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Projections on future impact and vulnerability of climate change towards rubber areas in Peninsular Malaysia

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Abstract. Known to perform best in tropical climate, rubber (*Hevea brasiliensis*) thrives in this country. It is acknowledged as one of the important crops to the country that provides income and employment, especially to the smallholders, estate workers and their families. One of the factors that may influence rubber yield and its productivity is meteorological factors. The outline of this paper is to analyze and assess the future impact and vulnerability of climate change towards rubber in Peninsular Malaysia based on three prominent features, which are increase in temperature (drought), rainfall (flood) and sea level rise. Maps and data-related model in rainfall, temperature, and river basin have been supplied by the National Hydraulic Research Institute Malaysia (NAHRIM). ArcGIS software were further used in this study. This preliminary assessment showed that projections on drought, flood and sea level rise for rubber areas in peninsular Malaysia may not be severely affected by the climatic event. However, current assessment is only at its preliminary stage and in-depth assessment is needed. This work implies that projections are necessary in providing a possible future impact on rubber, being a smallholder's crop, and further adaptation and mitigation approaches can be carried out accordingly.

1. Introduction

Studies based on historical time period on changes of climate in Malaysia show an alarming trend. The amount of rainfall in Peninsular Malaysia has decreased from the period of 1979 to 2010 [1] while temperature has increased from the range of 0.6 to 1.2°C from the period of 1969 to 2009. In addition, sea level rise has increased at least 1.3mm/yr and rainfall intensity has also increased from an observable period of 2000 to 2007 compared to the period of 1971 to 1980 [2]. Thus, it is not surprising that climate change issue has become a buzzword lately. The impact of climate change can be severe. It was proposed that the impact might be severely felt by the developing countries as most of their people still depend on agriculture for their livelihood and as a source of their local income [3]. Rubber tree (*Hevea Brasiliensis*) is a non-native crop that thrives in this country. It is acknowledged as one of the important



crops to the country that provides income and employment [2]. Currently, most of the rubber tappers in Malaysia are from smallholders which dominate 90% of the total rubber planters. Thus, it is deemed vital to assess the vulnerability of climate change not only towards the sustainability of the rubber industry but also the smallholders which highly depend on rubber as their source of income. Rubber yield in Malaysia is indeed influenced by the climatic factor. During the dry spell in the month of January to March, rubber tree defoliates its leaves. This process is known as wintering. Wintering occurs naturally as a self-defense mechanism in preventing water in the tree from being transpired through the leaves [4]. In a year, rubber production in Malaysia has an annual seasonal pattern where the climatic factors affect the number of tapping days. Briefly, in a year, January will record the highest production before declining in April as wintering season falls on March and April. The production will increase again in July and August. In November, there will be a fall in productivity due to the monsoon season before an increase again in December [5].

Latex yield production is indeed vulnerable to drastic weather fluctuations. With reference to the massive El Niño phenomenal that occurred in 1997-1998, there was a reduction of latex yield compared to the latex yield obtained during normal climatic conditions. It is further found that drought that occurs for less than two months does not affect the latex productions. However, a prolonged drought of more than three months will affect the production of latex from rubber plantations. The production of latex yield was only affected by the strong and very strong stages of El Niño phenomenon, while the presence of La Niña phenomenon for the following periods might further adverse the impact due to the reduced number of tapping days [6]. Nevertheless, the study also implied that the El Niño-Southern Oscillation (ENSO) phenomenon is not the sole factor that causes the latex yield productions to decline. Several other factors should also be assessed such as a decrease in total rubber planting areas, disease occurrence, poor agronomic practices and technology adoption, shortage of skilled tappers, unstable latex price, haze and other non-climatic related conditions [6].

The assessment of the vulnerability of climate change for rubber sectors is in need due to the heavy concern on the growth of rubber tree, yield and productivity of rubber tree and the possibility of pest and disease emergence following the event. These factors can definitely affect the smallholder's income and directly disrupt the rubber industry. Thus, climate change should be viewed in a holistic way in which its impact can be very damaging. In rubber productivity analysis, temperature and rainfall are the primary factors that have the highest impact on the tree growth and rubber productivity. According to [7], rubber tree can still survive with an annual rainfall between 1000 to 1100mm but requires at least above 1200mm annually to fully perform. In terms of temperature, the rubber tree performs best at 24°C to 28°C. However, there is a concern if the temperature is above 30°C. This study was initiated following the obligation as one of the important agencies within the agriculture sector in the country to analyze and assess the future impact and vulnerability of climate change towards rubber plantation in Peninsular Malaysia.

2. Data Collection

This study was accomplished by the cooperation between government agencies. The analysis were based on secondary data provided by the National Hydraulic Research Institute Malaysia (NAHRIM). Maps and data-related model in rainfall, temperature, and river basin have been supplied by (NAHRIM) which the projected future values (under the years 2021-2050) were compared with the historical values (years 1993-2010 and 2001-2020). The climate projection were based on 13 watersheds and 12 coastal regions in Peninsular Malaysia. These data were intended to predict the occurrences of drought, flood affected areas, level of sea rise and observation to any physical changes to the original structure. The rubber data layer was then used for analytical purposes to assess the impact of the changes taking place. ArcGIS software was used throughout the completion of the task. The scope of this task was only concentrated in Peninsular Malaysia as a case study.

3. Results

3.1. Drought Projection

The projection on future drought analysis was based on the projected rainfall which comprised 13 watersheds and 12 coastal regions in Peninsular Malaysia for years 2017 to 2099 supplied by NAHRIM. It was found that the year 2024 has the highest ARI (Average Recurrence Interval) as compared to other years. Based on **Figure 1**, the drought frequency analyses for the year 2024 in Kemaman, Kuantan, and Dungun Watershed will be the highest with 50.1 to 100-yr return period, which have been projected as the most severely affected areas. The percentage of rubber areas that are most likely affected by this event is around 1.2%. The less severe with the return period of 20.1 to 50-yr are likely to hit the East Coast Region (i.e. Kelantan, Terengganu, and Pahang) with 38.7% of affected rubber areas. Major parts of the Northern Region (e.g. Perak, Kedah) and Southern Region (i.e. Johor) will experience the return period of 10.1 to 20-yr with 32.5% of affected rubber areas. Several areas in Peninsular Malaysia such as Perlis, Selangor, Negeri Sembilan and Malacca will only experience normal drought with a return period of 2.9 to 10-yr with 27.6% of affected rubber areas.

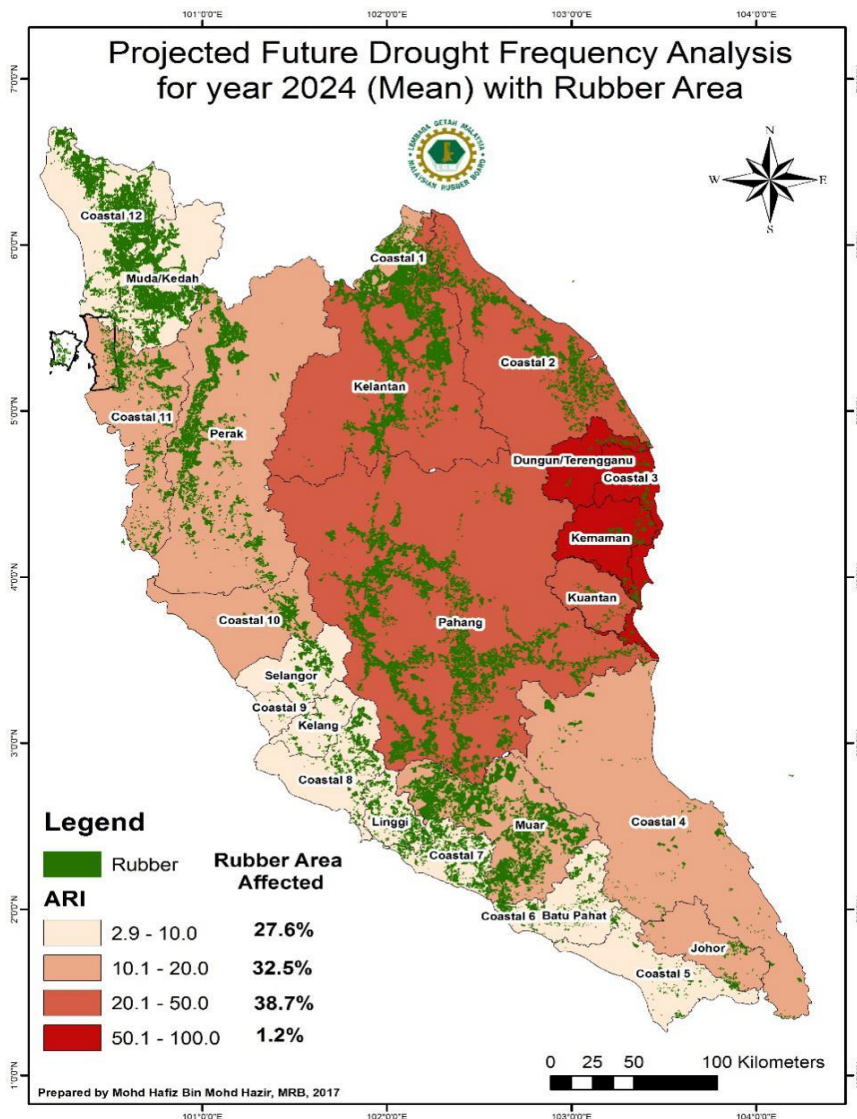


Figure.1. Projected drought frequency analysis for the year 2024 (mean) overlay with rubber areas

3.2. Flood Projection

The projection on future flood analysis was conducted in selected river basins in Peninsular Malaysia and generated by the Flood Extend Map. Based on the projection, the rubber flood prone areas in 2030 (**Figure 2**) are around 15% and will increase only to 15.2% in 2050 (**Figure 3**). Areas that have been identified as a rubber flood prone area include coastal 11 (between Perak and Kedah), Coastal 12, Coastal 2 (situated in Terengganu), selected areas in Pahang and the Muar Basin.

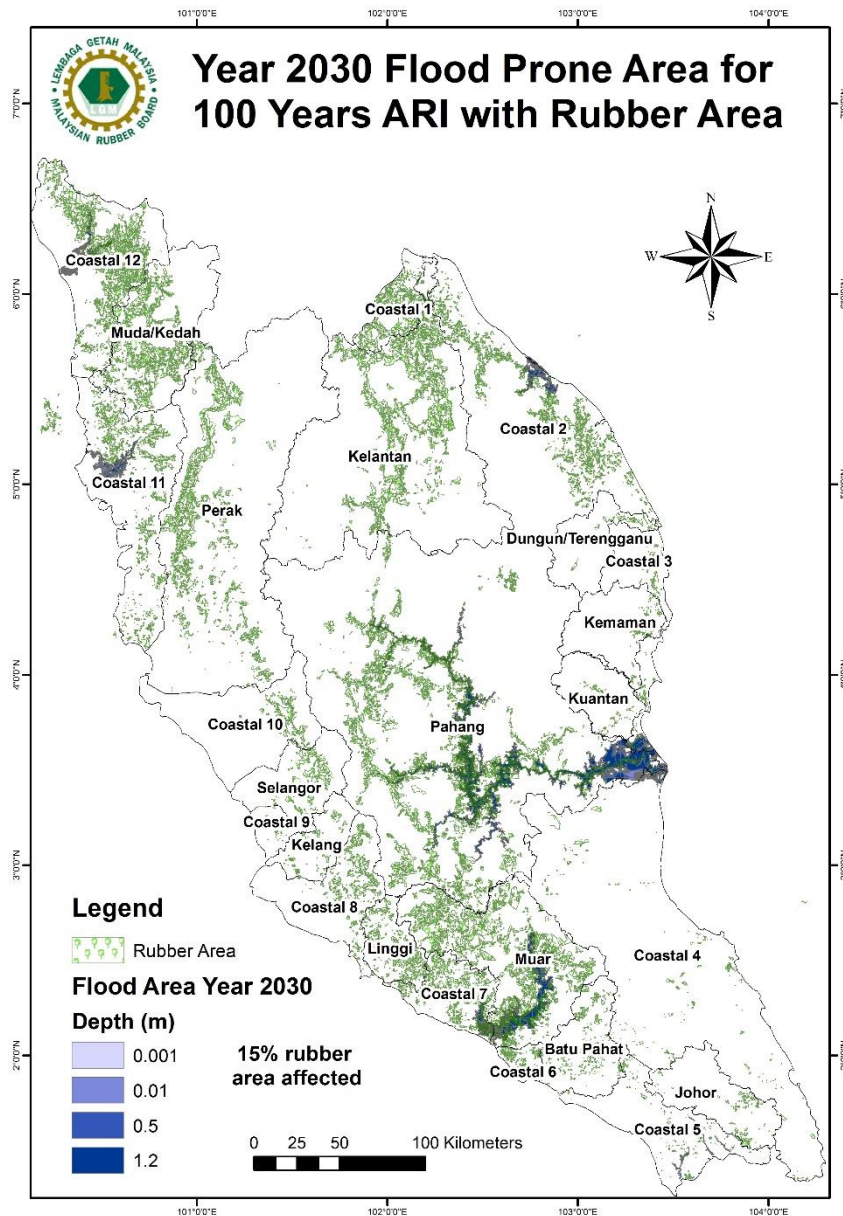


Figure.2. Projected rubber flood prone area for year 2030

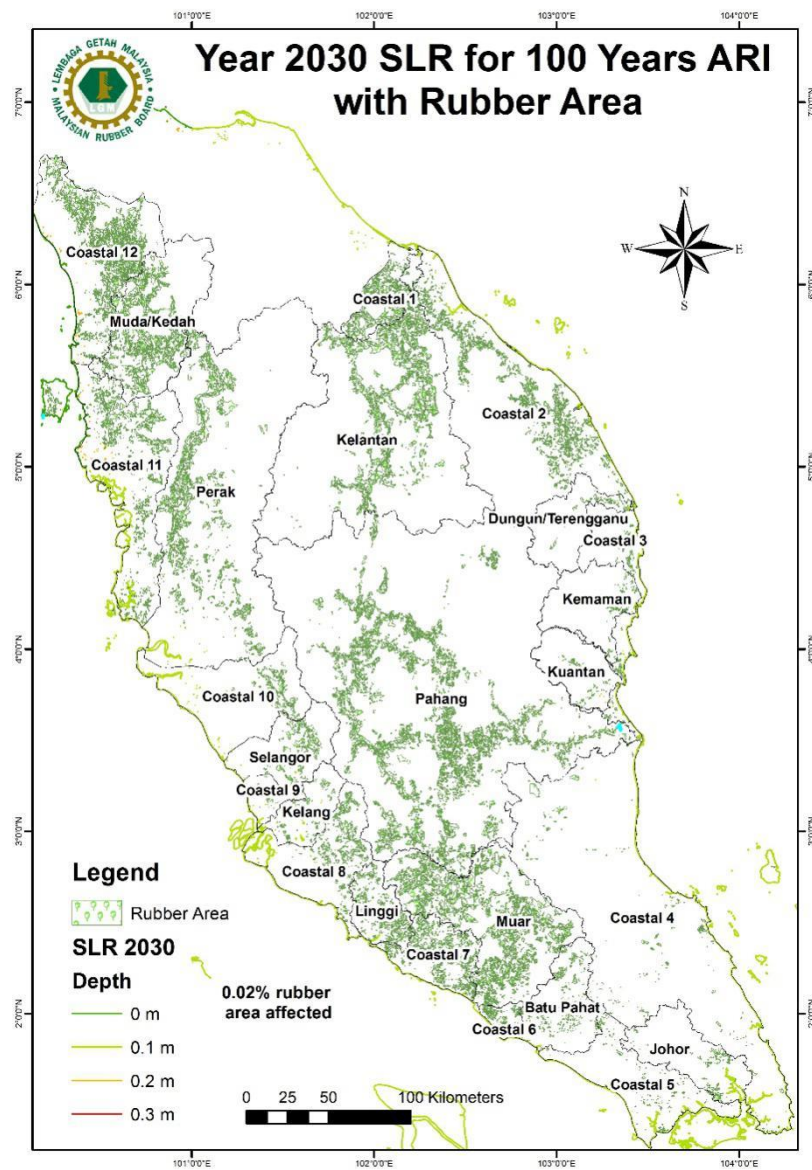


Figure.4. Projected sea level rise overlay with rubber area for the year 2030

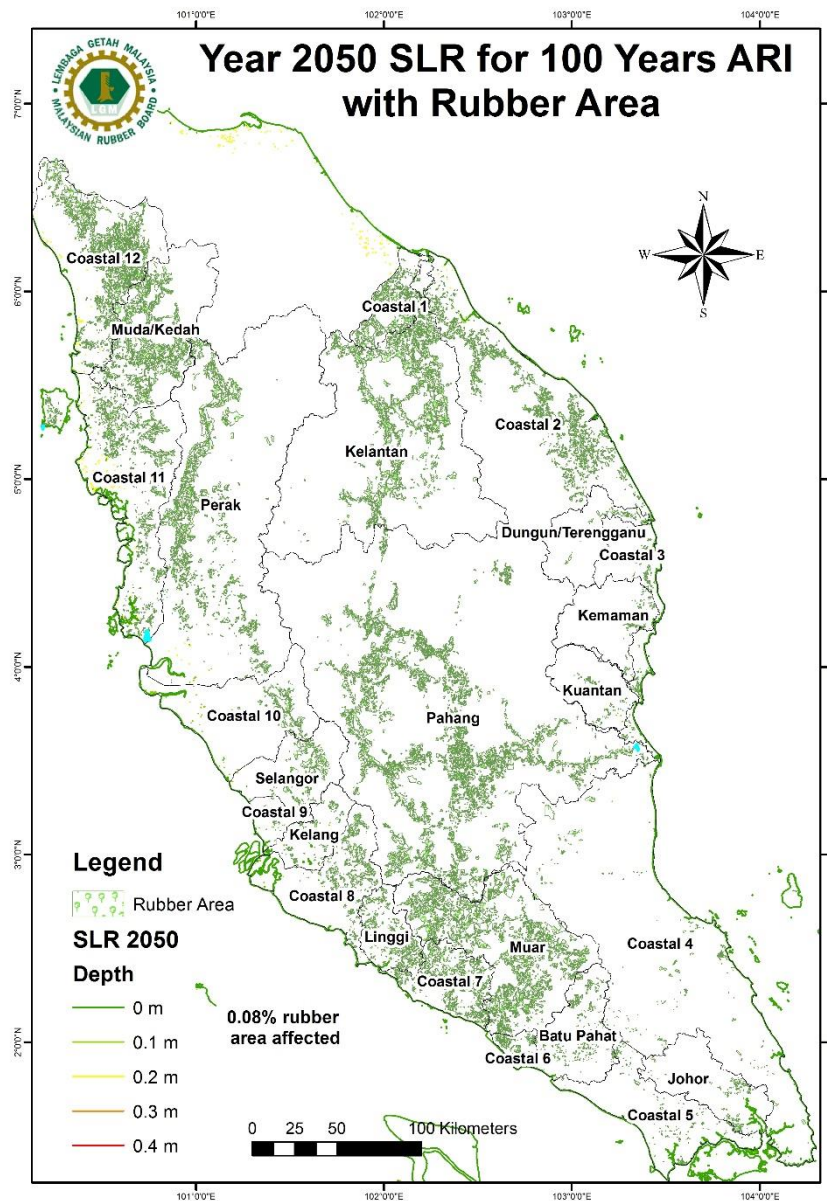


Figure.5. Projected sea level rise overlay with rubber area for the year 2050

4. Discussion

Rubber trees are adapted to the moderate temperature of the tropics. Thus, the concern arises on the probability of an extreme event in temperature and other climatic variables that might affect rubber tree productivity [9]. Temperature and rainfall are the primary factors that can give impact to rubber tree growth and its productivity. Rubber responds to the temperature and moisture fluctuation due to its low stomatal resistance which results in a high transpiration process [10]. Although it is proposed that sunshine hours are positively correlated with rubber yield [7; 11], an increase in temperature might become the limiting factor towards rubber productivity [9]. Wintering which is usually associated with a dry period or normal drought is common among rubber planters. During this period, tapping is halted. However, a prolonged dry season such as the one reported in the east coast of Peninsular Malaysia is

sufficient evidence that drought can indeed affect the smallholders involved [12]. This projection, however, is a straightforward probability case based on climatic measurement. The severity of impact of climate change on rubber is more complicated, which depends on other factors such as duration of the drought period, age of plantation and management practices [13]. Factors on duration of drought period and age of plantation might be uncontrollable, but good agricultural practices such as conservation measures by planting leguminous ground cover to reduce water loss can be carried out to reduce the impacts [8; 13]. Nevertheless, the impact can be overcome by selecting rubber clones that are tolerant to the event [14]. Globally, a number of scientists are working in selecting an early drought resistance parameter to assist in rubber tree breeding programs as shown by [15; 16; 17; 18] whose studies vary from genetic, physiology and anatomy.

On the other hand, the impacts of excessive rainfall and flooding are severely felt and well documented compared to drought events. Normally, in a year, the number of rainy days should be around 100-150 and an increase in rainy days will lead to loss of tapping days [8]. The current flood projection showed a minimal impact with roughly only 15% of affected rubber areas. However, it is vital to note that the current assessment is only based on 15 river basin analyses and an increase in the number of basin into the analysis might give a greater value. In 1967, flooding has been recorded in Terengganu with its rubber area affected due to the event. It was observed that different clones have different tolerance to flooding. RRIM 601 defoliated its leaves while RRIM 600 and RRIM 605 managed to retain its leaves during a standing water of nearly 5m that lasted around 6 to 7 days [19]. Thus, it is proposed that studies on clones adapted for different areas that experience different climate conditions might be a better adaptation approach [8]. In addition, occurrence of disease such as *Phytophthora* abnormal leaf fall is high during the monsoon season which falls roughly on September to December. Environmental factors such as rainfall contribute to the onset of this disease [20]. The occurrences of the flooding areas on the projection that overlapped with the *Phytophthora* disease areas which greatly occurred in the north and east coasts of Peninsular Malaysia [21] raise a concern.

5. Conclusion

In managing the climate issue, assessing the vulnerability is considered a necessity in order to prevent further damage and yield loss. In most rubber producing countries, rubber has predominantly been a smallholder's crop. The use of projections in this study is to provide the potential consequential effects of climate change towards rubber productivity. Further studies and any adaptation measures should be carried out accordingly.

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