Assessment of Forest Fires Risk in U Minh Ha National Park-Vietnam and Proposed Adaptation Measures

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Abstract. Forest ecosystems are part of the vital and indispensable resources for human survival and social development. Forests not only provide materials such as wood and firewood for some industries, but also maintain and protect the environment, such as climate regulation, erosion control and sedimentation, water regulation and flood mitigation. However, due to some uncontrolled activities of people and abnormal natural conditions, forest fires occur more frequently and severely. U Minh Ha National Park (UMHNP) is one of forest which has the highest risk of forest fires in the Mekong Delta. This study was conducted to assess the status of forest fires and the impacts of climate change on forest fire risk in UMHNP then proposed appropriate measures to reduce the risk of forest fire to minimize damage to the environment, humans, biodiversity, economics as well as people’s livelihoods protection in the Mekong Delta. By the method of data collection and rapid assessment, the topic has statistics of fires within 5 years as well as causes, key areas and its impacts on forest ecosystems. At the same time, it was pointed out that UMHNP is facing an increasing risk of forest fire due to climate change. Forest fire prevention and fighting in UMHNP is being well implemented but still faces some difficulties. Therefore, it is necessary to take appropriate measures such as strengthening communication, completing mechanisms and policies, supplementing fire protection equipment and facilities to improve environmental quality and local’s people life.

Keywords: Melaleuca, forest, climate change, sustainable

1. Introduction

Forest ecosystems play an important role in human life. It maintains the habitat and contributes to the sustainability of each country. Forests provide not only raw materials such as timber, firewood and non-timber forest products for some production sectors but also maintain and protect the environment such as climate regulation, erosion control and sedimentation, regulating water resources and limiting floods. However, the frequency of forest fires has increased considerably in recent years due to climate change, human activities and other factors.

U Minh Ha Forest is one of the three remaining forest ecosystems in the Mekong Delta. This is an essential area that guarantees resurrection of endemic species in wetland ecosystems with many species listed in the Red Book of Vietnam such as: king cobras, pangolins, hairy nosed otter, etc. However, U Minh Ha Melaleuca forest is one of the forests that are most vulnerable to forest fire in the Mekong Delta. During the dry season, the entire forest is drought-prone and very high fire risk which is predicted at level IV (dangerous level) and level V (extremely dangerous level).

One of the causes of forest fire is due to climate change. Due to changes in temperature, precipitation, and humidity in the atmosphere, drier soil leads to less evaporation, reduced rainfall, thereby increasing heat waves and the risk of forest fire. Due to the impacts of climate change, forest fires are more frequent and more intense.
The effect of forest fire has been studied extensively in recent years. This study was conducted to assess the status of forest fires and the impacts of climate change on forest fire risk in UMHNPN then proposed appropriate measures to reduce the risk of forest fire to minimize damage to the environment, humans, biodiversity, economics as well as people’s livelihoods protection in the Mekong Delta. By the method of data collection and rapid assessment, the topic has statistics of fires within 5 years as well as causes, key areas and its impacts on forest ecosystems. At the same time, it was pointed out that UMHNPN is facing an increasing risk of forest fire due to climate change. Forest fire prevention and fighting in UMHNPN is being well implemented but still faces some difficulties.

2. Methodology
Forest ecological survey, verification and rapid assessment including: (i) Plan with the assistance of rangers, technicians and U Minh Ha National Park staff to accurately identify locations affected by fire, areas with endemic biodiversity and species; (ii) Short-term survey was conducted at affected sites. Collecting environmental information, information on flora, collecting data on forest fires occurring in recent times; (iii) Prepare a sample table to collect data on fires occurring in the forest stand of the National Park - U Minh Ha, with verification from the forest rangers here and (iv) Collect information and data on the status of forest fire management in Ca Mau province. Collect maps, current state of forest resources - dry season flammable material images from the National Park - U Minh Ha to better know the focus of the fire zone, which areas are prone to fire or difficult to burn, forest areas, designs work, population distributed along the forest.

Data collection methods: The forest fire situation in U Minh Ha National Park was analyzed and assessed through the statistical system of Forest Protection Department during 2012-2017. In addition, data is collected and synthesized from scientific works related to research subjects to serve as the basis for the research contents.

Data processing methods: The data collected will be synthesized, analyzed and taken as a research result for the article. Data were analyzed using Microsoft Excel 2010 software to synthesize, analyze, calculate data and draw charts.

3. Results and discussion
3.1 The current status of forest resources in U Minh Ha National Park

| Type of land, type of forest                      | Total natural area (ha) | Tran Van Thoi commune | U Minh commune |
|--------------------------------------------------|------------------------|-----------------------|----------------|
| Natural area                                     | 8,528,0                | 4,100,0               | 4,427,80       |
| Forest area                                      | 7,639,8                | 3,817,7               | 4,142,70       |
| Natural forest area                              | 1,100,6                | 1,100,6               | 753,60         |
| Planted forest area                              | 6,539,2                | 2,631,1               | 3,154,00       |
| Non forest area                                  | 888,5                  | 368,3                 | 520,20         |
| Land have no forest                              | 294,8                  | 119,8                 | 175,00         |
| Land of transportation, dykes, rivers, canals, construction | 593,7805,2            | 244                   | 349,7          |

From the above table, the total forest land area is 7,639,3 ha which accounts for 85.6%. Of which natural forest land occupies 1,854,2 ha, planted forest land accounts for 5,785,1 ha which is more than three times natural forest land. The reason is that the government increasingly promotes forest plantation replacing the natural forest was lost by fire, conversion of forest use purposes and overexploitation. Vo Tong Anh (2013) stated that “Ca Mau province decided to allocate land and forest for households to
move in the buffer zone of the National Park during 1998-2005. These households must commit that 50% of the land received is used for planting Melaleuca trees, and the remaining 50% can be used for other agricultural purposes”.

a. Flora
Forest vegetation in U Minh Ha forest is evergreen tropical rain formed in acidic soil and submerged conditions. U Minh Ha National Park is the Melaleuca forest in the ecosystem of wetland forest, so the main vegetation is *Melaleuca* tree. In the existing forest types, it is noteworthy that *Melaleuca* forest area is the most flammable forest area. *Melaleuca* tree has essential oil which can cause forest fire and easily spread to other areas.

In addition, some flora species in U Minh Ha National Park are:

- **Group of trees:** *Melaleuca cajuputi, Lex thorelli Pierre, Alshiuia spathulata, Eugenia zeylanica, Eugenia famlolana.*
- **Group of shrubs:** *Melastoma polyanthium, Licuala spinosa, Lygodium microphyllum, Euodia lepta, Actonychia laurifolia.*
- **Group of herbaceous plants:** *Phragmites karka, Flagellaria indica, Stenochlaena palustris, Diplazium esculentu, Machaerina falcate, Eleocharis dulcis.*
- **Group of aquatic plants:** *Eichhornia crassipes, Pistia stratiotes, Salvinia cucullata, Pomoea aquatic* …(Phan Thi Thanh Thuy, 2016).

According to the survey data of the Mangrove Forest Research Center, U Minh Ha forest vegetation includes 78 species, 36 families, 65 genus and 11 species of trees.

b. Fauna
Floodplain vegetation has created a favorable habitat for many wildlife species. U Minh Ha National Park is a long-standing forest. Thus, forest animals here are typical. Although there is no species abundance, the concentration of each species is very large, such as bats, birds. Currently, the area of Melaleuca forests in the surrounding area is being narrowed so that the wild animals in this area are very crowded.

| Classes  | Species | Families | Orders |
|----------|---------|----------|--------|
| Mammal   | 23      | 12       | 7      |
| Bird     | 91      | 33       | 15     |
| Reptile  | 36      | 16       | 3      |
| Amphibian| 11      | 5        | 2      |
| Total    | 161     | 66       | 27     |

(Source: Environmental Planning Report of Ca Mau Province, 2010)

Some common fauna species such as mammals: *Manis javanica, Aony cinerea, Lutra sumatrana, Viverra zibetha, V. megaspila, Viverricula indica, Prionailurus bengalensis, P. viverius, Cynoterus branchyotis, Pteropus vampirius.* Bird: Waterfowl are very abundant such as *Ixobrychus, Dupetor, Porphyrio porphyria.* The world's endangered bird species are recorded here such as *Pelecanis onocrotalus, Leptoptyles dubius, Adea sp., Xenerhynchus asiaticus.* Reptile: *Ceincella sp., Preas margaritopurus, Chrysopelea ornate, Dendralaphis pietus, Trimeresurus albolabris, Varanus salvator.* Amphibian: Crab-eating frog (*Fejervarya cancrivora*), Chinese edible frog (*Hoplobatrachus rugulosus*), etc.

3.2 Effects of climate change on situations and risks of U Minh Ha national park

Variable characteristics of climate indicators Within 11 years (from 2006 to 2017), the climate of Ca Mau province changed due to the strong impact of climate change. Specifically, the average temperature of Ca Mau province is increasing (increasing by 0.3°C within 11 years) while the total rainfall and average humidity are decreasing (decreasing by 211.8mm and 3.8% respectively). Thereby, U Minh Ha forest is facing with drought and forest fire. Through the above chart, we can see that due to the long-lasting effect from the El Nino phenomenon, the year 2015 - 2016 is a year with very high temperatures but very low humidity and rainfall. Therefore, in 2016 there were 2 forest fires that were
caused by lightning. In particular, attention should be paid between April and May. This is a time when extreme weather events occur between two seasons (from the dry season to the rainy season), the first rainstorms in the season will appear, leading to lightning strikes causing forest fires. According to the 2016 CCA, the average temperature from 2016 to 2035 will increase by 0.9°C, the rainfall will increase by 6.7% compared to the base period. However, rainfall tends to decrease slightly in the dry season (spring) by 8% and increases in the rainy season (summer) by less than 5% in most of the country. Thereby, we can see that U Minh Ha National Park faces the risk of forest fire in the future.

Figure 1. A chart with average temperature of Ca Mau province 2006 - 2017.

Figure 2. A chart with average rainfall of Ca Mau province 2006 - 2017.

Figure 3. A chart with average air humidity of Ca Mau province 2006 - 2017.
3.2.1. Effect of water management regime on forest fire risk
Every year in the dry season, U Minh Ha National Park conducts water level measurements for each zone. The water level data was collected at the end of April in both 2016 and 2017. After big fires, the National Park continuously maintains a high-water level in the canal. Specifically, water levels of protection zone and ecological restoration zone are 2.93 and 2.31 m respectively (updated in April 2017), which is twice as high as the water level in 2016. If we do not maintain high water levels during the dry season, it will cause low moisture in peat soils combined with high temperatures during the dry season which increase the risk of forest fires.

However, U Minh Ha National Park continuously maintains high water levels in canals making Melaleuca trees grow in extremely unfavorable conditions. When the water level is over 50 cm in the period of 8 months or more, the Melaleuca tree will fall and die because the root system is deeply submerged in the water for too long. Through that, if we keep the water level high, the Melaleuca tree grows slowly and vice versa.

![Water level chart](image)

Figure 4. A chart with water levels of U Minh Ha National Park in 2016 - 2017.

3.3. Effect of groundwater level on soil moisture for forest fire risk.
The soil moisture content is determined by the general regulations as dry, moisture, moisture, and very wet. Combustible material with humidity <50%, low likelihood of fire and vice versa. Based on industry standard 04 TCN 88: 2006 on the fire prevention and fighting procedures for Melaleuca forests issued by the Ministry of Agriculture and Rural Development, Vietnam shows the relationship between groundwater level and humidity of combustible materials. The underground water level is divided into 3 levels according to the risk of melaleuca forest fire as follows in Table 3.

| No | Depth of groundwater level | Humidity of combustible material | Danger level of fire |
|----|---------------------------|---------------------------------|---------------------|
| 1  | <50cm                     | Moisture                        | Less dangerous      |
| 2  | 50-90 cm                  | Dry                             | Danger              |
| 3  | <90cm                     | Very Dry                        | Very dangerous      |

The moisture content of the dry vegetation in the hottest days is related to the depth of groundwater. When the groundwater level is not more than 50 cm from the ground, the burning material in the hot and hot days will have a low fire-ignition ability and less danger to forest fires. The weather situation in U Minh Ha area develops quite complicatedly during the peak period in the dry season months, the forest area in the whole area is at an alarmingly high level (level 4 and 5) in months. During the peak of
the dry season, the risk of forest fires can happen at any time. On the peat surface, there is a layer of withered vegetation, if there is canopy fire - burning on top and burning under canopy will make source heat spreads into peat layer, high risk of underground fire. At present, the fighting giants still retain the water, so the botanical bait group has not dried yet because the water is still supplied to the group so the fighters can absorb water so they cannot dry. Some dry vegetation falls in harsh weather during this dry season that cause fires. Finally, observe the topography and vegetation cover (Vegetation mulch determines the properties of the soil and its latent potential fire capacity. Based on the fire classification table of the Ministry of Agriculture and Rural Development combined with the experience and visual judgment of the staff at U Minh Ha National Park, the forest fire classification in the forest stand is divided as the Table 4.

| Forest fire classification                                                                 | Image |
|-------------------------------------------------------------------------------------------|-------|
| **Level 1.** The soil still has dry surface moisture. (less likely to happen)               | ![Image](image1.jpg) |
| **Level 2.** Dig holes deep with water still. (There is a possibility of a forest fire)    | ![Image](image2.jpg) |
| **Level 3.** Squeeze the sprout leaves and still have water. (Dry weather is prone to wildfires.) | ![Image](image3.jpg) |
Survey results and forest fire classification are based on many factors such as weather, humidity of burning materials, and forest fire season. The time of fire easily happens in the dry season, the high temperature is combined with the following factors:

- The soil profile has moisture <50% (fire is unlikely). During the survey, experts identified soil soil moisture in the range of 60-70%. The weather is dry and the temperature changes erratically. In the dry season, forest fires are high in the dry season. Out-of-season rains appear during the drought and easily lead to forest fires caused by lightning. Wind direction is not the cause of the fire but directly and indirectly affects the intensity and scale of the fire. The canal water level decreases in the peak months of the dry season due to evaporation (the water level of the canal below 1m, the higher the risk of fire). However, the amount of vegetation here is quite dry, the vegetation of vines begins to dry, the vegetation Deciduous trees, withered trees are easy to burn forest canopy and burning on the tops can easily lead to underground fire. Through the field process based on the objective factors from the determination of moisture of the burning material, identified The forest stand is at high risk of fire reaching level 5 in April every year.

3.4. Forest fire situation in the period of 2012 - 2017
Forest fire season in U Minh Ha started from December to April. Especially in March and April, the entire U Minh Ha forest was dry which is predicted at level V (extremely dangerous level) and level IV (dangerous level).

| Year | Number of fires | Area (ha) | Fire area | Reasons | Measures          |
|------|----------------|-----------|-----------|---------|------------------|
| 2012 | 0              | -         | -         |         | -                |
| 2013 | 1              | No damage | K16, TK3  | Lighting| -                |
| 2014 | 1              | No damage | K3, TK1   | Lighting| -                |
| 2015 | 0              | -         | -         |         | -                |
| 2016 | 2              | 13,97     | K2, TK61  | Lighting| Reforestation    |
|      |                |           | K3, TK76  |         |                  |
| 2017 | 0              | -         | -         |         | -                |

Based on comprehensive statistics on forest fire from 2012 to 2017 (Table 3), U Minh Ha National Park has occurred 04 forest fires, with a total area of 13.97 ha within 5 years. We can see that in the
current period, forest fires tend to increase again in both cases and damages. The main cause is the natural disaster phenomenon, in particular, lightning strikes. Another resonant reason is the prolonged drought caused by climate change that makes the air in the forest become hotter and drier. The dry season in U Minh Ha National Park lasts from 4 to 5 months and is influenced by the northeast monsoon, the average wind speed is 5 m/s. The highest average temperature is at the end of March and the beginning of April, causing low humidity, dry surface, dead and dry vegetation layer which are very easy to catch fire. Therefore, the risk of forest fire in U Minh Ha National Park is very high, which can occur at any time during the dry season.

Forest fires in the dry season of 2015 - 2016 are because of extreme weather transferring between the two seasons (from dry season to rainy season). Therefore, the first rainstorm rains have appeared with lightning strikes, leading to forest fires. In addition, the canal network is made alternating which make the water likely to leak and evaporate. Especially in the dry season, the water level in the canals is lower and dries quickly, leading to lack of water for fire prevention.

Indirect reason is that the flora here mainly are vegetable ferns, polypody plants, *Melaleuca* tree, etc., which can burn well when dry and fresh. Especially, *Melaleuca* tree contains many essential oils so it can cause rapid and intense fire. In addition, U Minh Ha forest land is mainly peat land. The Forestry handbook (2009) pointed out that “When the forest fires occur, it is smoldering in peat land which makes firefighting works become extremely difficult”.

### 3.5. Consequences of forest fires affecting U Minh Ha forest ecosystem

When the forest is burnt, forest fire will destroy the area of valuable *Melaleuca* forests. Forest fire cause mass Melaleuca tree deaths. If these trees survived, it had poor growth, susceptible to pests and diseases. Other precious plants and animals in Melaleuca forests are also destroyed by forest fire, losing biodiversity, ecological balance due to the strong development of weeds. The big fire in U Minh Ha in 2002 eradicated some species such as big flying fox, fishing cats, Asian palm civet, wild cats and changed the composition of birds and reptiles due to habitat loss.

Forest fire is also a major threat to land resources reducing the amount of organic matter and nutrients in the soil which cause the degradation of the soil environment. Forest fires in U Minh Ha National Park have burned peat layers that have accumulated and formed for a long time. This peat layer is valuable in many aspects, when it is destroyed it can not be recovered. It has been confirmed that “In 1976, the total area of peat land was about 20,167 ha, so far only over 6000 hectares remaining. From 2000 to 2003, U Minh Ha peat land was reduced about 1,400 hectares by the large forest fire in 2002” (Do Dinh
Sam et al., 2011). The peat layer and the organic matter layer lowers the surface of the soil causing severe flooding during the rainy season which makes it difficult to recover the forest.

In addition, local people are one of the groups most directly affected by forest fires. They are closely dependent on the environment and forest resources. Forest fires reduce the forest resources such as plant, animal and fishery resources, thus affecting local people’s incomes. Forest fires have contributed to exacerbating the inherent difficulties of local people, such as reduced incomes, food security and unemployment, thereby increasing poverty and instability in human life.

3.6 The solution reduces the risk of forest fires in U Minh Ha National Park

3.6.1 Management solutions To raise awareness about forest protection, fire prevention and fighting for communities and reduce the causes of forest fires by anthropogenic activities such as cultivation, hunting and honey exploitation, we need to promote investment in propaganda, raise awareness for the people and strengthen the ability for the staffs.

(i). Strengthening the propaganda, dissemination and education of the law and regulations about forest protection for local people.
(ii). Organizing training, firefighting exercises regularly for the staff and local people.
(iii). Encouraging local people to actively participate in forest fire prevention and fighting.
(iv). Reviewing, promulgating and supplementing management regulations of protection activities, forest fire prevention and fighting.
(v). Prohibiting local people who burn fields for cultivation, go to the forest to hunt wild animals or collect honey illegally.
(vi). In addition, it is necessary to study, develop and improve the legal system on forest environment services to enhance the forest resources and develop sustainable forest production.

3.6.2. Technical solutions (i). Strengthening and supplementing fire prevention and fighting equipment which includes means of transport, pumps and specialized firefighting equipment; (ii). Building more forest fire prevention and fighting works such as fire watchtowers, warning signs of forest fire, reservoirs, fire stations, etc; (iii). Applying integrated forest fire prevention methods such as the construction of white and green runways to against fire, reduce the volume of fire materials, etc.; (iv). Developing more effective economic models such as intensive forest plantation, planting rice, crops, fruit trees, raising fish in order to improve people’s lives, limit forest fire

3.6.3. Technology Solutions (i). Applying information technology in forest fire prevention, warning and reporting information to managers, forest owners and communities; (ii). Applying remote sensing technology, GIS and GPS for sustainable management of forest resources in order to improve efficiency and minimize forest fire damage; (iii). Researching technologies using fire materials to produce fuel, building materials, household appliances, fertilizers, etc. to promote the removal of these materials in the forest.
4. Conclusions

In the early days of establishment, U Minh Ha National Park was always at risk of forest fire. The forest fire season starts from December to April. The reasons of forest fires are mainly caused by people who burn forest land for shifting cultivation, hunting or using smoke to get honey. Another reason is the prolonged drought caused by climate change. Climate change makes the environment in the forest warmer and drier which increase the risk of forest fire. However, the fire prevention and fighting has been improved recently so that forest fires in U Minh Ha National Park have been reduced. By the method of data collection and rapid assessment, the topic has statistics of fires within 5 years as well as causes, key areas and its impacts on forest ecosystems. At the same time, it was pointed out that UMHNP is facing an increasing risk of forest fire due to climate change. Forest fire prevention and fighting in UMHNP is being well implemented but still faces some difficulties. Therefore, it is necessary to take appropriate measures such as strengthening communication, completing mechanisms and policies, supplementing fire protection equipment and facilities to improve environmental quality and local’s people life.

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