regional spatial planning, Flight planning
		1b	Delineation (logging), LC/LU classification/ interpretation, Management planning (harvest, replant) Basic map for participatory mapping
	Confronted problems	1a	*Cost*, *Capacity*, Cloud, Location accuracy, Insufficient ground truths, Hard to be comprehensive throughout a wide area, Subjective interpretation, Image quality
		1b	*Cost*, *Capacity*, Low resolution, Cloud
Q2. What are your expectations to remote sensing?	Expected uses	1a	Monitoring (deforestation, biomass, habitat, land suitability), LC/LU modeling, DEM extraction, Spatial data infrastructure & sharing, Database for regional planning
		1b	Initial harvest planning, Forest inventory by high resolution image, Immediate observation and response, Classification (forest type, succession stage)
		1c	Initial forest assessment, Updating info, Forest type mapping, Stand parameters, Monitoring (silviculture, damage)
	Possible constraints	1a	*Cost*, *Capacity*, Consistency for long period, Ground truth, Usable result on the ground, Insufficient info flow between RS experts and users
		1b	*Cost*, *Capacity*, Availability of high resolution image, Ground truth, Reliable info from lower resolution image, Timely updating

Note: 1a, 1b and 1c represent classes of the respondent's experiences: well-experienced, less experienced, and no experience, respectively. *Cost* and *Capacity* (italic in Table 1) are the two issues that almost all the respondents (12 and 11 among 13, respectively) identified as either problem or constraint for implementing RS. Other issues are in arbitrary order.

- Reliability of the other's information, including administrative information from the governments
- One-way dissemination, or lack of feedback mechanism

In the group discussions, participants were assigned into one of three discussion groups, and then each group chose one or more from the three pre-designated questions, 1) Experiences in interpreting high resolution images, 2) How to overcome the issues related to human resource and capacity, and 3) How to solve the problem of time and cost. The results of the group discussions were summarized as the recommendations, as shown in the next sub-section.

2.3. Recommendations from the Discussion

As the conclusion of the discussion, the most important issues identified for RS implementation in forest management were summarized as below;

1. Bridging the RS users and the RS experts
2. Promoting collaboration among institutions

3. Identifying/adjusting the boundary gaps between the administration and the reality
4. Sharing the data, information and technology in public

Recommendations from the group discussions were stated as below;

1. For high resolution image, it is encouraged to utilize such image in forest management because it can be interpreted more easily by both the RS experts and the users
2. For capacity building, trainings for the users are indispensable
3. And outsourcing of the analyses is the last option, because it would not promote institutional capacity of the forest management organizations
4. And it is also important to distribute materials through internet or CD rather than printed materials for disseminating the technology
5. For cost reduction, it is necessary to promote the data sharing across the institutional barriers and the use of open-source software

3. DISCUSSION AND CONCLUSION

The discussions revealed that, despite a wide range of experiences and expectations on RS to forest/land management and a shared view that RS was the only means to monitor a wide area, there were several constraints that prevent RS from implementation. Many of them were institutional rather than technical, and have been already identified by many experts (Wynne et al. 1997; Holmgren et al. 1998; Franklin 2001). However, they have been left unsolved yet. We think it is because RS experts have not taken the institutional constraints as their matters. Instead, a new technical framework of satellite monitoring systems can be presented by taking such institutional constraints into account.

The biggest concerns shared by the respondents were cost reduction, capacity building, and information sharing. The costs includes that of images, software and ground truths. Capacity building is necessary for the users so that they can make use of the technology with confident.

And information sharing arose as a key issue for solving these constraints. Duplicated investment could be avoided by data sharing and the capacity of the users could be promoted by knowledge sharing. Sharing the resultant maps should be the first step, but it would be effective only when the legend is compatible among the sharing institutions. Sharing raw satellite images would be a direct means to reduce the cost. And sharing ground truths would not only contribute to reducing the cost but also make the cooperation among the institutions more flexible and interactive. Above all, sharing the value of RS and GIS is important, and it’s a role of RS experts to facilitate such sharing. As a good example, a participant introduced a local GIS/RS forum which called on the local officials from different departments and sectors to share the information on RS and GIS and coordinate the data platform.

Managers are interested in image interpretation, in particular, of high resolution image, since they can intuitively do it by projecting their abundant empirical knowledge on their managing land. Such empirical knowledge is exclusive to those who are familiar with the land but hardly affordable by outsiders. Thus it should be utilized for image analysis

proactively and repeatedly. Bayesian inference is a way to utilize such empirical information (for example, Reguzzoni et al. 2003; Vaiphasa et al. 2006). And such empirical knowledge would be stored as a likelihood distribution as a function of spectral/ geographical/landscape attributes so that the available knowledge can be combined at user's judgment. Furthermore, any type of existing information, such as thematic maps of the past, can be also combined in a same manner. The accuracy of the results could be evaluated objectively with an independent set of ground truths as mentioned later.

Low accuracy of RS data was identified as a potential constraint for operational use only by two participants, both of whom were forestry companies that wanted to replace some of their ground inventories with RS. Quantitative accuracy at a given compartment is very important for them, thus the monitoring system should be carefully designed to meet their demands as much as possible. For other participants, especially for those who wanted to use the resultant maps for landuse planning, we wonder if accuracy is out of their question. There have been countless scientific and technical reports on landscape analyses that use landuse/landcover maps from satellite images with inappropriate accuracy assessments or without assessment at all. We have found even RS and/or GIS experts do not always deal with the accuracy assessment properly. For a sound RS implementation to an operational management, an objective and systematic assessment system with adequate ground truths is required.

Ground truths are indispensable for transparent evaluation but expensive and time consuming. However, managers cannot afford time and money for such an extra task (Sheil 2001). Thus, ground truth collection should be embedded in their regular activities. The items to be measured should be limited to stand parameters that managers have been familiar with (Danielsen et al. 2005) and that satellite can observe from above; for instance, land cover/forest type, tree density for high resolution images or canopy height for LIDAR (Takao et al. 2008). Unobservable parameters should be estimated with models independent from RS, otherwise the estimation and evaluation of such parameters can be applicable to only local area (Foody et al. 2003). Sharing ground truths among stakeholders/neighbors would help reduce the costs. To make it work well, ground truth plans should be coordinated among them, which should be another role of RS experts.

Capacity building should be the most important process for disseminating RS in the operational management. The participants were willing to build their own capacities than outsourcing the analyses despite their limited resources, since they wanted their own eyes to keep watching their lands. To respond to their requirements, RS experts should develop technologies as simple and less expensive as possible, and not only transfer the technologies but also consult to tailor a system by interactively learning from each other.

In conclusion, we identified from the discussion with forest managers and RS experts that cost reduction, capacity building and information sharing were the most important issues to be promoted for disseminating RS in the operational forest/land management. To address these issues, we proposed a conceptual framework of satellite monitoring system which consisted of a flexible and open estimation/interpretation of satellite images coupled with a systematic evaluation system using ground truths collected as a management activity. RS has been developed as a professional tool which requires special skills of the experts. It is clear from the discussion, however, that appropriate technology, or the intermediate

technology (Schumacher 1973), is also required now for the implementation of RS to the operational forest/land management with the professional managers.

ACKNOWLEDGEMENT

We acknowledge all the participated organizations, namely (in alphabetical order), PT Alas Kusuma, BAPPEDA Kabupaten Bungo, Burung Indonesia, Center for International Forestry Research (CIFOR), Institut Pertanian Bogor, JICA - Gunung Halimun Salak National Park Management Project, PT Komatsu Marketing and Support Indonesia, Taman Nasional Gunung Halimun Salak, Taman Nasional Gunung Palung, Tropenbos Indonesia - Kalimantan Program, Universitet Mulawarman, WARSI, and World Agroforestry Centre (ICRAF), and appreciate all the participated individuals. This study is supported by the CIFOR-Japan Project “Sustainable Utilization of Diverse Forest Environmental Services” sponsored by the Government of Japan.

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