Identification of Forest Fire Vulnerable Forest Types and Suitable Areas for Forest Restoration in Sri Lanka

Mohan Heenatigala¹, and Geoffrey Duh²

¹. Forest Department, Battaramulla, Sri Lanka
². Department of Geography, Portland State University, Portland, Oregon, USA

Abstract: Forest fire is the main driver on deforestation that severely impact for the forest resources annually. As per the past records of forest fires from the Forest Department, annually about 100ha to 1000ha of forest and forest plantation were destroyed due to forest fire in Sri Lanka. According to the current government mandate called “Vistas of Prosperity of Splendors”, percentage of forest cover of Sri Lanka will be increased from 29.7 to 30 at the end of 2025. In order to achieve this target, forest degradation and deforestation need to reduce while improving the forest restoration activities. In this study shape file like forest cover, population density, forest fire ignition points, temperature and rainfall data from 2000 to 2020, slope and elevation data were used to analysis. Using several GIS tools such as special joints, intersect tools forest fire vulnerable forest type maps was created by using Arc GIS pro software. Multi-criterial analysis technique was used to perform to identification of site suitability for replanting activities. Findings clearly indicated that dry monsoon forests are having high vulnerability for the forest fires followed by the forest plantation. The forested areas that are having canopy cover equal of less than 15% are the area which are more suitable for forest cover enhancement programs. Scrubland, Open and Sparse forested areas that are located in Rathnapura and Kaluthara districts are the best forested areas that can be highly recommended for forest restoration activities. On the other hand, Open and Sparse Forest, Savanah, and Scrubland forested land areas in Monagarala, Hambanthota, Ampara, and Batticaloa Districts can be used for the forest restoration activities.

Key words: forest fire, forest restorations, dry monsoon forest, Multi criterial analysis

1. Introduction

Forest degradation and deforestation are the main causes for the reduction of forest cover in Sri Lanka. Forest fire is the main driver on deforestation that severely impact for the forest resources annually. According to the Forest Department data (Forest Inventory and Management division) annually about 100 ha to 1000 ha of forest and forest plantation were destroyed due to forest fire [1]. Forest Fire damages seem to be increase with time falling to forest resources further threaten. Forested lands contribute about 29.7% of the land extend from the total land in Sri Lanka. The Sri Lankan Government and the Forest Department of Sri Lanka were planned to improve the percentage of forest cover from 29.7% to 30% within next five years [2]. In order to achieve that target forest degradation and deforestation need to reduce while improving the forest restoration activities. On the other hand, still, the Forest Department does not have proper forest fire vulnerable areas maps to identify the threaten forest resources for forest fires.

Forest lands and their abundant lands are more common in the north-central and the northeastern (Fig. 1) parts of the country, where the human population is sparse. In the areas with forest cover (forested lands), Sri Lanka maintains a high biodiversity and ecosystem diversity. Those forested areas are the main catchments of the main rivers and tributaries in Sri Lanka. Under the provisions of forest ordinances and wildlife conservation ordinances, some of the forest areas are declared as conservations, reserve or protected areas to
conserve ecosystem services, biodiversity and, specifically, elephant habitats [4].

Normally, forest fire damages are highly reported in forest plantations like pine [5]. However, when we consider the last few years, forest fire damages in the dry monsoon forests have also significantly increased. Human carelessness is a major cause of Forest fires in Sri Lanka. The problem of forest fire in Sri Lanka can be summarized by examining weather conditions, fuel types in the forest, and human attitudes in the area [1]. The agent causing natural forest fires, such as dry thunderstorms or volcanic eruptions, are not present in Sri Lanka, so all fires have a human origin. Carelessness seems to be the main cause [1]. For example, sources of human-caused fire may include arson, accidental ignition, or the uncontrolled use of
fire in land-clearing and agriculture such as the slash-and-burn farming [6]. Forest fire damages have been increased from 2002 to 2016 (Fig. 2) which have been arisen the question need to prioritize the forest fire management activities to mitigate the fire damages to forest resources. Meantime, when adapting the forest restoration activities like replanting, afforestation, and assisted natural regeneration, identification of less risky forested areas for forest fires is mandatory, because otherwise effort and investment that will allocate for forest restoration activities may be wasted. In the last 10 years the Sri Lankan government has changed its policy regarding its remaining rain forest from one that promoted commercial exploitation to one of conservation. The growing importance of uplands as catchments for water production, biodiversity conservation and other downstream services has been recognized by the Sri Lankan government. In order to achieve optimum output from the forest restoration, rain forest dynamics have been investigated by reviewing of past 15 year research [7].

Forest fire damage on Dry Monsoon forest increased after 2012. Before 2012 sub montane and Forest plantation fire damages were higher than the Dry Monsoon forest types (Fig. 3). This figure (Fig. 3) is giving clear evidence that dry monsoon forest in having high vulnerability for forest fire. Dry monsoon forest is covering about 2/3 of the total forest resources in Sri Lanka. Also in the dry zone, there are useful land areas that can be used for the replanting activities.

Fig. 2  Extend of damage due to forest fire from 2002 to 2019 [3].

Fig. 3  Forest fire damages for different forest type [3].
2. Material and Methods

2.1 Methods

2.1.1 Study Area
The entire Island of Sri Lanka is going to be addressed from the study. Every forest type and administrative area in the entire Sri Lanka will be focused from this study.

2.1.2 Data Used
- Sri Lankan forest cover shape files, Forest Department, Sri Lanka.
- Forest fires ignitions point in different years with shapefiles- NASA-FIRMS.
- Administrative areas shape files, Population census data, Census Department.
- Temperature and Rainfall data, Meteorological Department, Sri Lanka.
- Slope and Elevation data- DEM Sri Lanka- Survey Department.

2.2 A Conceptual Description of the GIS Methods: Forest Fire Vulnerable Area

Using fire ignition points (2012 to 2018) downloaded from NASA, (MODIS satellite data) produced one map using either spatial joint or intersect tools. Each fire ignition point layer from 2012 to 2018, spatial joint was performed to produce one map that was shown the total fire ignitions. Then Intersect tool was used to joint above mention layer with the forest cover layer. Then based on the Joint count (ignition points) within the given polygon the fire vulnerability map was produced. If the no of ignition points are equal to or higher than the 10 then those areas (polygon) consider as forest fire vulnerable areas.

2.3 Site Suitability Analysis for Replanting (Forest Restoration Activities): Multi-criterial Factors That Going to be Considered to Select the Proper Site for Replanting Activities/Forest Restoration

- Meteorological data (Rainfall) converted into raster layers. Past 10-year weather data mapped and converted into raster format and produced one output for 10 year that shows the variability of the weather events.
  - Using DEM, Slope raster layer was produced to cover the Sri Lankan Land used types.
  - Using Rainfall data that were taken from the Meteorological Department of Sri Lanka from 21 island wide measuring stations (District wise distributions). Average Annual rain was calculated. These data are point features, so based on the Inverse Distance Weighted Interpolation (IDW) method point based annual rainfall data were Interpolated to represent the whole country rainfall distributions. (One rainfall distribution raster layer was produced from IDW tool).
  - In order to get the Population densities in each district, population data gathered from the Census Department of Sri Lanka (Downloaded as Excel format) was joint with District boundary layer (add table joint), and the District Boundary vector feature layer was converted into raster forms based on the population densities value.
  - From the forest cover layer, forest fire vulnerable areas were removed using Erase tool and forest fire less vulnerable areas (forest) map was produced and converter into raster format based on the forest types.
  - All four raster layers (Slope, Population density, Average rainfall, Forest fire less vulnerable areas) reclassify into 10 classes. High values were assigned into fewer slope areas (more suitable), less populated areas, high average rainfall received areas and forest classes that are having less forest cover (dense forest received less rank). High slope areas (slope more than 40 degrees) were restricted on multi-criteria analysis, river-rine forest, montane forest were also restricted. Population areas that were having less population density of 250 (per km) can be considered as suitable sites. Moreover, if no of ignition points are less than 30 per annum can decide as suitable sites for forest restorations.
2.4 Weighted Overlay Was Performed on Four Raster Layer Based on Following Weight

- Forest types (less forest fire vulnerable forest types and less forest cover) — 35%.
- Average Rainfall (less drought) — 32%
- Slope — 28%
- Population density — 5%
- Finally, con and Majority filter tools were used to filter out the optimum and best site for replanting activities. Raster values that are having 8, 9, 10 were filtered as the best sites for the forest restoration activities.

3. Results and Discussion

3.1 Results

The Fig. 3 and Fig. 4, clearly show that the dry monsoon forests are having high vulnerability for the forest fires followed by the forest plantation. Dry monsoon forests are located in the North, North-East, East, and South-East part of the Island which received rainfall from North-East Monsoon, active from November to February in every year. Most of the forest fire vulnerable forest types are located in the dry zone of Sri Lanka. The dry zone is also having enough state land bank for forestry activities. Fig. 5 indicates the suitable areas for forest restoration while Fig. 6 shows the best sites for replanting activities. Those areas are needed to need to improve the forest cover of Sri Lanka by proper forest restoration activities.

Multi-Criteria findings to identify the best site for replanting activities.

Fig. 4  Forest fire vulnerable forest types.
Identification of Forest Fire Vulnerable Forest Types and Suitable Areas for Forest Restoration in Sri Lanka

3.2 Discussions

Based on the forest fire vulnerability (Fig. 4) the highest forest fire vulnerable forests types are dry monsoon forest followed by forest plantation. The graph (Fig. 3) plot from the field data, also gave evidence that the findings from the vulnerable are correct. This study was given evidence that the best sites for forest restoration (replanting) are the forested areas that are having canopy cover of less than 15% (Fig. 5 and Fig. 6). These forest types are open and sparse forest lands, scrublands, and savanna lands (rank is 9 and 10). On the other hand, dry monsoon forested areas are also having some potential for replanting activities that cover 2/3 of the total forest lands. High elevation forested lands are normally not suitable for
forest restoration being having high operation and maintenance costs as well as high canopy cover.

Fig. 6  Best Forested areas for forest restoration in Sri Lanka (Con and Majority Filter tools).

Srubland, Open and Sparse forested areas that are located in Ratnapura District and Kaluthara (Fig. 5 and Fig. 6), which can be highly recommended for forest restoration activities. On the other hand, Open and Sparse forest, Savanah, and Scubland forested land areas in Monagarala District, Hambanthota District, Ampara District, and Batticaloa district (Fig. 5) can be used for the forest restoration activities (rank 09/Dark green color). Furthermore, Open and Sparse forests which are located in other districts in the dry zone of
Sri Lanka (Fig. 5) are having some suitability (rank 08/dark red color) for replanting activities that can be used to achieve the forest cover enhancement midterm and short-term targets. As my findings, Open and Sparse forested areas are having high suitability for forest restoration (Fig. 6), because these landscape type is with less canopy cover (less than 15%), received considerable annual rainfall, and having less land sloppiness. Moreover, these forest lands are neighboring the villages and human settlement areas. so labor forces that are need for forest restoration and maintenance activities can be easily found from the neighboring villages. So, forest Restoration in these areas can be more effective and productive. Lastly, couple of years the Forest Department of Sri Lanka has been carried out some field inventory to find out suitable forested areas for forest restoration. These data are tally with my findings and from this analysis, I have recommended additional land areas from the Northern and Eastern, Southern and Central parts of Sri Lanka that are not having adequate data and findings from the Forest Department. According to our skills, and knowledge there are useful land banks situated in the Dry Zone of Sri Lanka that can be easily used to improve the forest cover in Sri Lanka. However, some Studies has identified that some areas in the central hills to restoration activities. The National Physical Plan for Sri Lanka (2011-2030) has correctly identified a ‘Central Fragile Area’ for environmentally friendly development. Over 133,600 ha of environmentally sensitive areas within this critical watershed that are presently under poorly managed cash crop cultivation have been identified for reforestation [8].

Fig. 4, clearly illustrates that Administrative areas like Monaragala, Vavunia, Ampara, Pollonnaruwa are highly impacted by the annual forest fire. As a result of those disturbances that created by the human (Human factors are the main causes for the Sri Lanka forest fire and there are no natural causes for forest fire ignitions) daily life of the people who are living in impacted areas are highly disturbed. My findings of suitable areas for forest restoration can be used by the Forest Department to achieve the targets of forest cover enhancement. In order to improve the forest cover from 29.7% to 33% within the next 5 years, abundant lands, less forest cover lands that are having potential for replanting need to be identify properly. For proper restoration programs, initially we need to have identified and documented these information. From this study, I have Identify those lands that can be easily used to achieve the expected forest cover enhancement targets.

3.3 Validation of the Findings

According to the ground level forest fire data collected by the Forest Department clearly implies that the Badulla district is recorded the highest annual forest fire damages followed by the Monaragala district. The Map shows the forest fire damages in district wise and forest type level (Fig. 3), forest vulnerable forest types are located mostly in these districts. Areas that are suitable for restoration activities are located in the Ratnapura, Kaluthara, Hambathota, Ampara district, except the Badulla districts and some parts of the Monaragala districts (Fig. 6). As the Forest Department ground level figures implies that from the above mentioned district which are located in the dry zone are having high potential for forest restoration.

4. Conclusions

- Dry Monsoon forest has a high vulnerability for forest fire damages fallowed by forest plantations.
- Open and sparse forest, Scrubland which are located in Ratnapura district and Kaluthara District are the best sites for forest restoration activities.
- Open and spares forested land, Savannah lands, and Scublands, areas which are located in dry zone are having high suitability for forest restoration (Replanting activities).
Dry Monsoon forested areas that are having less canopy cover also have the potential for replanting activities.

People who are live in Pollonnaruwa, Monaragale, Ampara, Vavunia are highly impacted by the annual forest fire damages.

References