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Spatial Analysis to Identify the Priority Rehabilitation Area to Re-Introduce Ironwood (*Eusideroxylon zwageri*) in Meranti Sungai Merah Protected Forest, South Sumatra

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Abstract. About 3 % remain Indonesia's forest is distributed in South Sumatra Province. It is a key habitat for high biodiversity flora-fauna which has Asiatic character. On the other hand forest in some protected areas is surrounded by cultivation activities were managed by communities and privates. Those all human activities make pressure to the forest lead to the deforestation and caused critical land as well as habitat loss. Forest rehabilitation is an option to be proposed in preventing critical land and enhancing forest cover. This paper will discuss rehabilitation planning in landscape level of Meranti Sungai Merah Protected Forest. Spatial analysis has been used to determine land use changes and critical land level of the study area. The priority area has been analysis based on technical guidance for spatial analysis of critical land (MoF decree No. P.4/V-set/2013) and it modified in the sub-landscape level. Focus group discussion has been done to identify key parameters both biophysics and social economics. The result shows that about 2,442 Ha (21.5%) of the study area is classified as very critical and critical land and it could be expected as the priority area for rehabilitation. Native species such Ironwood (*Eusideroxylon zwageri*) would be recommended to be planted in the priority area of rehabilitation.

1. Introduction

Forest area of South Sumatra, home of high diversity of flora and fauna, is recorded about 3.6 million Ha or about 3 % of the total Indonesia's forest [1]. Pristine forest covers mostly in national parks, wildlife reserve as well as protected forests [2]. However, due to population growth and human economic activities, the existence of the forest especially in lowland area faced various pressures including expansion of agriculture and plantations, illegal logging, mining exploitation, and increasing settlement which are resulting in declining percentages of forest cover and causing forest fragmentation [2][3][4]. Forest conversion into other land uses have significant role to the appearance of the critical land. Based on



Statistics Agency of Indonesia, total critical land of South Sumatera in 2013 which classified as critical and high critical land is reported about 313.000 Ha (3.4% of total area of South Sumatera).

The condition shows that preserving of remaining forest have to be initiated not only to prevent the reduction of forest cover but also to ensure the existence of important flora fauna as well as to enhance land quality. Increasing forest canopy cover can be done by rehabilitation activity. Actually, the Indonesian government has implemented various rehabilitation programs since the 1950s [5], but rate of forest recovery has much lower than that of forest degradation. Hence, acceleration of afforestation is becoming increasingly important.

One of the forest areas in South Sumatera that need to get immediate intervention through rehabilitation activities is Meranti Sungai Merah Protected Forest (MSM-PF) ($\pm 11,389$ Ha). MSM-PF is habitat of several important plant species that are now rarely found in forests of Sumatra, including ironwood (*Eusideroxylon zwageri*), merbau (*Instia palembanica*), and meranti (*Shorea* Sp). Ironwood or better known in South Sumatra as *bulian* or *onglen* or *ulin* is a favorite wood for both local trade and export commodity. Ironwood is widely used by community as heavy construction such as boat docks, sluices, dams, bridges, and pillars of traditional houses [6][7]. The existence of this tree in the protected forest area is documented from the name of one village adjacent to the forest called *Pangkalan Bulian* means that ironwood is abundance in that area. This shows that ironwood is a main species growth and utilized by community lived in the MSM-PF since long time ago.

In order to have a reliable planning on rehabilitation program to re-introduce ironwood that will be implemented in the MSM-PF, the priority location of rehabilitation has to be analyzed. This study aims to examine priority location of rehabilitation of MSM-PF by using spatial analysis. The result of study can be used as guidance for the rehabilitation activity that will be implemented in the near future. Participating parties may use the map and the technical design document for regular rehabilitation and monitoring programs.

2. Method

2.1. Study site

The MSM-PF is located within the Meranti Forest Management Unit (FMU), Musi Banyuasin District, South Sumatra. The MSM-PF is adjacent to Dangku Wildlife Reserve as a part the Dangku-Bentayan landscape which has high biodiversity including Sumatran tiger [8]. There are 4 villages located close to the forest namely Lubuk Bintialo, Pangkalan Bulian, Sri Mulyo and Sungai Napal. In general, the communities rely on the forest for their needs including collection goods from the forest such as rattan, pandanus, bamboo, rubber, *sialang* honey, durian and bitter charm [9]. Unfortunately, some other people primarily from other villages utilized the forest by converting it into plantations (mainly rubber and oil palm). The location and extent of the study area is illustrated in Figure 1.

2.2. Materials and method

Data used for analysis includes soil map at scale of 1:100,000 collected from Indonesian Center for Agricultural Land Resources Research and Development (ICALRD), Digital Elevation Model of 30 meter resolution derived from Consultative Group on International Agricultural Research (CGIAR), map of Meranti FMU patrol information at scale of 1:10,000, map of burnscars year of 2015 at scale of 1:10,000 from South Sumatra Forest Service, and land cover map years of 2014 and 2016 at scale of 1:5,000. Land cover data used are based on analysis using RapidEye imagery of 5 meter resolution.

Generally, there are two stages of analysis in establishing rehabilitation program in Meranti FMU. Firstly, determining focus area of rehabilitation within Meranti FMU by using land cover change analysis

and focus group discussion. Secondly, spatial analysis using GIS tools in order to examine critical land classification and priority location for rehabilitation.

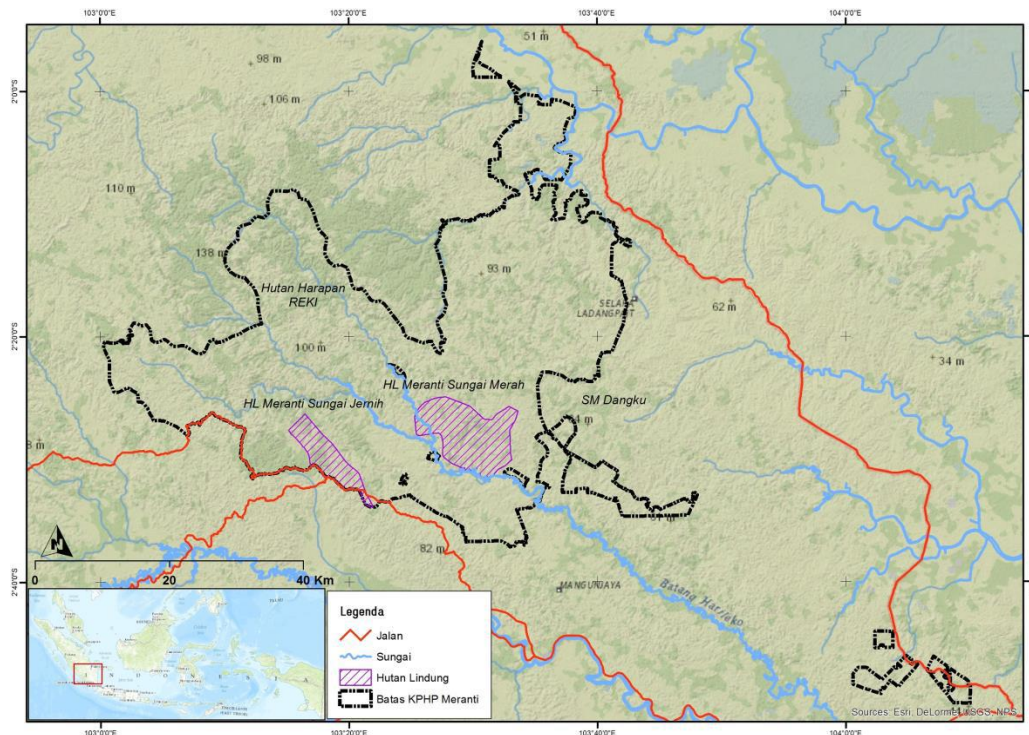


Figure 1. Location of study area

2.2.1. Focus area of rehabilitation within Meranti FMU

Land cover change is one of parameters in determining focus area of rehabilitation. Satellite imagery of RapidEye (2014 and 2016) were used in determining the distribution of land cover changes. The distribution of deforestation would be used as one of the physical indicators in choosing the focal area of project. Other parameters such forest function (protected or non-protected forest), social economics condition of the communities, and stakeholders activities within Meranti FMU would be taken into account in determining focal area of the program. Another consideration is input from stakeholders of Meranti FMU including communities and private sectors. Hence, focus group discussion method is used to collect information from stakeholders.

The spatial analysis using GIS tools is used in determining priority location for rehabilitation. The spatial analysis of MSM-PF has been conducted based on technical guidance for spatial analysis of critical land (MoF decree No. P.4/V-set/2013). The main parameters to be analyzed in this study are including land cover, slope, soil erosion, and management activities of Meranti FMU [10]. All those data would be quantified using scoring method. Areas with high degradation risks would have small value (1), whereas areas with low degradation risks would have high value (5) [10].

2.2.1.1. Land cover

Land cover data of RapidEye imagery year of 2016 was used in the analysis. The more densely canopy cover such forest area, it suppose to have low degradation risks. Then, it would get high score. On the other hand, the open area such bare land assumed would have high risk to be degraded.

2.2.1.2. Slope

The slope was classified from SRTM-DEM with 30 meter resolution. The area with slope > 25% (steep) means that it has high risk to be degraded. So that it would get low score. While, flat area (0-2%) would have high score means that it has low degradation risks.

2.2.1.3. Erosion

Soil erosion data derived from soil type information based on soil map of ICALRD. The information provided includes texture, structure, and solum (soil depth) that can be used as indicators of level degradation risks. There are several classes of soil types that are common on South Sumatera and provide very important information for this study. For instance inceptisol soil dominantly by sandy texture so that it is easily to be eroded compared to ultisol and oxisol. Therefore an easy type of soil to be degraded such inceptisol would have low score.

2.2.1.4. Management of FMU

The management parameter is site specific and it could be different in each FMU. Management factor is very important in preventing land degradation. In this study, three indicators were used as management parameters. 1) Protection activity. Forest patrols frequency would play role in preventing forest degradation. Then, an area with high frequency of forest patrol would have high score. 2) Extension to the communities. The communities have direct access to the forest so that it would be negative impact to the forest if they do not much pay attention of forest ecosystem. 3) Fire hazard map of 2015. It indicates the performance of management of Meranti FMU in preventing forest degradation caused by fire. An area prone to fire would have low score.

2.2.2. Critical land assessment and priority of rehabilitation

A statistical analysis was conducted to sum up those four parameters in assessing critical land. The statistical formula used was based on the technical guidance for spatial analysis of critical land[10]. The accumulated values would be around 120 – 500 which low score indicates high degradation risks and vice versa. The distribution of score values that have been analyzed, then grouped equally to determine priority classes for rehabilitation. There are 5 classes of priority area of rehabilitation program (Table 1). The simple statistical formula for spatial analysis is as follows;

$$\text{Critical land} = ((50 \times \text{land cover}) + (20 \times \text{slope}) + (20 \times \text{erosion}) + (10 \times \text{management})) \quad (1)$$

Table 1. Priority rehabilitation classes

No	Priority	Score	Criteria and Intervention
1	Priority 1	120 – 180	Very critical, highly degraded; reconstruction, rehabilitation with intensive planting
2	Priority 2	181 – 270	Critical, degraded; rehabilitation with intensive planting
3	Priority 3	271 – 360	Moderately critical, moderately degraded; rehabilitation with enrichment planting
4	Priority 4	361 – 450	Potentially critical, slightly degraded; monitoring, assisted natural regeneration
5	Priority 5	451 – 500	Non critical, non degraded; monitoring, natural regeneration

3. Results and Discussion

3.1. Land cover changes and focus area of rehabilitation within Meranti FMU

The land cover change analysis provides information the distribution of deforestation within two years (2014-2016) in the Meranti FMU. Not only in the non-forest area, deforestation has also occurs massively in the protected forest which is showed by red color (Figure 2). Beside land cover changes data, other criteria to be considered in determining focus area of rehabilitation program are including; 1) an area that designated as protection area. This area needs more attention from stakeholders to maintain the ecosystem. 2) an area that have ecological benefit. Area within Meranti FMU which has high biodiversity of flora fauna could be considered as priority rehabilitation program, 3) an area that provides social-economics benefit. An area in which communities have involved in managing of forest and benefiting both directly and indirectly from forest is consider to be selected as focus location for rehabilitation. Based on the discussion with all those considerations, MSM-PF has been selected as focal area for rehabilitation program.

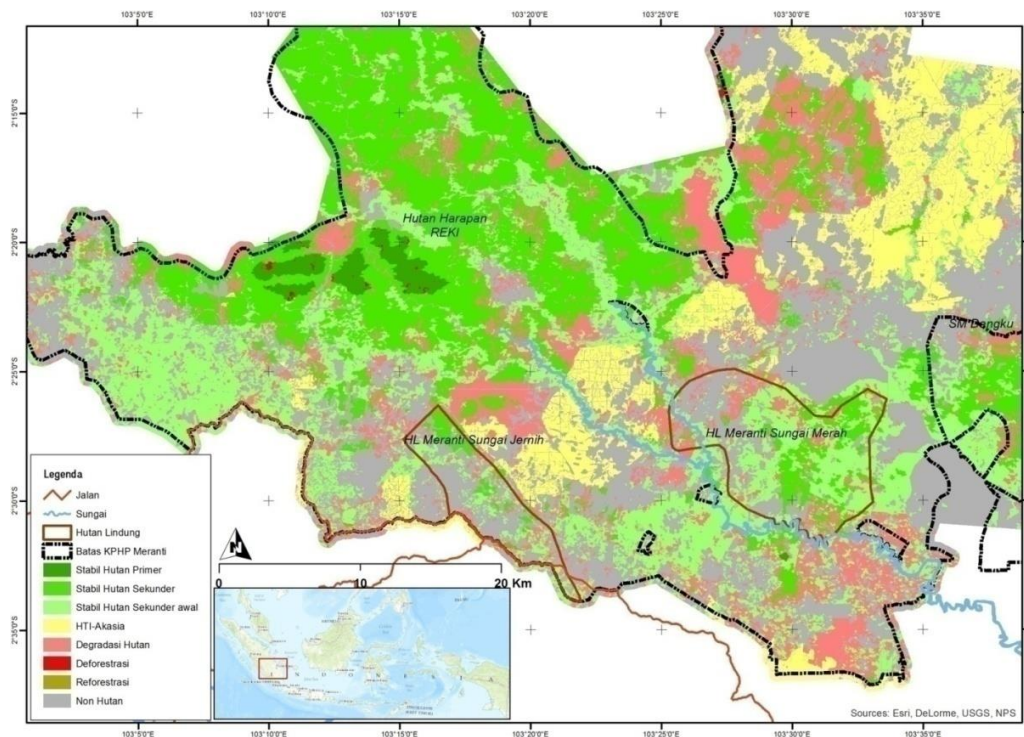


Figure 2. Land cover change in Meranti FMU

3.2. Critical land and priority of rehabilitation

As mentioned before that MSM-PF has been chosen as focus area of rehabilitation program. Hence, further analysis on this study would be focused in MSM-PF area ($\pm 11,389$ hectares). The result of analysis of critical land of MSM-PF area is described in Figure 3 and Table 2. It shows that about 19 Ha (0.2%) of area is classified as very critical, while 2,423 Ha (21.3%) is classified as critical land. It means that priority rehabilitation would be focused in this area. About 57.0% or 6,490 ha of total area is classified as moderately critical and the remaining area is potentially critical and non critical which covers about 2,456

Ha and 1 ha respectively. However, by using Landsat ET+7 in the spatial analysis, another study showed different result of total critical land that was prioritized for rehabilitation program for only 757.35 Ha (6.6% of total area of MSM-PF)[11]. Satellite imagery resolution and method of analysis used suppose to causing different result. The distribution of area classified as critical and very critical of MSM-PF mainly located in the area accessed by community either road or river. Therefore, beside bio-physical parameters, social economics condition has to be considered in determining critical land distribution and priority of rehabilitation.

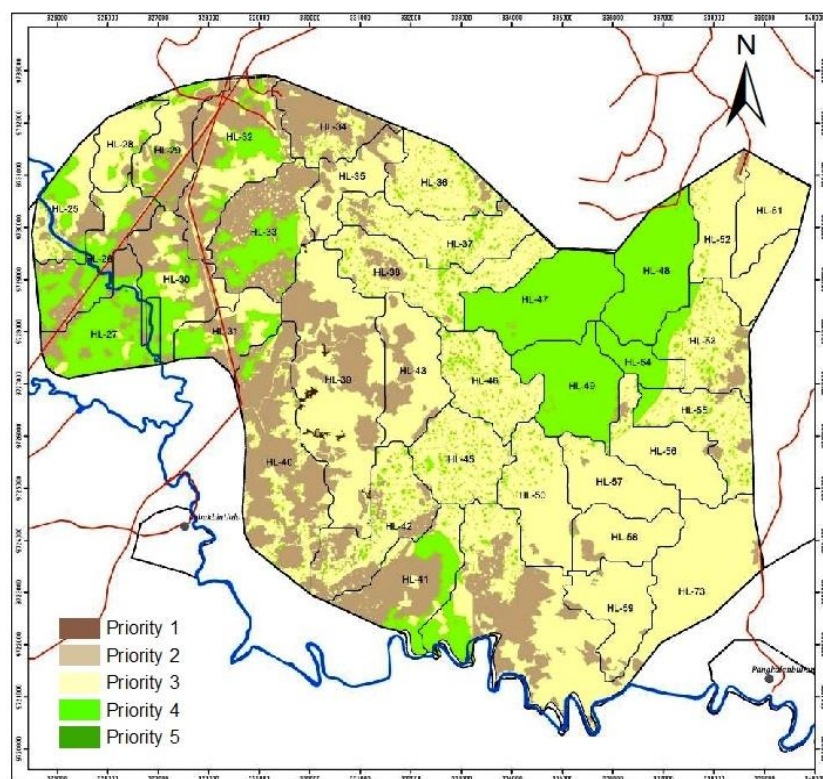


Figure 3. Map of priority area for rehabilitation in MSM-PF

The priority map of rehabilitation could be used as a baseline for Meranti FMU in determining strategy of rehabilitation program in the near future. Based on the target priority of Meranti FMU, two scenarios of rehabilitation would be proposed: 1) Scenario A (short and medium term rehabilitation. in this scenario the priority rehabilitation would be within the critical and very critical classes with a total area of 2,442 (21%). 2) Scenario B (long term rehabilitation); priority rehabilitation would be in very critical, critical, and moderately critical areas with total area of 8,932 Ha (78%). However, other area that is classified as potentially critical and non-critical have to be also managed properly since there are potential threats in managing this area.

Community involvement plays important role in managing MSM-PF. So that, they would be involve in every rehabilitation stages including planting, monitoring, and preventing from fire and other disturbance. Several companies operated in Meranti FMU were expected to join in the program as rehabilitation partner. Oil and gas companies, plantation forest company, oil palm companies area among stakeholder that could be engage into the program.

Table 2. Number of each priority rehabilitation classes

Rehabilitation program	Critical land classes	Number	
		Ha	%
Priority 1	Very critical	19	0.17
Priority 2	Critical	2,423	21.27
Priority 3	Moderately critical	6,490	56.98
Priority 4	Potentially critical	2,456	21.56
Priority 5	Non-critical	1	0.01
		11,389	100.00

3.3. Pilot rehabilitation program using Ironwood (*Eusideroxylon zwageri*)

After priority location of rehabilitation has been mapped, then 2 Ha of pilot rehabilitation program has been established. The location classified as priority 2 of rehabilitation is located adjacent to the Pangkalan Bulian Villages (Figure 4). The species chose to be planted is based on discussion with the communities including bulian, merawan (*Hopea mangarawan*), meranti (*Shorea balangeran*), petai (*Parkia speciosa*), durian (*Durio zibethinus*), jengkol (*Archidendron pauciflorum*), rotan (*Calamus* Sp.). Those last four species would provide non timber forest products (NTFPs) which is benefiting to the communities.

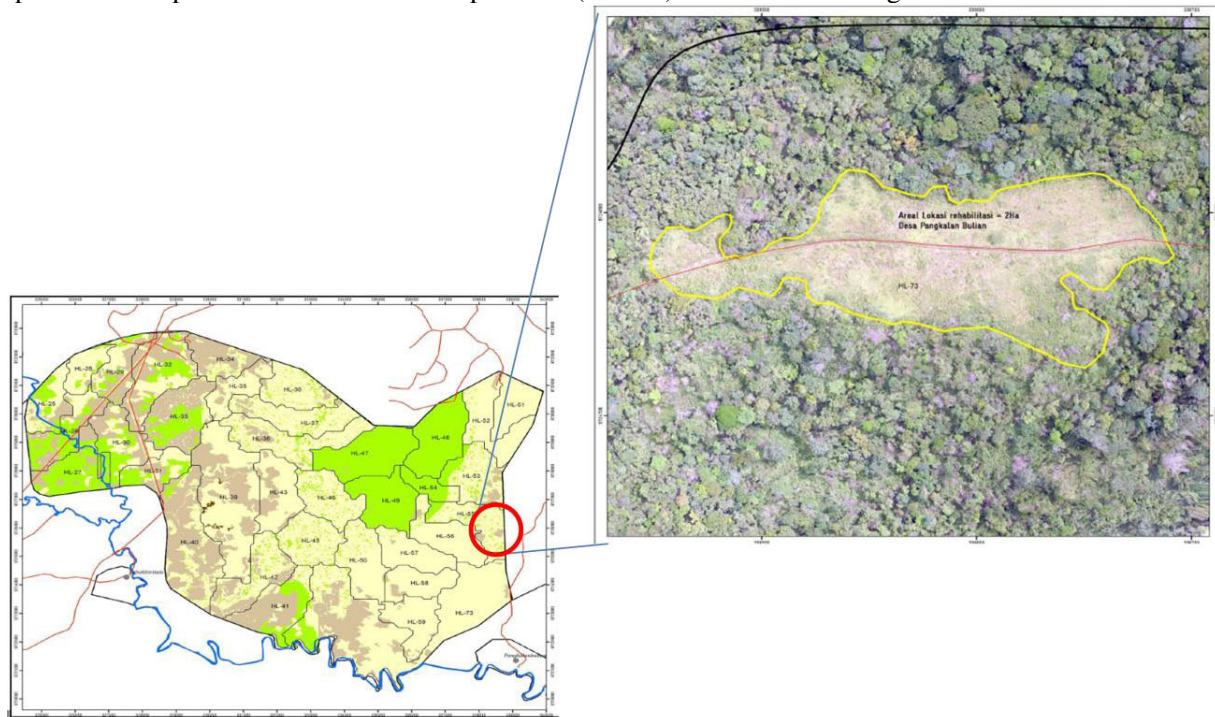


Figure 4. Location of pilot rehabilitation Ironwood is native tree species of Indonesia grows in sandy clay loam soil of lowland forest of Sumatra and Kalimantan [12].

The distribution of ironwood of Sumatra was recorded in Jambi (Batanghari District) and South Sumatra (Musi Rawas and Musi Banyuasin District) [13]. It is very strong and very durable wood, hence it

is widely used for various purposes such as foundation in water and wetlands, shingle roof, frames and doors [7][14]. However, due to high demand as raw material of construction the existence of ironwood in its natural habitat has decreased dramatically in the last two decades [14]. Hence, International Union for Conservation of Nature and Natural Resources (IUCN) has registered this species belongs to vulnerable category, which means that in natural habitat it is at a high risk for extinction.

Like other natural habitats of ironwood in Indonesia, MSM-PF and its surrounding area including Pangkalan Bulian Villages has also threat mainly by logging and forest conversion. Recently, huge ironwood trees could not be found in this area unless some juveniles sprouting from logged stump. Therefore, promoting ironwood as main species in the rehabilitation program conducted in MSM-PF is very useful not only to increase forest canopy cover but also to prevent this species from extinction. Whereas, some NTFPs species were planted so that community would get direct value from the forest in the near future. Community was involved in every stages of rehabilitation in term of site selection, nursery, planting and monitoring.



Figure 5. Ironwood planting activities in MSM-PF

4. Conclusion and recommendation

4.1. Conclusions

- Priority area of rehabilitation of MSM-PF has been classified into five classes (priority 1 – 5) with number of area is 19 Ha (0.2%), 2,423 Ha (21.3%), 6,490 Ha (57.0%), 2,456 Ha (21.8%), and 1 Ha (0.01%) respectively.
- The focal area of rehabilitation in MSM-PF would be in area classified as priority 1 and 2 with total area about 2,442 Ha (21.5%).
- Promoting ironwood as main species in the rehabilitation program is very useful not only to increase forest canopy cover but also to prevent this species from extinction.

4.2. Recommendations

- Monitoring and evaluation system have to be prepared to ensure successfulness of rehabilitation program
- Involving communities and private sectors is necessary in the rehabilitation program of MSM-PF

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