J.Natn.Sci.Foundation Sri Lanka 2025 54 (2): 171 - 183
DOI: http://dx.doi.org/10.4038/jnsfsr.v54i2.12650

RESEARCH ARTICLE

Forestry

Influence of climate change on the geographic distribution of forest fires and their potential scale in Sri Lanka

M Heenatigala[1*], M Nielsen-Pincus[2], S Dissanayake[2], A Sathurusinghe[3] and C Evers[2]
[1] *Department of Forest Conservation, Sampathpaya, Battaramulla, Sri Lanka.*
[2] *Department of Environmental Science and Management, Portland State University, Oregon, USA.*
[3] *Sri Lanka Climate Fund, Pelawatta, Sri Lanka.*

Submitted: 25 April 2025; Revised: 19 March 2026; Accepted: 20 March 2026

Abstract: Forest fires pose a significant threat to the conservation of forest resources in Sri Lanka. Forest fire modeling is a novel technique to study and predict the behavior of forest fires. This study utilizes simulation techniques to investigate the relationship between forest fire occurrence and climate change particularly in the dry zone of Sri Lanka. The frequency and duration of phenomena such as sea current oscillation *El Niño* southern oscillation (ENSO) change due to climate change, can create extreme dry conditions that increase the risk of intensified fires, especially in the dry zone of Sri Lanka. To assess fire vulnerability under prevailing weather conditions and projected climate change scenarios, the FConstMTT simulation algorithm was used with 1,000 iterations per scenario. In this analysis forest types across Sri Lanka were classified into six classes based on elevation, rainfall, and fuel characteristics. Customized fuel models were created using BehavePlus and spatial data was processed through the ArcFuel extension of ArcGIS. The results indicate that under projected climate scenarios, fire hazards in the dry zone particularly in the districts of Mullaitivu, Monaragala, Anuradhapura, Polonnaruwa, and Badulla, are likely to worsen in the future. In the climate change scenarios, Monaragala district accounted for approximately 53% of total fire damage, with Badulla district showing a significant baseline vulnerability. Anuradhapura district also showed significant levels of fire vulnerability under the projected climate change conditions. Based on fire frequency and intensity, the 25 administrative districts in Sri Lanka were categorized into high, moderate, and low-risk areas. Forest types such as dry monsoon forests, shrublands, open and sparse forests, and savannahs are particularly vulnerable under the predicted climate change scenarios.

Keywords: FConstMTT, fire simulation, dry monsoon forest, ArcFuel, climate change

INTRODUCTION

The world has been experiencing an increase in forest fires due to drier climates. Extreme drought conditions, which are one of the main effects of climate change (Groves et al., 2012) have affected the eruption and spread of forest fires.

In Sri Lanka, forest fire damages are very high in the months between July and October. This period falls within the southwest monsoon season where the dry and intermediate zones of Sri Lanka face dry winds that carry less moisture content favoring fire ignition. Further, less rain and prevailing high atmospheric temperatures in this period make the fuel load drier, creating an optimum condition for forest fires (Ariyadasa, 2002). It is reported that dry monsoon forests and monoculture homogenous forests such as forest plantations (pine) have high dry fuel loads ranging from 35 to 42 tons/ha (Ariyadasa, 2002), compared to other forest types in Sri Lanka.

[*] Corresponding author (mohanhee@gmail.com; https://orcid.org/0000-0003-0081-7435)

When considering forest fires in Sri Lanka, temperature, precipitation, relative humidity, and wind are the four main weather variables that control fires (Hapuarachchi et al., 2015). It has been reported that there are no natural causes such as lightning, heavy winds, or volcanic eruptions for forest fires in Sri Lanka. Anthropogenic factors such as negligence, slash and burn cultivation, and animal husbandry cause forest fires. In dry zone forests weather factors and human impacts are the main contributors to forest fire damages. (Bandara, 2019). According to the Forest Department, approximately 100 ha to 2000 ha of forest and forest plantations are destroyed due to forest fires annually in Sri Lanka showing an increasing trend in the occurrence and extent of fire damage over time. Figure 2 illustrates the extent of the area damaged by forest fires from 2002 to 2019 (source: Forest Department). Usually, forest fire damages are high in pine forest plantations (Pathirana, 1998). However, in recent years' forest fire damages in the dry monsoon forests have also increased significantly.

There are several forest simulation models developed by the United States Department of Agriculture (USDA) to predict risk areas for wildfire under prevailing conditions and potential climate change scenarios. These models are Fsim and FConstMTT, FSpro and FlamMap (Scott et al., 2013). In Sri Lanka, investigations on modeling the risk of forest fires have not been done before. As some forest types in Sri Lanka are comparable to the forest types in Brazil and the USA, studies done in those countries are applicable here. The study conducted by Guedes et al. (2019) in the Paraiba do Sul River Valley in Brazil to identify the vulnerability of small forest patches for forest fires, using the FConstMTT fire simulation algorithm can be taken as an example.

The objectives of our study were to identify the relationship between climate change and forest fire occurrence in Sri Lanka, to develop a fire model platform capable of simulating a library of plausible fires under prevailing and projected conditions, and to identify and map forest fire vulnerable areas in Sri Lanka.

MATERIALS AND METHODS

Study area

The total land area of Sri Lanka was selected as the study area for this study. The study covered all forest types managed under the Department of Forest Conservation (DFC) and the Department of Wildlife Conservation (DWC) (Figure 1).

Data collection

Weather data including rainfall, temperature, relative humidity, wind speed and wind direction were obtained from the Meteorological Department of Sri Lanka. Data pertaining to the extent of forest fire damage in different forest types, forest fuel loads, canopy height, location of fire ignition, perimeter of damage, value of fire damage, fire control efforts, and the distance to the nearest village or residential area from the location of fire were obtained from the DFC. All weather and fire data were collected over a 20-year period, from 2000 to 2020. Data on forest canopy cover, canopy height and canopy base height, were taken from the National Forest Inventory data collected by the DFC from 2017 to 2018.

As data on canopy bulk density and fuel moisture content were not available in Sri Lanka for the relevant forest types concerned, this information was sourced from foreign studies conducted in Brazil (White et al., 2012), Netherlands (Oswald et al., 2017), USA (Scott et al., 2005) and India (Mondal et al., 2016). Since field level data for fuel moisture content was unavailable for herbaceous and woody vegetation at 1 hr, 10 hrs and 100 hrs time lag periods, relevant data were taken from the above published studies.

Preparation of forest fire vulnerable area maps

Vulnerable areas for forest fire were mapped using ArcGIS geographic information system, and vulnerable forest areas were identified in a sequential manner.

Identification of climate change impact on forest fire occurrence and distribution

Since dry weather reduces fuel moisture content, wind speeds were used for fire simulations.

Preparation of landscape files (LCP)

A digital elevation model of Sri Lanka obtained from the DFC was used to derive raster layers of elevation, slope, and aspect, using ArcGIS Pro. An Excel spreadsheet was prepared for canopy cover, canopy bulk density, canopy base height, and fuel model, listing the magnitude for each parameter for each forest type. Data on canopy cover, canopy base height, and canopy height were taken from the National Forest Inventory data collected in 2017 and 2018. Custom fuel models were prepared to represent each forest type in Sri Lanka.

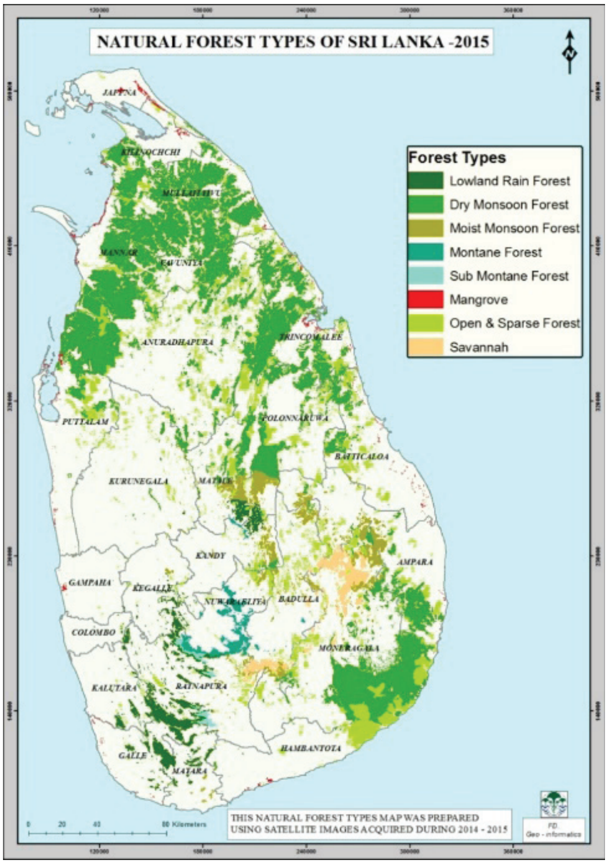

Figure 1: Forest cover map of Sri Lanka based on the 2015 forest inventory data (Source: Department of Forest Conservation, Sri Lanka).

Custom fuel models

Custom fuel models were derived based on Scott et al. (2005), White et al. (2012) and Oswald et al. (2017). Sri Lankan forest types were categorized based on elevation and rainfall pattern as (i) dry monsoon forest (ii) forest plantation (iii) high elevation wet forest (iv) low elevation wet forest (v) scrubland and (vi) open & sparse forests. The custom fuel models were numbered from 30 to 36 except number 33. The 'BehavePlus' computer application was used to develop these custom fuel models. It has been reported that the surface fuel load of a tropical forest ranges from an average of 12.5 t/ha to 40 t/ha (Ariyadasa, 2002) while forest plantations have an average of 10 t/ha to 15 t/ha. The surface fuel load in a low elevation forest ranged from 13 t/ha to 17 t/ha while in scrubland and grassland it averaged 9.18 t/ha, and 3.7 t/ha, respectively. The fuel bed depth in wet forests and dry forests was measured at 0.6 - 0.9 m and 0.45 m, respectively, while in forest plantation it was 0.3 m.

Fire simulation

Fire simulation was conducted using FconstMTT fire simulation executive files, which uses the minimum travel time (MTT) algorithm (Finney, 2002). This algorithm is commonly used to model fire spread and analyze burn probability in the United States Forest Service. The FConstMTT wildfire simulation algorithm uses mandatory switches as inputs for the simulation process including Landscape Files in .lcp format, resolution of the simulations (cell size), grid distance unit (either in meters or feet), wind speed (miles per hour), wind direction, number of fire iterations, fuel moisture files in fms format, FConstMTT output file name and locations, and duration of the fire in hours. Since the dry and intermediate zones face dry wind conditions during the southwest (SW) monsoon, the wind direction was considered as of 225 with a wind speed of 4 miles per hour based on data from the Meteorological Department of Sri Lanka. Data for fuel moisture content was taken from the study done by White et al., (2012) in the Itabaiana National Park, Brazil. Based on the simulation results, districts were categorized by the extent of damage, number of ignitions, and the extent of damage per ignition (Figure 3).

Justification for using Brazilian studies for fire simulation

- Both Sri Lanka and Brazil have tropical and subtropical forest ecosystems located near the equator, sharing similar climate characteristics such as high temperatures, seasonally variable rainfall, and relatively consistent humidity patterns that influence vegetation moisture dynamics.
- Cross regional data application is an accepted interim practice in ecological modeling, especially in regions where empirical data collection is limited. Previous studies (e.g., Guedes et al., 2019) have demonstrated the validity of using data from ecologically analogous regions to model fire behavior in data-scarce environments. While recognizing the inherent limitations of using proxy data, this study selected Brazilian fuel moisture content values due to ecological comparability and the urgent need to assess fire risk in Sri Lanka under climate change. The results offer a preliminary yet valuable baseline for understanding potential fire behavior, pending future field-based calibration and validation efforts in local forest ecosystems.

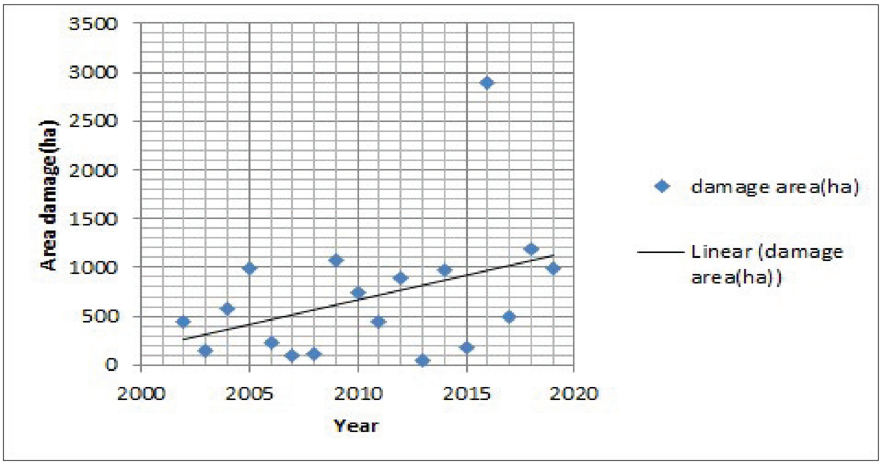

Figure 2: Extent of area damaged by forest fires from 2002 to 2019 (Source: Department of Forest Conservation, Sri Lanka).

Data for canopy bulk density were based on studies done in some forests in Brazil, the Netherlands, and the United States that are comparable to forests in Sri Lanka. These data were used for the analysis after some modifications together with the data obtained from the National Forest Inventory, which were done on Sri Lankan Forest types.

To identify the impact of climate change on forest fires, a simulation was conducted with 1000 iterations under dry weather conditions and low fuel moisture content (with 1hrs, 10 hrs and 100 hrs time lag periods, for both woody and herbaceous vegetation). These fire locations were determined based on an ignition grid (Figure 3) created using the kernel density tool in ArcGIS pro with historical fire data downloaded from the MODIS satellite platform and weather data.

The output from the fire simulation process for dry weather conditions was compared to scenarios to determine the impact of climate change on forest fire occurrence and spread in Sri Lanka. The simulated fire results were overlaid with the forest cover layer to identify the most affected forest types by forest fires under projected climate change scenarios. Since 1000 fire iterations would not be sufficient to saturate the forested landscape to obtain a precise value, the burn probability was calculated using equation 1 (Guedes et al., 2019) to calculate it numerically.

$$Burn\,probability = \frac{Total\,Fire\,damege\,area(ha)}{Total\,forest\,land\,areas(ha)} \qquad ...(01)$$

Based on equation 1, the burn probability for the entire forest area of Sri Lanka was calculated under the baseline and projected climate change scenarios for each district and forest type category. Results were visualized on a bar chart to get a clear understanding on the change that would occur under both situations.

Weather data for the past twenty years for temperature, wind speed and direction, and relative humidity in all districts were plotted using Excel to identify the weather variability in each district, particularly the districts falling within the dry zone and the intermediate zone. Statistical analysis was done to verify the significance of variations in temperature, rainfall and relative humidity.

The fire simulation results were compared with weather variables to identify areas prone to increased forest fire occurrence under impending impacts of climate change. Results were prepared using ArcGIS maps, graphs, and tables. Ground level fire data obtained from Badulla, Puttalam, Anuradhapura and Monaragala districts were used to validate the results. These data were converted to percentage values based on the total damaged area and compared with the values obtained for the two scenarios.

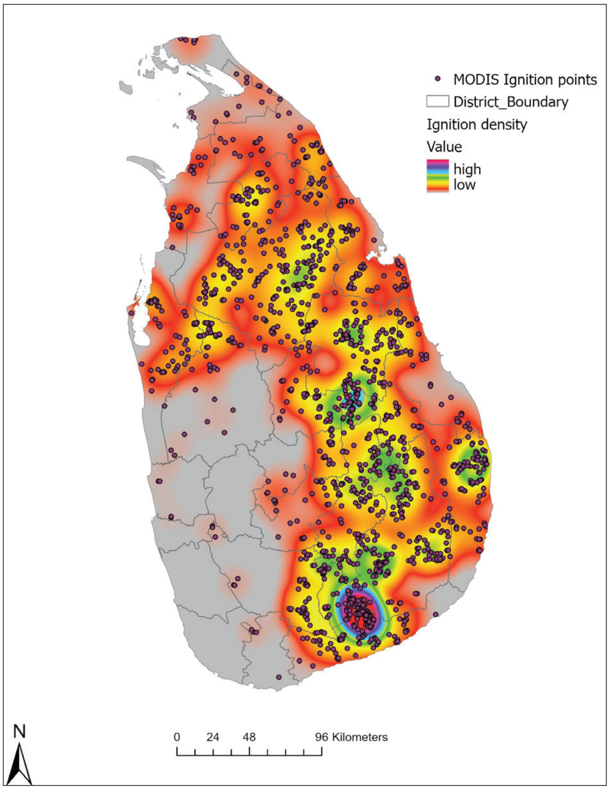

Figure 3: Ignition density map used to make an ascii grid file to be used as an input (as one of the switches in the simulation model) on FConstMTT fire simulation process.

RESULTS AND DISCUSSION

The landscape file representing Sri Lanka is shown in Figure 4. Historical fire data indicate that most forest fires fall under the surface fire category, with very rare occurrences of crown fires. In this context elevation, slope, aspect and fuel models play a more significant role in fire behavior than the canopy characteristics. Forests in the east, north, southeast and northeastern parts with high dry burnable fuel loads are categorized as the forest fire vulnerable areas in Sri Lanka. Figure 4 shows that the landscape file (LCP) derived from ArcFuel with eight raster layers including elevation, slope, aspect, fuel model, canopy cover, canopy height, canopy base height and canopy bulk density from the top left to the bottom right. The LCP reveals that most forest plantations, dry monsoon forests, and sub montane forests have high fuel loads (13-30 mt/ha) that become more inflammable under dry weather conditions. The fuel moisture content decreases over time periods of one hour, 10 h, and 100 h in woody and herbaceous vegetation.

Fire simulations were done under baseline and projected climate change scenarios. Figure 5 summarizes the simulation results showing that compared to the baseline condition, parameters such as fire intensity line and area damaged by fire increased in the predicted scenario for all districts. In Monaragala, Ampara and Anuradhapura districts, the projected climate change scenario significantly increased fire damage to forests (Figure 6). As shown in Figure 6 (left), the number of fires increased from 375 and 409 under the baseline condition and climate change scenario, respectively. For districts in Figure 6 (left), these numbers were as 316 and 324.

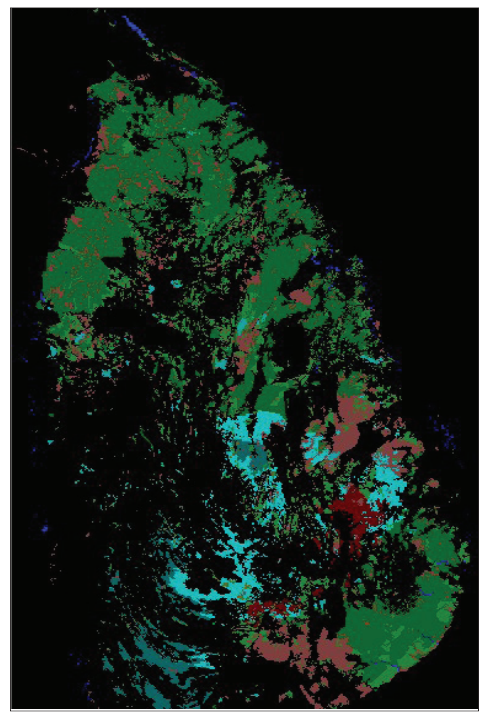

Figure 4: Landscape file map with the eight themes elevation, slope, aspect, fuel model, canopy cover, canopy height, canopy base height and canopy bulk density (raster layers).

Monaragala district had the highest simulated forest fire damage under baseline conditions as well as the projected climate change scenario, which were about 726 acres and 387 acres, respectively. For the northcentral and north eastern parts of the country, the simulated fire damage was 247 acres and 518 acres, respectively, under both conditions (Figure 6 (left)).

The fire intensity level (FIL) is the rate of heat energy released per unit length of the fire front (Byram, 1959;

Scott, 2012), which depends on the rate of spread (ROS) of the flame, forest fuel type, fuel load, and forest fuel moisture content (McEvoy et al., 2020). In this study, the fire intensity level increased, but not significantly, with the projected climate change scenarios compared to the baseline condition. This means that the intensity of fire damage due to fire occurrence has increased making the fire more hazardous for forest resources under the impact of climate change.

In the Anuradhapura district, the FIL increased slightly under the simulated climate change scenarios (Figure 7). However, despite this slight increase, the ROS and flame length increased significantly in the Anuradhapura district. In the Monaragala, Badulla and Ratnapura districts, FIL3 was slightly higher under climate change conditions when compared to the baseline level (Figure 8).

However, these figures are considerably higher in average fire intensity level (FIL) and FIL3 under climate change conditions than the baseline level (Figure, 8) but the rate of spread (ROS) of the fire, flame length (FL) and heat release per unit area, which determine the fire severity, smoke production and crown scorch height (Scott, 2012) increased significantly under the projected climate change scenarios when compared to the baseline condition. This means that the fire hazard has increased significantly under the climate change scenario indicating that forest resources are facing a serious threat. The vulnerability of forest resources in the country will be increased in the future under drier and hotter weather conditions.

From 2006 to 2009 there were no records reporting damages to the dry monsoon forest due to forest fires (Figure 9). During this period, forest plantations were the most vulnerable forest category. On the other hand, after 2009, a significant increase in forest fire damage was recorded in the dry monsoon forests. Burn probability was calculated from ratios between the total burned area and total forested area for a particular district. As shown in Figure 10, Badulla district has the highest burn probability under the baseline conditions. This means that the future risk for fire vulnerability under climate change scenarios in the Badulla district is significantly reduced. Due to the probability of rainfall occurrence increasing and changing wind characteristics in the Badulla district, the fuel moisture content will increase. Therefore, the burn probability in the Badulla district will be drastically reduced with the modeled climate change scenario.

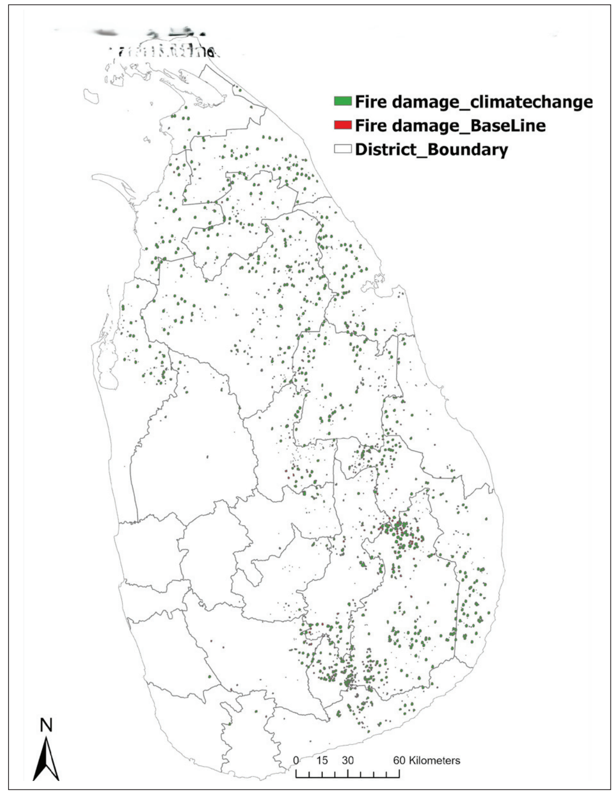

Figure 5: Fire simulation output result under the projected climate change and baseline scenario (Total simulated damages for the 1000 fire iterations are 293,758 acres and 56,617 acres on both projected climate change and baseline scenario.)

Forests in the Monaragala, Anuradhapura and Mullaitivu districts have become the most vulnerable forests for forest fires under impending climate change scenarios. In the Matale and Ampara districts, the burn probability is less severe under the climate change scenario. Currently the Matale district is considered a moderately forest fire vulnerable district. It is shown that Matale has become a less vulnerable district for forest fires under the future climate change scenario. When the burn probability of different forest types is compared (Figure 11), dry monsoon forests show the highest burn probability followed by open and sparse forests, and forest plantations under baseline conditions, while open and sparse forests show the highest level of burn probability under projected climate change scenarios. Thus, it can be concluded that dry monsoon forests, and open and sparse forests show the highest vulnerability for forest fires in impending climate change events (Figure 11). Based on the baseline scenario, the Monaragala district shows the highest fire damage.

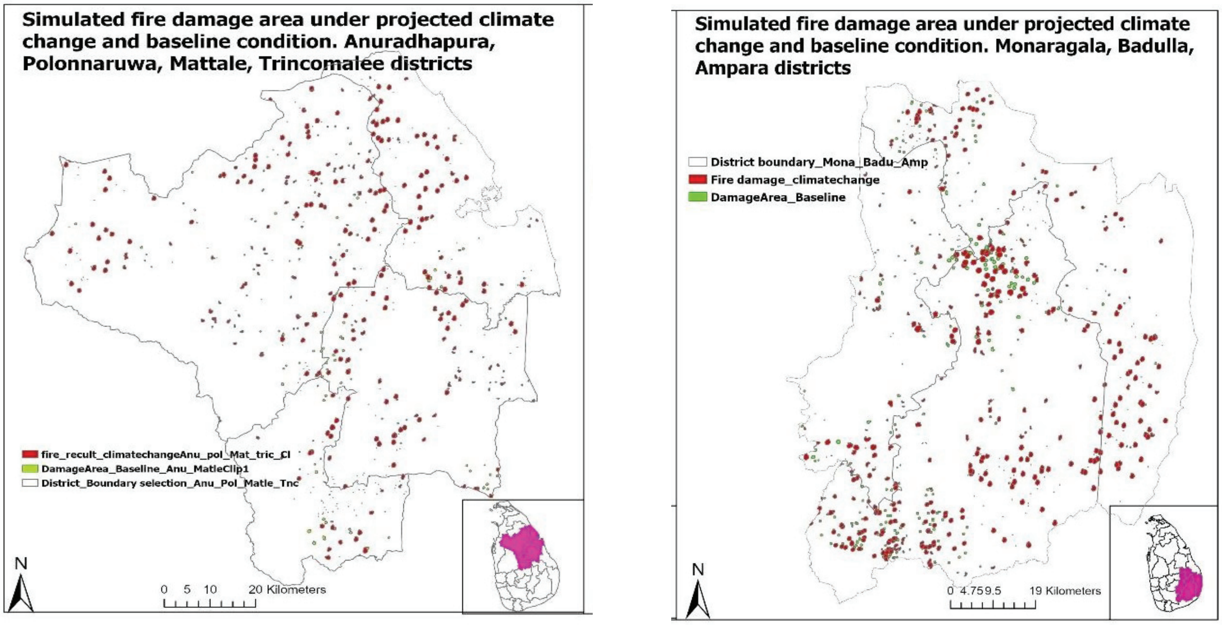

Figure 6: Forest area damaged by simulated fire under baseline conditions and the projected climate change scenario in (left) Anuradhapura, Polonnaruwa, Matale and Trincomalee districts and (right) Monaragala, Badulla and Ampara districts.

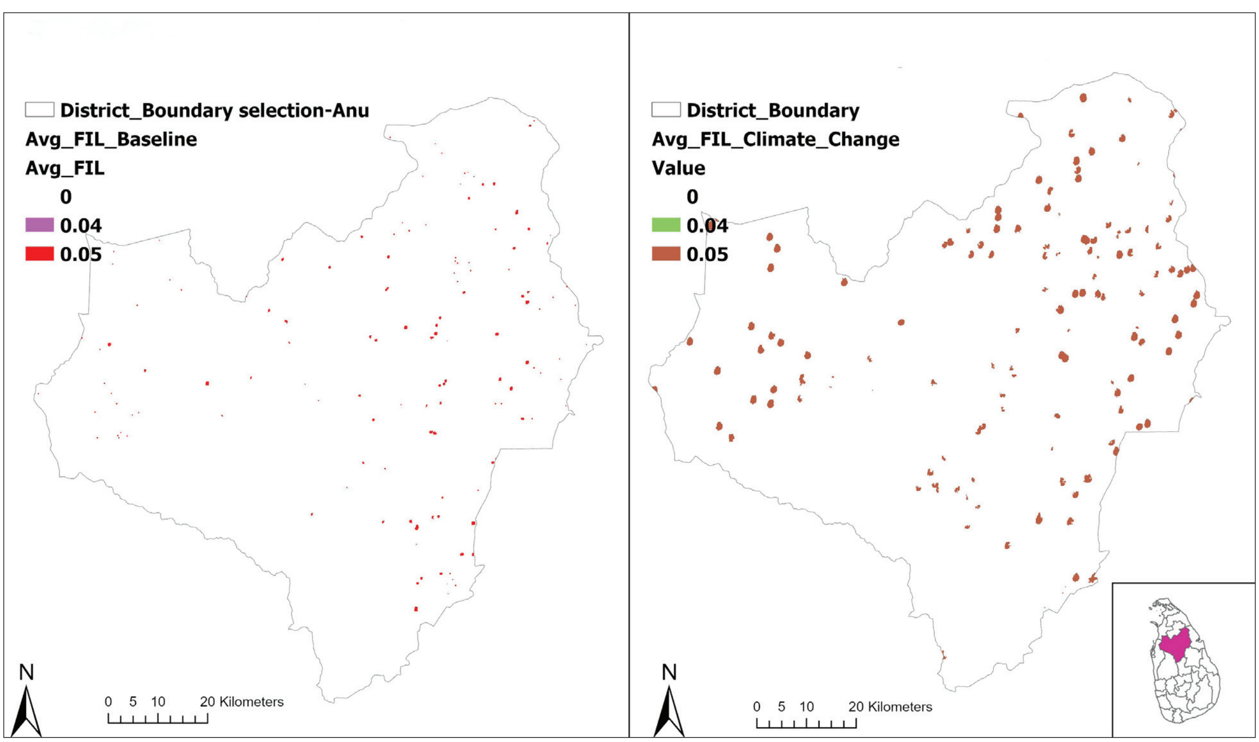

Figure 7: Average Fire intensity level (FIL) under (left) the baseline condition and (right) projected climate change scenario in the Anuradhapura district.

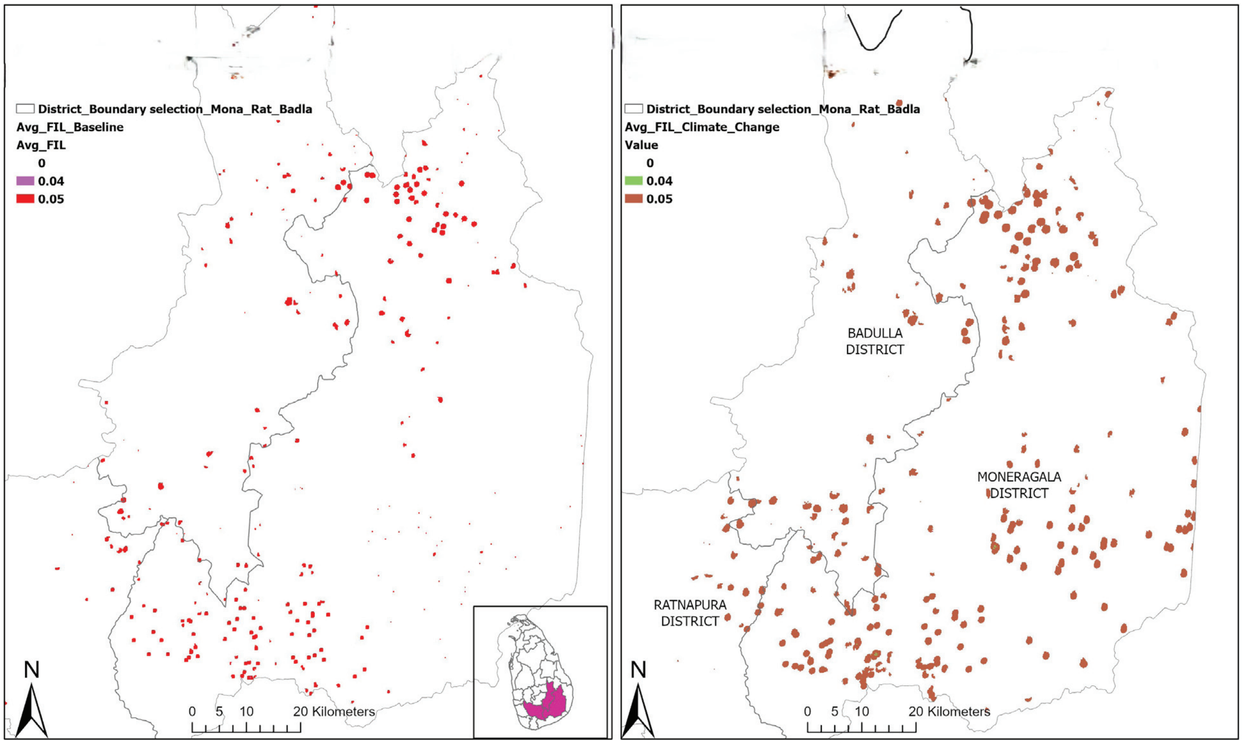

Figure 8: Fire intensity level 3 (FIL3) under (left) the baseline condition and (right) projected climate change scenario in Monaragala, Badulla and Ratnapura districts

Risk areas were categorized as low, moderate and high forest fire areas, based on the total forest area damaged by fire, number of fire ignitions, and the area damaged per one fire incidence (Figure 12). The threshold level was decided based on the total extent of the damaged area and the number of fire ignitions. It was found that under projected climate change scenarios, the severity of fire damage and fire hazard increased drastically in the Monaragala district.

When the projected climate change scenario is considered, Figure 12 (left) shows that Monaragala, Ampara and Anuradhapura districts are at high risk based on the total damaged area while Figure 12 (right) shows that Monaragala, Ampara, Anuradhapura, Polonnaruwa, Trincomalee, and Mullaitivu districts are at high risk based on the number of fire ignitions.

The total simulated fire damage area was approximately 293,758 acres and the Monaragala district accounted for 41% of the damage. Assessment of data in the past few years shows that the dry monsoon forest has the highest forest fire damage. Figure 13 (left) shows that dry monsoon and open and spare forests are prone to the highest forest fire damage. Forest types in the districts in Figure 13 (right), including dry monsoon forests, scrubland and savannah, open and sparse forest and forest plantations reported the highest vulnerability for forest fire damages in descending order. In this study, the simulated baseline results were validated with actual field data obtained from the DFC.

Field data on the extent of forest fire damage for districts in this study obtained for the years 2016 and 2018 were used for validation. These two years were selected because they reported the highest forest fire damages in the country compared to other years. The fire results obtained in this study by simulation under the baseline conditions were clearly validated with the field level data. In Sri Lanka, one of the main causes of forest fire damage is human involvement as there are no natural causes for forest fires such as heavy winds and lightning. The forest fire season in Sri Lanka is from July to September. Some of the causes of forest fires are careless behavior by tourists in forested areas, intentional or accidental ignition of fires to clear land for chena cultivation to chase animals away, or to create new pasture land for cattle herding.

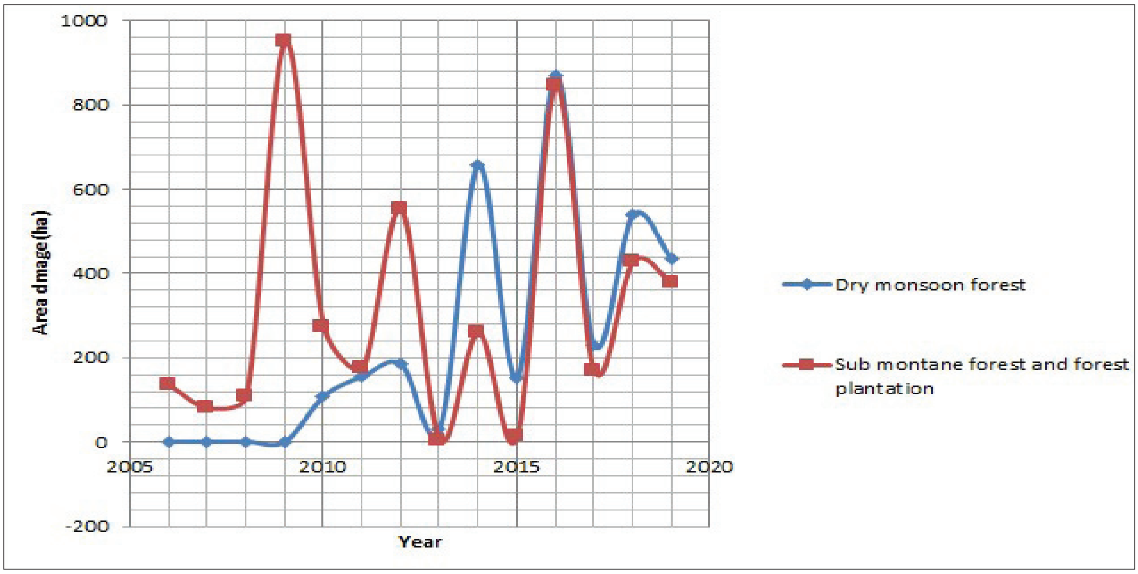

Figure 9: Forest fire damages from 2006 to 2019 in the dry monsoon forest and forest plantation and sub- montane forest (Source: Department of Forest Conservation)

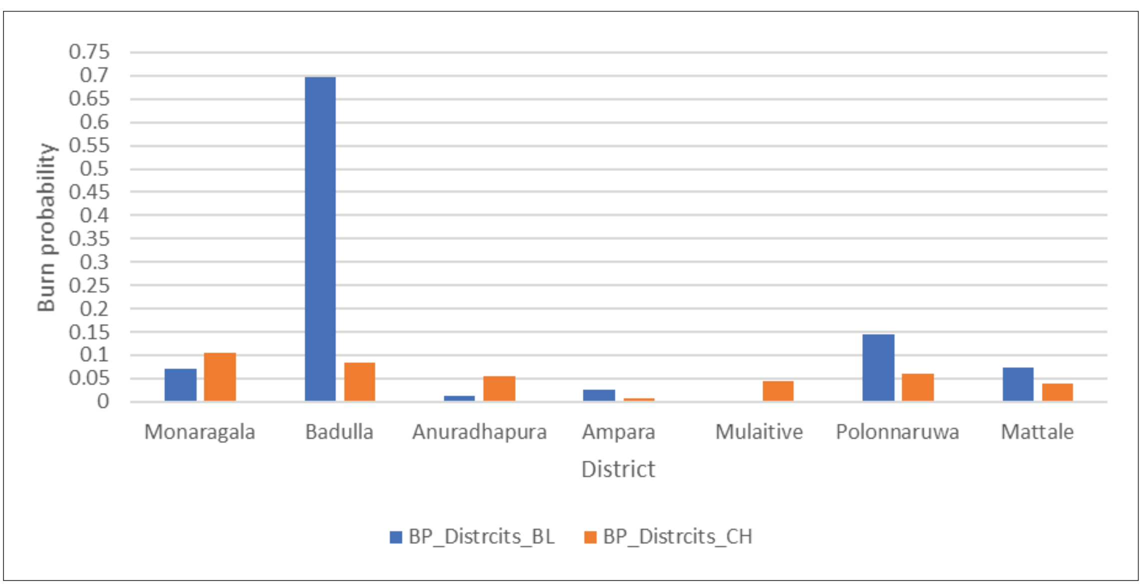

Figure 10: Burn probability under baseline scenario (BL) and projected climate change scenario (CH) in Monaragala, Badulla, Anuradhapura, Ampara, Mullaitivu, Polonnaruwa and Matale districts

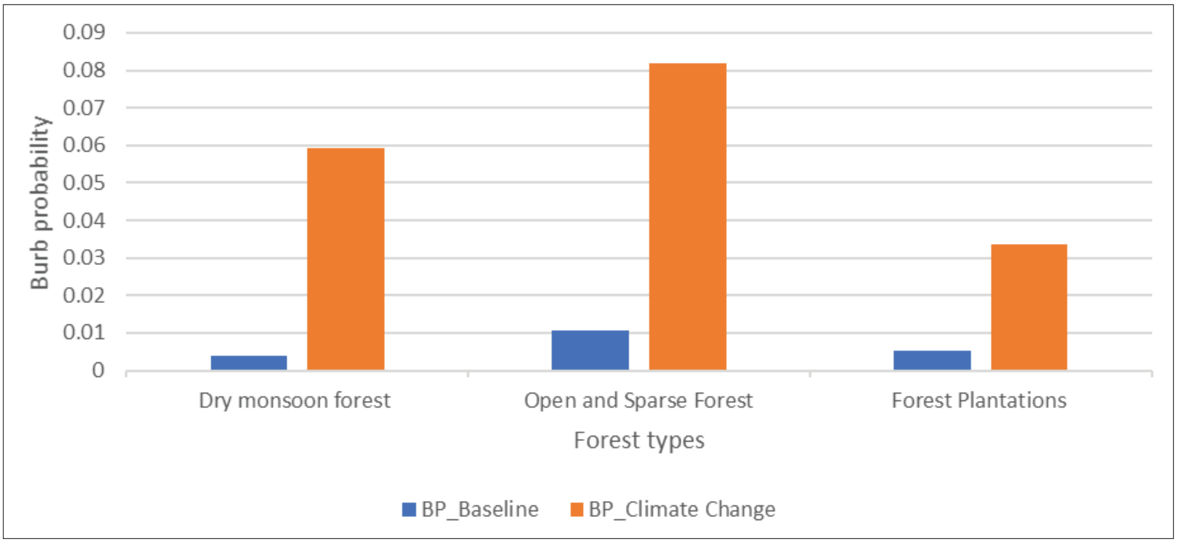

Figure 11: Burn Probability of simulated fire under baseline condition and projected climate change scenario for different forest types in the study.

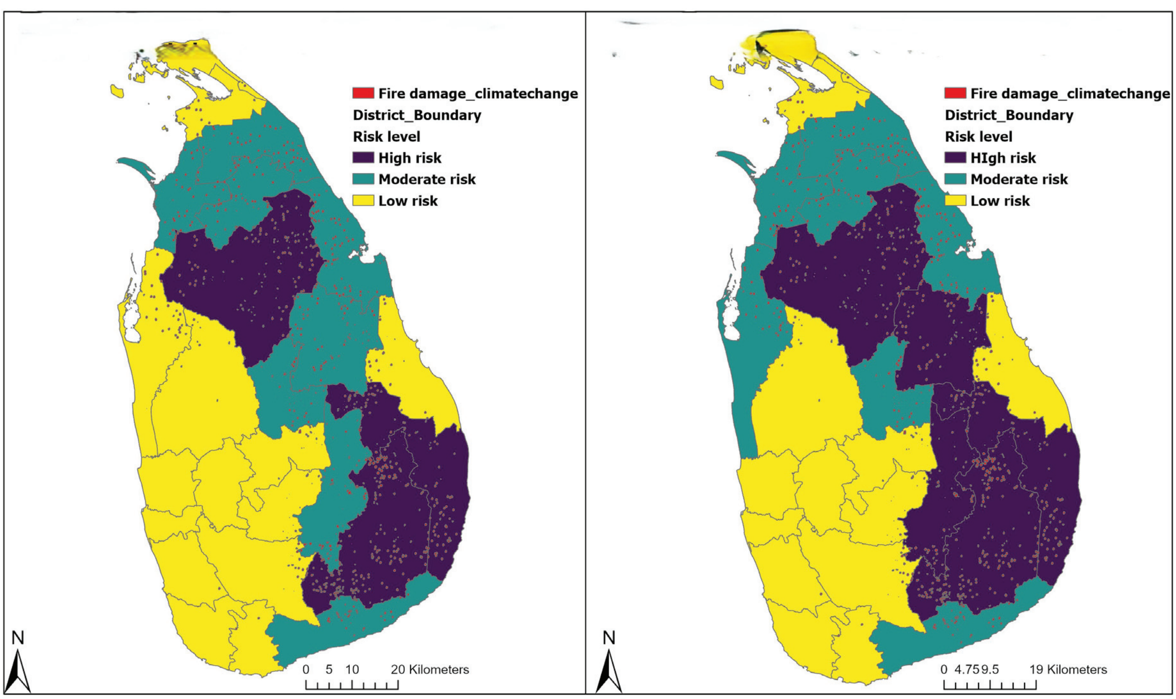

Figure 12: Risk area assessment in fire simulation for the country under the projected climate change scenario based on (left) the total area damaged by forest fires and (right) the number of fire ignitions.

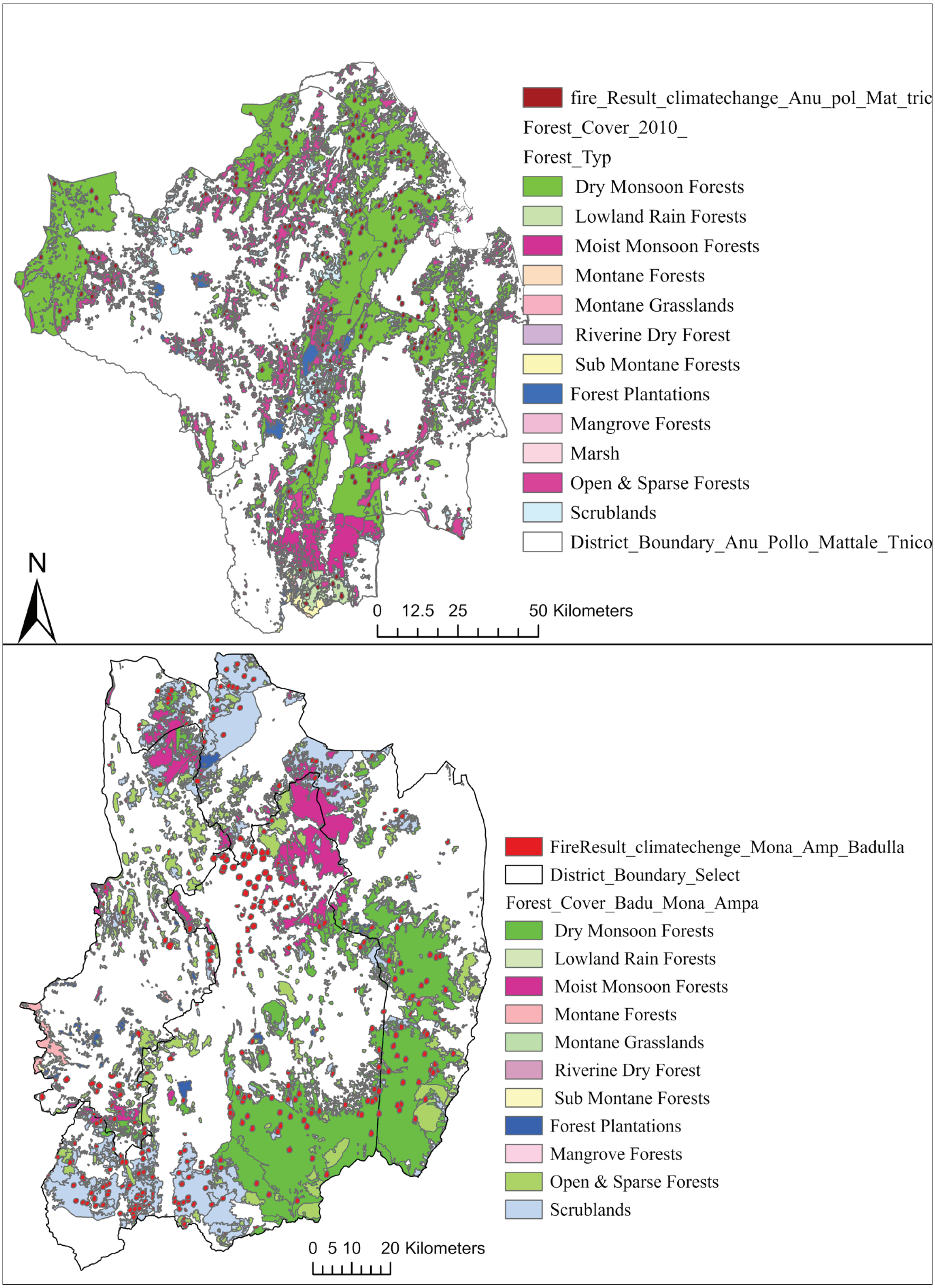

Figure 13: Risk forest types for forest fire damages under the projected climate change scenario (upper) Anuradhapura, Matale, Polonnaruwa and Trincomalee districts (lower) Monaragala, Badulla and Ampara districts.

It was noted that most forest fire ignitions start from open and sparse forests and spread to dry monsoon forest types, which are often located adjacent to them. This is the main reason for dry monsoon forests having the highest forest fire damages under both climate change and baseline scenarios. Analysis of historical fire occurrence data indicates that many ignition locations are associated with open and sparse forest areas. These vegetation types are often located adjacent to dry monsoon forests, facilitating the spread of surface fires into these forests and resulting in higher fire damage levels in dry monsoon forest ecosystems under both baseline and projected climate change scenarios. Previous studies have shown that forest fire ignition in Sri Lanka is strongly associated with human activities such as chena cultivation, tourism-related negligence and livestock grazing practices (Ariyadasa, 2002; Bandara et al., 2019). Similar patterns have been observed in this study where many ignition points occur in accessible forest landscapes. This suggests that human accessibility may contribute to fire ignition in these areas, although the present study primarily focuses on fire spread dynamics rather than ignition mechanisms.

Fire simulation can also be used to evaluate how fire is expected to spread across the landscape including the likelihood and intensity of expected fires (McWethy et al., 2018). The projected increase in the number of simulated fire occurrences under the climate change scenario does not represent an increase in human ignition sources. In the simulation framework used in this study, ignition locations were kept constant while climatic variables influencing fire behavior such as fuel moisture content, wind speed and burning duration were modified to represent projected climate conditions. Under drier and warmer conditions, fire spread characteristics such as rate of spread, flame length and burn probability increase significantly. Therefore, once ignition occurs, fires are more likely to propagate across larger areas, resulting in a higher number of simulated fire events and increased burned area under the projected climate change scenario. The study reported a 3.8-fold increase in fire damaged areas over the whole island under the projected climate change scenario. In this analysis, the burning period of the baseline condition was set to 180 minutes, which aligned with the 2016 fire information obtained from the DFC and the burn period of the projected climate change scenario was set to 210 minutes with a slight increase in wind speed. Burn probability in the Monaragala, Anuradhapura and Mullaitivu districts increased significantly under the projected climate change scenario.

In addition to the increase in forest fire hazards, the fire size also increased significantly in almost all the districts in the dry zone of Sri Lanka. The distribution of fire ignitions is influenced by several causes such as climate factors (rainfall and temperature) and vegetation type that determine the continuity of fire, significance, fuel characteristics, and population density and level of human activities (Holz et al., 2012). Hot, dry and windy conditions accelerate large fires in dry monsoon forests, scrublands, forest plantations, including savannah forests that can be found in Badulla and Monaragala districts. It was evident that warming and drying trends that are projected to continue in the future under the climate change scenario, would affect a major part of the dry zone to promote fires in its fuel-rich forests, such as dry monsoon forests and forest plantations.

CONCLUSIONS

Forest fire modeling conducted in this study aimed to explore the behavior of forest fires in the dry and intermediate zones of Sri Lanka under potential climate change scenarios. The results have shown that forests in these zones are at a significant risk of increased fire damage in the future due to climate change.

Dry monsoon forests are the most vulnerable to forest fires under projected climate change conditions, followed by open and sparse forests and scrublands. Monaragala and Anuradhapura districts show a higher vulnerability compared to other districts. Forests within and around places where there are areas with high human impact are more prone to fire, with ignition usually beginning near roads and spreading into forested areas. In such instances, fire spreads initially affect village-type forests such as open and sparse forests before spreading into nearby dry forests, scrublands and forest plantations.

This study reveals a significant increase in burn probability, damaged area and fire intensity under the projected climate change scenario. This suggests that the dry zone will be threatened by more fire hazards in the future necessitating more focused forest fire management strategies to address this situation.

This study provides valuable insights for identifying high-risk areas for forest fires in the country. Effective forest fire management strategies should include guarding high-risk ignition locations, maintaining existing fire belts, establishing new fire belts, managing fuel in vulnerable forests and plantations at risk, and establishing fire protection units by the communities affected by forest fires. Findings generated by this research study can be used to anticipate, prevent, and control forest fires more efficiently and develop more effective forest fire management strategies aimed at mitigating forest fire damage.

Acknowledgement

This project is carried out for the fulfillment of the requirement of my Master Degree of the Environment Management at the Portland State University, Oregon, USA. This Graduate Degree was funded by the Ecosystem Conservation and Management (ESCAMP) project which is financially assisted by the Word Bank. Therefore, my sincerely gratitude given to The ESCAM project. Moreover, my special thanks are going to the Forest Department and the Meteorological Department in Sri Lanka because of giving required data for the project. Furthermore, Special thanks are extended to Dr. Linnea Spitzer for her support in reviewing and refining the English language of the manuscript.

REFERENCES

Ariyadasa, K.P. (2002). Fire Situation in Sri Lanka, *International Forest Fire News*, Food and Agriculture Organization, 26, 96-100.

Bandara, I., Meegahakotuwa, U. and Nianthi, R. (2019). ‘Risk of Forest Fire in Uva Province of Sri Lanka’, *Proceedings of the 24th International Forestry and Environment Symposium 2019,* Department of Forestry and Environmental Science, University of Sri Jayewardenepura,

Byram, G. M. (1959). Combustion of forest fuels. In: Forest fire: Control and use, 2nd edition. New York, NY: McGraw-Hillpp. 61-89.

Finney, M. A (2002). Fire growth using minimum travel time methods. *Canadian Journal of Forest Research*, *32,* 1420-1424.

Groves, G.R., Game, E.T., Anderson, M.G., and Cross, M. (2012). Incorporating climate change into systematic conservation planning. *Biodivers Conserv, 21*, 1651-1671.

Guedes, B. J., Massi, K. G., Ever, C., Nielson-Pincus, M. (2019). Vulnerability of small forest patches to fire in the Paraiba do Sul River Valley, southeast Brazil: Implications for restoration of the Atlantic Forest biome, *Forest Ecology and Management,* 465, 118095.

Hapuarachchi, H. A. S. U., Jayawardena, I. M. S. P. (2018). Modulation of Monthly Rainfall in Sri Lanka by ENSO and ENSO Modoki Extremes. *Sri Lanka Journal of Meteorology. 3,* 28-42.

Holz ,A., Kitzberger, T., Paritsis, J. ,and Veblent T.T. (2012). Ecological and climatic controls of modern wildfire activity patterns across southwestern South America. *Ecosphere, 3*, 11-103.

Kyte, R., 2018. Climate Change Is a Challenge for Sustainable Development, Gaidar Forum, Wold Bank.

McEvoy, A., Nielson-Pincus, M., Holz, A., Catalano, A. J. and Gleason, K.E. (2020). Projected Impact of Mid-21st Century Climate Change on Wildfire Hazard in a Major Urban Watershed outside Portland, Oregon USA. Fire.

McWethy, D.B., Pauchard, A., Garcia, R.A., Holz, A., Gonzalez Veblen., T.T, Stah, J. and Currey, B. (2018). Landscape drivers of recent fire activity (2001- 2017) in south-central Chile. PLoS ONE, *13*, 10-28 e0205287, https: //doi.org/ 10.1371/ journal.pone. 0205287.

Mondal, N. and Raman Sukumar, R. (2016). Fires in Seasonally Dry Tropical Forest:Testing the Varying Constraints Hypothesis across a Regional Rainfall Gradient. PLoS ONE *11*(7), e0159691, https: //doi.org/10.1371/journal. pone.0159691

Oswald, B.P., Brouwer, N. and Willemsen, E. (2017). Initial Development of Surface Fuel Models for The Netherlands, Forest *Res,* 6, 207.

Pathirana, N.R. (1998). Survey on Sri Lankan Forest Fires. *Wana Widhurawa,* , 82 -86.

Scott, J. H. (2012). Introduction to Wildfire Behavior Modeling. National Interagency Fuels, Fire, & Vegetation Technology Transfer. Wildland fire Management, https://pyrologix. com/wp-content/uploads/2014/04/Scott_20121.pdf

Scott, J.H. and Burgan, R.E. (2005). *Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel’s Surface Fire Spread Model*, General Technical Report RMRS-GTR-153, United States Department of Agriculture& Forest Service. Rocky Mountain Research Station. U.S. Department of Agriculture & Forest Service, Rocky Mountain Research Station. p.72.

Scott, J.H., Thompson, M. P., Calkin, David, E. (2013). *A Wildfire Risk Assessment Framework for Land and Resource Management*, General Technical Report, RMRS-GTR-315., United States Department of Agriculture & Forest Service, Rocky Mountain Research Station. 83 .

White, B.L.V., Ribeiro, A.S., Ribeiro, G.T., Souza, R.M. (2012). Building fuel models and simulating their surface fire behavior in the Serra De Itabaiana National Park, Sergipie, Brazil, *Floresta*, 43:27,