THE ROLES OF GIS/RS IN THE NATIONAL MOVEMENT OF FOREST LAND REHABILITATION

Development of a GIS-based monitoring and evaluation system – the next step

by

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Abstract

Indonesia forests have dramatically changed. Interpretation of Landsat imageries 1999/2000 indicated that 55 million hectares of forest lands (45% of total forest lands) are degraded; for this, therefore, a national movement of forest and land rehabilitation is timely and essential action. Within five years (2003-2007), MoFRI planned to rehabilitate 3 million ha degraded forests/lands across the country.

Establishment of a master plan was the first step in the movement. Identification of locations for Namfor was a key important factor in the Master Plan in order for activities, efforts and budget could be planned appropriately. Spatial identification of Namfor locations involved GIS/RS technologies specifically in determining degraded forests, and setting priority of forest lands that need for rehabilitation. This paper described the process of identification, highlighted problems encountered, and proposed a GIS-based monitoring and evaluation system as a further role of GIS/RS for the success of this national movement.

Keywords: critical lands, degradation, forest land rehabilitation, evaluation, monitoring.

I. Introduction

In year 2003, the Ministry of Forestry of the Republic of Indonesia (MoFRI) introduced a national program to improve condition of degraded forest and land called a national movement in forest and land rehabilitation (Namfor). Namfor is a moral movement in forest and land rehabilitation to drive and encourage all Indonesian citizen to get involve in the movement, and gradually do forest land rehabilitation on their own. This program is parts of the MoFRI five policies: combating illegal logging, controlling/preventing forest fire, restructuring forest industry, and strengthening decentralization of forestry sector in the regional autonomy.

Indonesia forests have not been as good as they were in the past, some parts of forests are now heavily degraded. Interpretation of Landsat imageries 1999/2000 indicated that 55 million hectares forest lands (45% of total forest lands) are degraded. This condition is mainly because of forest exploitation, illegal logging, forest fires, and forest encroachment.

The five policies specifically the Namfor program is expected to improve and recover forest condition and functions so that forests could provide sustainability

of ecological, economic and social benefits for the people well being. In five years (2003-2007), MoFRI planned to rehabilitate 3 million ha (300,000 – 900,000 ha per year) degraded forest and land across the country.

At the very outset, establishment of Master Plans of forest and land rehabilitation (MP-FLR) was firstly carried out. Master Plan is a five year macro plan describing general policies, strategies and activities of FLR including distribution of locations where FLR should be implemented. The master plan is translated into technical plan – an annual plan describing operational activities on the ground such as field preparation, nursery development, seed deployment, tree planting, weeding/thinning etc.

Identification of FLR locations was important step to ensure that the project is directed to the right target locations. Therefore, FLR locations was essential data/information in the master plan establishment. Identification of FLR locations involved the use of GIS/RS technologies specifically in obtaining data of degraded forests, and setting priority of forest lands to be rehabilitated. This paper described the process of this identification, highlighted problems encountered, and proposed a GIS based monitoring and evaluation system as further roles of GIS/RS in order for this national movement could be successfully achieved.

II. Identifying locations of forest and land rehabilitation

GIS/RS techniques were applied in identification of spatial distribution of FLR locations for the Master Plan establishment. The following paragraphs describe the process of identification.

1. Criteria

Criteria for FLR was firstly determined in identification of spatial distribution of FLR locations. As the criteria has been defined, the use of GIS/RS in the identification process was straightforward.

Rehabilitation of forest and land should be aimed at critical lands. Critical land is a land that was degraded or in danger of degradation due to inappropriate land use and deforestation. Critical lands may be categorized into four levels: very critical, critical, rather critical, and potentially critical lands (the Directorate General of Land Rehabilitation and Reforestation/ DGLRR – MoFRI, 1998). Four parameters determining critical lands are land cover, slope, erosion and management. From four parameters, range values are calculated by summing up multiplication of weight and score of each parameter. Criteria of critical lands based upon range values are illustrated in Table 1.

Table 1. Criteria of critical lands.

Level	Description	Range Values		
		Protected areas inside forest lands	Agriculture Area	Protected areas outside forest lands
1	Very critical	120 – 180	115 – 200	110 – 200
2	Critical	181 – 270	201 – 275	201 – 275
3	Rather critical	271 – 360	276 – 350	276 – 350
4	Potentially critical	361 – 450	351 – 425	351 – 425
5	Uncritical	451 – 500	426 -500	426 – 500

Due to time and data constraint, criteria to determine spatial distribution and location of Namfor were based upon three parameters: (i) land cover, (ii) forest

function, and (iii) land sensitivity. Land covers describe phenomena of earth surface such as forest, shrub, bush, agricultural land, settlement etc. Forest functions divide forest lands into three functions: conservation, protection and production, whereas land sensitivity determines sensitivity of land in watershed areas based upon erosion hazard rate and sedimentation rate as described in the Minister of Forestry Decree No. 284/Kpts-II/1999. Watershed area is an ecological unit of forest land depending upon physical and chemical characteristics of the area, and drainage system such as direction of rivers and streams in the area. Criteria of location for Namfor were then determined as follows:

Priority I : areas with high land sensitivity, and unproductive. Priority I is directed to rehabilitation with 100% tree planting.

Priority II : areas with moderate land sensitivity, and less productive. Priority II is directed to enrichment planting or weeding/thinning.

Priority III : other areas outside priority I and II that need for conservation and environmental quality enhancement.

2. Collecting and processing data

Data concerning three parameters were collected in the process of identification to determine priority location of forest land rehabilitation.

(i) Land cover.

Interpretation of Landsat imageries was the main sources of land covers. Landsat imageries were classified into 23 classes; from these classes three groups were then generated to meet the criteria.

- Group I is unproductive, non forested areas consisting of bush/shrub, dry agricultural land mixed up with bush/shrub, swamp areas, and bare land.
- Group II is less productive, logged over areas consisting of secondary forests of - dry land, swampy areas and mangrove.
- Group III is other land covers consisting of savanna, agricultural land, rice field, mining, and settlement.

(ii) Forest functions.

MoFRI categorized forest lands into three functions: (i) conservation – to preserve specific characteristics and biodiversity, (ii) protection – to protect land from erosion, preserve drainage and hydrological patterns, and (iii) production – to produce wood/non-wood products. Identification was carried out in all forest functions. Digital data of forest functions were created from provincial forest land use plan maps.

(iii) Land sensitivity.

As previously described, land sensitivity was determined based upon sensitivity of land in watershed areas in terms of erosion rate, and sedimentation rate as described in the Minister of Forestry Decree No. 284/Kpts-II/1999. The decree categorized areas of watershed management into four priorities: priority I – super priority, priority II – high priority, priority III – moderate priority, and priority IV – less priority. Digital data was derived watershed mapsmfrom the DGLRR.

3. Results

Results of identification indicated, forest lands that need rehabilitation are 55 million ha consisting of 4 million ha in conservation forests, 10 million ha in protection forests, and 41 million ha in production forests. As an illustration,

Table 3 presents results of identification in one province of Indonesia i.e., Central Kalimantan. Table 3 shows that Central Kalimantan consists of 9 watersheds; total indicative areas for rehabilitation are 11.5 million ha, mostly in production forests - 11 million ha (of which 7 million ha in priority II), 212,000 ha in conservation forests, and 316,000 ha in protection forests.

4. Problems

Problems encountered in the use of GIS/RS for identification of spatial distribution and locations of FLR, among other things, are:

- Source of base maps

Indonesia covers 192 million ha land territory consisting of 30 provinces, 340 districts, 17,000 islands. Land surface map of Bakosurtanal (Coordinating Agency for National Survey and Mapping), and Topographical map of DitTop-AD (the Directorate of Topography-Indonesia Army) at scale of 1:250,000 and 1:50,000 are the standard sources of base maps. The maps however, have not covered the whole country, and for this reason other sources of base maps were also used (e.g., JOG/Joint Operation Graphical map of US army). Problem with different sources of base maps was inconsistency of map features/details in adjoining sheets (even for the same source of map). Other problem was different shape, size, direction of rivers, and shore lines between base maps (from different sources) and results of Landsat data interpretation. This problem was solved by adjusting adjoining map sheets as well as results of interpretation.

Table 3. Indicative locations of FLR in Central Kalimantan Province (x 1000 ha)

WATERSHED	PRIO-RITY	FOREST FUNCTIONS				
		CONSERV.	PROTECT.	PRODUCT.	OTHERS	TOTAL
Kotawaringin	I	-	10	230	-	240
	II	-	28	815	-	843
	III	-	-	29	-	29
Seruyan	I	11	5	457	-	473
	II	161	45	712	-	918
	III	-	-	18	8	26
Mentaya	I	-	2	746	-	748
	II	-	5	462	-	467
	III	-	-	64	-	64
Katingan	I	6	2	324	11	343
	II	22	18	928	-	968
	III	-	-	23	-	23
Sebangau	I	-	-	232	-	232
	II	-	-	393	-	393
	III	-	-	11	-	11
Kahayan	I	-	-	543	-	543
	II	-	11	809	-	820
	III	-	-	76	-	76
Kapuas	I	-	1	359	-	360
	II	-	3	964	-	967
	III	-	1	89	-	90
Barito Hulu	I	-	15	442	-	457
	II	12	175	1,153	-	1,340
	III	-	-	17	-	17
Barito Hilir	I	-	-	440	-	440
	II	-	-	555	-	555
	III	-	-	82	-	82
SUM UP of all watershed areas	I	**17**	**35**	**3,773**	**11**	**3,836**
	II	**195**	**280**	**6,791**	**-**	**7,271**
	III	**-**	**1**	**409**	**8**	**418**
TOTAL		**212**	**316**	**10,973**	**19**	**11,525**

Source: Master Plan of Forest and Land Rehabilitation for Central Kalimantan Province.

- Very limited ground checks

Ground checks are important to ensure that results of satellite imagery interpretation are correct and represent actual covers of land surface. Interpretation of Landsat data 1999/2000 was carried out with very limited ground checks. Consequently, accuracy of interpretation results were not measured. This year, MoFRI is carrying out interpretation of Landsat data 2002/2003 followed by ground checks. As this year interpretation is supported by adequate ground checks, results of interpretation would be more accurate than that of Landsat 1999/2000 interpretation. Therefore updating spatial locations and distribution of FLR with this year interpretation would overcome the problem.

- Limited resources

Hardware, software and personnel with GIS/RS skilled were limited in the provinces. In this situation, cooperation with local university, procurement of hardware/software necessary for the project, recruitment and training of personnel with GIS/RS skilled were conducted.

III. The next step – GIS based monitoring & evaluation system for FLR

Identification of Namfor spatial locations has proved that GIS/RS provided significant contribution to this FLR movement. Data necessary for the Namfor plan such as where the locations, how large the areas and what the priority can be defined, so that efforts and budget for this rehabilitation movement can be planned appropriately for the right target locations. As the plan has been implemented i.e., 300,000 ha in 2003, the next step as a key factor for the success of the movement is to monitor and evaluate the performance of FLR implementation, and to do necessary and timely corrective actions.

In principles, monitoring is an observation to examine that Namfor was implemented as plans, the project inputs (budget, human resources, materials) are delivered and used, and resulted in outputs as planned. Monitoring may take place continually or periodically providing feedback to management at all levels to take timely corrective actions.

Evaluation, on the other hands is an assessment to analyze: (i) results, effects and impacts of particular project (FLR), (ii) appropriateness of project (FLR) design and implementation methods in achieving specific objectives, and (iii) factors affecting the level, distribution and sustainability of benefit produced. As such, monitoring and evaluation form a management tool to measure and influence the performance of the project (FLR) during operation.

In this context, the proposed Namfor monitoring and evaluation system should have, at least three characteristics. *First*, the system should be a spatial based system. It is obvious that since the nature of FLR data are both descriptive attributes and specific locations, a Namfor monitoring and evaluation system should be a spatial GIS based system. *Second*, the system should represent cycle of FLR activities. The monitoring and evaluation system should accommodate and record data of all FLR activities such as plan establishment, field preparation, planting, weeding/thinning, and harvesting. As such, the progress of implementation can be monitored and evaluated. *Third*, the system should be dedicated to a forestry office based at a province/region such as the office of Forest Land Gazettement (BPKH). Collecting FLR data on the ground for monitoring and evaluation purposes may be efficiently carried out at the provincial/regional level, as locations of FLR are spread in all provinces of the country. Therefore, development of monitoring and evaluation system as well as its operational implementation is more appropriate at provincial/regional offices. As an illustration, Figure 1 shows a proposed monitoring and evaluation system for FLR that addresses three characteristics previously mentioned. Figure 1 shows that the system consists of 5 processes associated with 6 data stores - descriptive and locational.

IV. CONCLUDING REMARKS

1. In the national movement of forest and land rehabilitation introduced by MoFRI, GIS/RS has provided significant contribution specifically during the establishment of FLR master plan. In this plan establishment, GIS/RS has played an important role by providing spatial distribution of FLR locations that were critical important in the FLR implementation.

2. Problems encountered in the process of location identification at the beginning of the movement should not be disturbing. In the future, quality of the data/information produced may be enhanced in many ways, such as increasing ground checks, improvement of processing procedures and skill of the personnel involved. It is important to note that from this movement, forestry central and regional offices have learned much to apply GIS/RS for the works.
3. As the Namfor has been implemented, monitoring and evaluation of FLR performance should be the next step of critical important. In this case, GIS/RS could play a key role in line with the nature of FLR i.e., associated with specific locations to provide data on the performance of FLR implementation as a basis to do necessary and timely corrective actions.

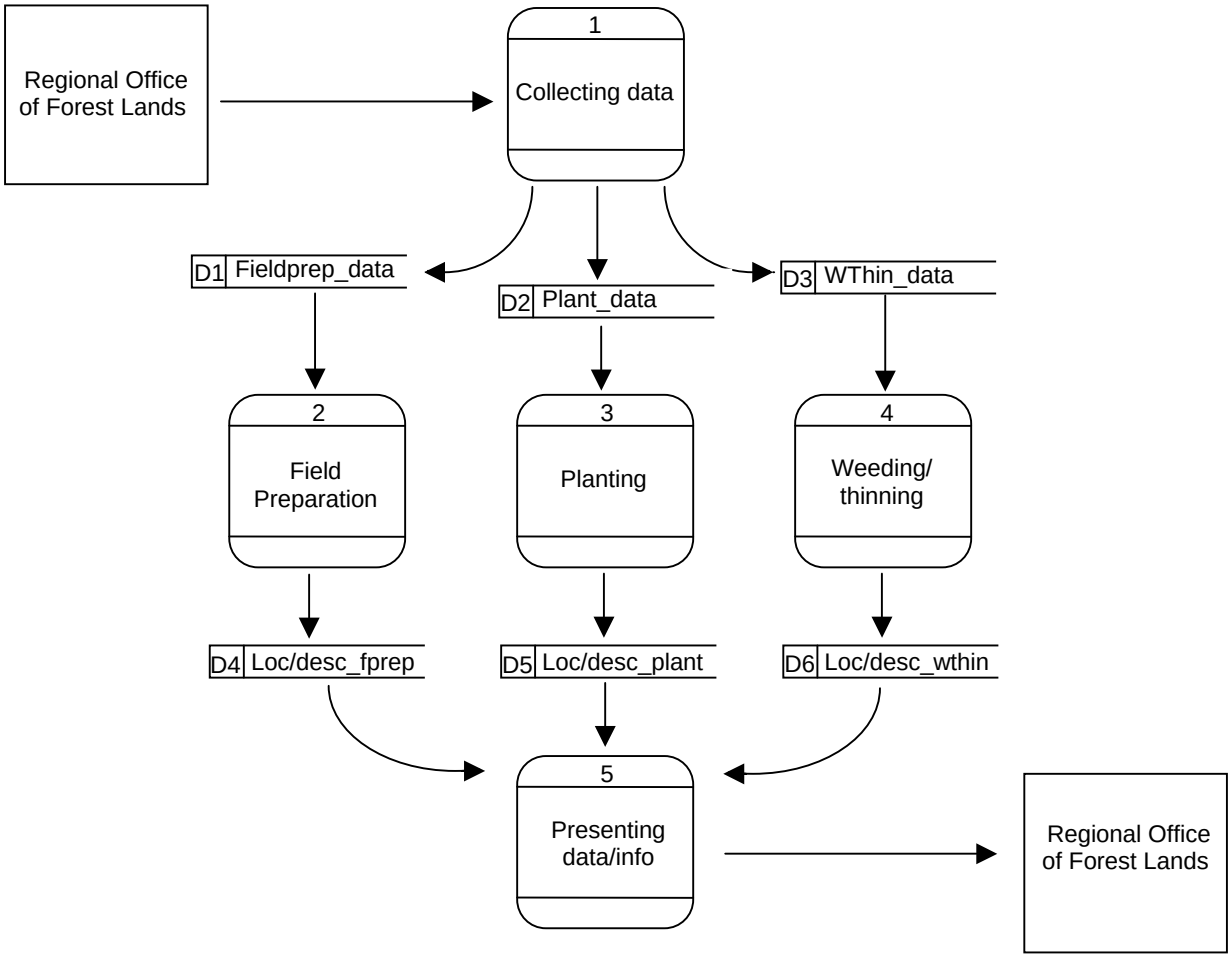

Figure 1. A data flow diagram of proposed GIS-based monitoring and evaluation system for FLR.