LINKING BETWEEN METEOROLOGICAL DROUGHT AND LAND USE/LAND COVER IN THE BA RIVER BASIN

Truong Nhat Kieu Thi[1], Pham Thi Mai Thy[1], Chau Nguyen Xuan Quang[2], Tham Thi Ngoc Han[1], Ho Van Hoa[2] and Lam Dao Nguyen[1]

[1]HCMC Space Technology Application Center, Viet Nam National Space Center, Vietnam Academy of Science and Technology, 1 Mac Dinh Chi, Ben Nghe Ward, District 1, Ho Chi Minh City, Viet Nam
Email: tnkthi@vnsc.org.vn
[2]Institute for Environment and Resources – Vietnam National University Ho Chi Minh City, 142 To Hien Thanh, Ward 14, District 10, Ho Chi Minh City, Viet Nam
Email: cnxquang@gmail.com

ABSTRACT

Viet Nam is considered as one of the countries most affected by climate change, especially the Ba river basin. Objective of this study is linking between meteorological drought and land use/land cover in the Ba river basin. Penman - Monteith model and SWAT model are the main tools used in the calculation of climate change scenarios, especially climate extremes. The results of drought trend in the baseline scenario in 2019 and climate change scenarios RCP 4.5 and RCP 8.5 in the period 2046-2065 have changed drastically. In agriculture, the no drought level area has decreasing while the moderate drought and severe drought level area has increasing. In forest, the no drought level area has decreasing while the mild drought, moderate drought and severe drought level area has increasing.

1. INTRODUCTION

Viet Nam is considered as one of the countries most affected by climate change, especially the Ba river basin. In recent years, the frequency and intensity of extreme weather events has increased. Climate change also leads to changes in weather, directly affecting crops, production of agriculture, forestry, industry as well as aquaculture and fishing. Especially, the El Niño event in 2015-2016 caused the scorching temperatures and prolonged drought in the Central and Central Highlands in Vietnam, which affected agriculture activities [FAO, 2016].

Water shortages are getting worse with climate change. According to the statistics of the Departments of Agriculture and Rural Development in 2016, the total drought area was over 60,000 ha in the study area. In 2015-2016, the crop area had been damaged by drought of 60,588.6 ha. In 1998 and 2015-2016, the Ba River basin had the most forest area burned up to nearly 481.6 thousand ha (General Statistics Office of Viet Nam, 2018). The reason is El Nino Southern Oscillation (ENSO), which causes an increase in temperature and a decrease in precipitation leads to moisture to dry out.

The Ba river is the largest river in the central coastal region with a main stream length of 374 km. It flows through the four provinces of Kon Tum, Gia Lai, Dak Lak and Phu Yen into the East Sea. The Ba river basin has about 13,900 km^2 area and is located from 12º35' to 14º38'

North latitude and 108º00' to 109º55' East longitude [Directorate of Water Resources, 2010].

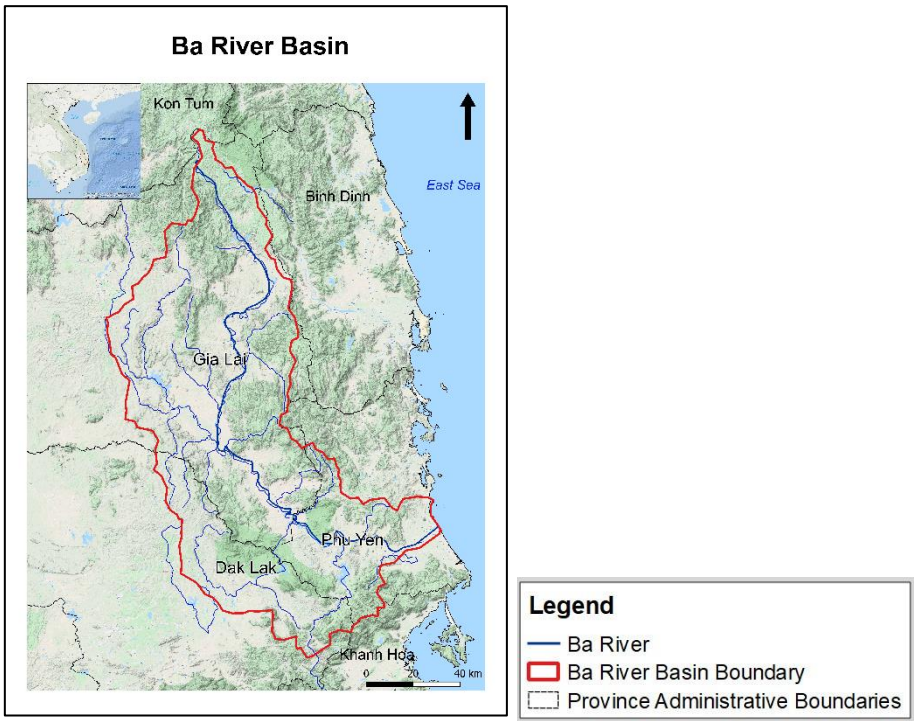


Figure 1. The Ba river basin location.

In recent decade, Remote Sensing (RS) and Geographic Information Systems (GIS) method have been widely applied to observe the surface of the earth such as environment, hydrometeorology, agriculture, land management, forecasting, etc. Therefore, objective of this study is linking between meteorological drought and land use/land cover in the Ba river basin, Viet Nam.

2. MATERIALS AND METHODOLOGY

2.1 Materials

Satellite images: Landsat 8 images were collected in dry season. They were collected from January to May in 2019.

Field data: Field survey samples were gathered in 2019 to assess the land use/ land cover (LULC) classification accuracy.

DEM, soil map, hydrometeorological data: current status, Representative Concentration Pathway (RCP) were also collected to aggregated into input data.

2.2 Methodology

Land use/land cover classification

Landsat image data was corrected atmospheric and removed cloud on the Google Earth Engine platform. Afterwards land use/land cover was processed and classified into forest, agriculture and others. Then the classification results were exported to the GIS formats to edit, evaluate the classification accuracy.

Develop maps of drought zoning

The study uses the results of "Investigating to develop maps of drought zoning in the Ba River basin in the context of climate change" (Thanh, 2019) based on the study method in the report based on the calculation of the drought coefficient (1) for sub-basins with potential evaporation calculated by Penman - Monteith model, average rainfall determined by Thiessen polygon method and average discharge of sub-basins:

$$K_{drought} = \sqrt{K_a K_b} \text{ ; với } K_a = 1 - \frac{X}{ET_p} \text{ và } K_b = 1 - \frac{Q_{j,i}}{\sqrt{Q_i Q_o}} \quad (1)$$

K_a: dry coefficient of the level of meteorological drought
K_b: river depletion coefficient represents the abundance of water resources for a certain period of the year
X: monthly rainfall
ET_p : potential evaporation
$Q_{j,i}$: average river discharge in the jth period of the ith year
Q_i : average river discharge in the ith year
Q_o : average water flow for many years
Q: determined by SWAT model for Ba river basin to the outlet section of Song Hinh station

$K_{drought}$ = 0,5: signs of drought
0.5 < $K_{drought}$ ≤ 0.6: mild drought
0.6 < $K_{drought}$ ≤ 0.8: moderate drought
0.8 < $K_{drought}$ ≤ 0.9: severe drought
0.9 < $K_{drought}$ ≤ 1: exceptional drought

Simulation scenario are set up for mapping the drought zoning of the Ba river basin in dry season:

- Scenario (BS): baseline scenario in 2019.
- Scenario 2 (RCP 4.5): the RCP 4.5 scenario in the period 2046-2065.
- Scenario 3 (RCP 8.5): the RCP 8.5 scenario in the period 2046-2065.

After the drought map (RCP 4.5 and RCP 8.5) is available, overlay drought map with LULC (agriculture and forest) in 2019 map by GIS tool.

3. RESULTS AND DISCUSSION

3.1 The change of agricultural and forest areas

The classification results for 2019 was demanding with kappa coefficient of 0.71 and overall accuracy of 89%.

Table 1. Land use/land cover in the Ba river basin in 2019.

LULC	Area (ha)	%
Agriculture	686,526	51.5
Forest	501,728	37.7

Others	144,356	10.8

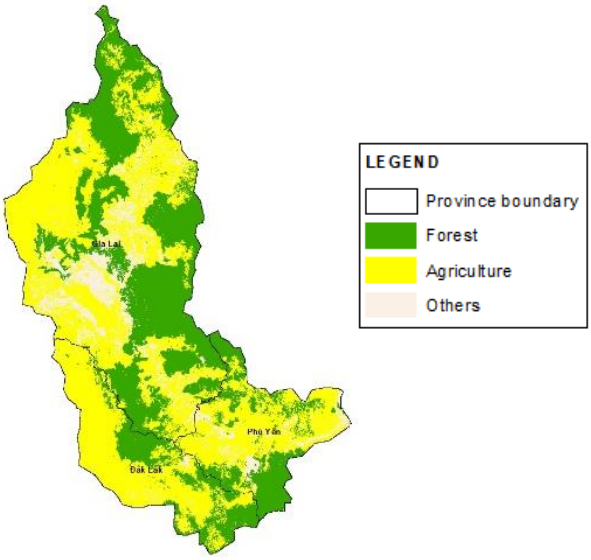
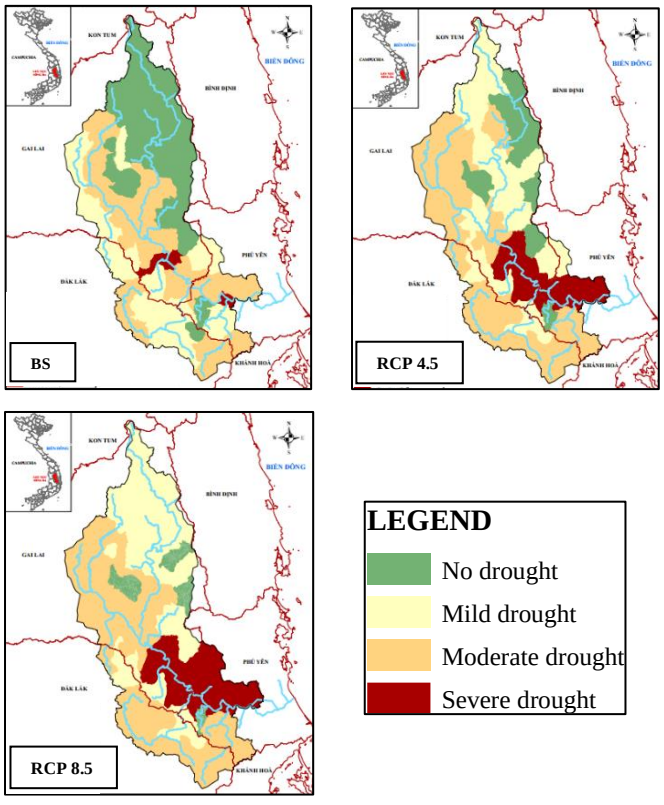


Figure 2. Land use/land cover change in the Ba river basin in 2019.

Table 1 and Figure 2 show that the forest cover was 37.7% (501,728 ha) while the agricultural areas accounted for 51.5% (686,526 ha) of the entire basin area in 2019.

3.2 Drought map of climate change scenarios



The data collected to forecast drought using the Penman - Monteith model is only limited to Cung Son station (Phu Yen province) because the water source is affected by salinity in the estuary, so the SWAT model and $K_{drought\ Penman-Monteith}$ coefficient can not be used. Thus, this study does not assess the drought in the entire Phu Yen province (excluding the estuary in Phu Yen province).

Simulation results of the climate change scenarios show that the no drought level area has decreasing while the severe drought level area has increasing according to the BS, RCP 4.5 and RCP 8.5. Besides, there is no exceptional drought in the Ba river basin (Figure 3).

Figure 3. Drought levels in the Ba river basin.

3.3 Linking between meteorological drought and land use/land cover

Agriculture drought and forest drought have changed drastically among climate change scenarios, especially no drought and severe drought levels. Mild and moderate drought are more dominant in 3 climate change scenarios (Figure 4 and Figure 5).

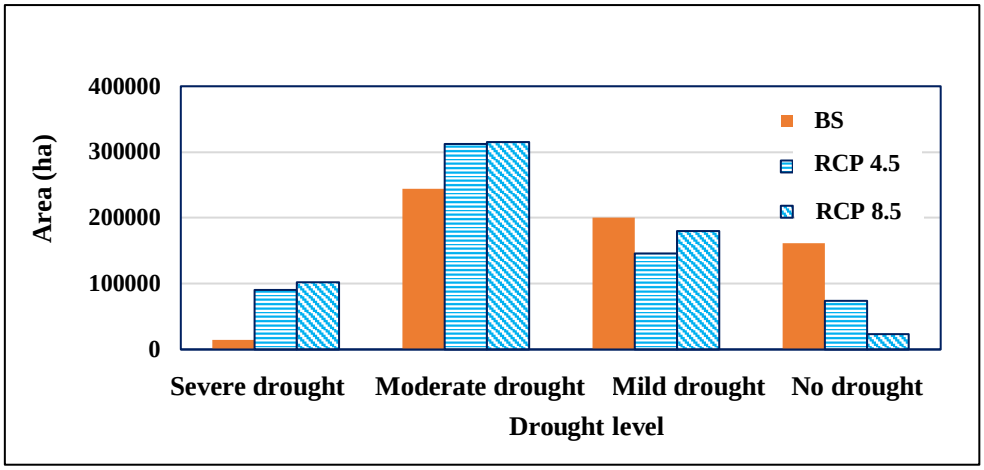


Figure 4. Agricultural drought area under climate change scenarios.

As described in Figure 4, the no drought level area in agriculture tends to decrease according to the BS, RCP 4.5 and RCP 8.5. The no drought level in agriculture in the BS scenario is the highest area, it is nearly 162,000 ha, in the RCP 4.5 scenario is 73,538 ha and the RCP 8.5 scenario is only 23,362 ha (decrease almost by 7 times). Therefore, it shows that future climate change will seriously affect the drought situation in the Ba river basin, the no drought level area in agriculture affected by drought is decreasing according to the simulation scenarios. In contrast, the moderate drought and severe drought level area in agriculture gradually increase according to the BS, RCP 4.5 and RCP 8.5. The area of moderate drought increases from 244,203 ha to 315,667 ha; especially severe drought has been much more serious, the area of severe drought in the RCP 4.5 and RCP 8.5 increases by 8 and 9 times compared to the area of severe drought in the baseline scenario. This will affect future agriculture, the trend of agricultural area can be reduced due to lack of water due to drought, especially in the upstream provinces of Ba River.

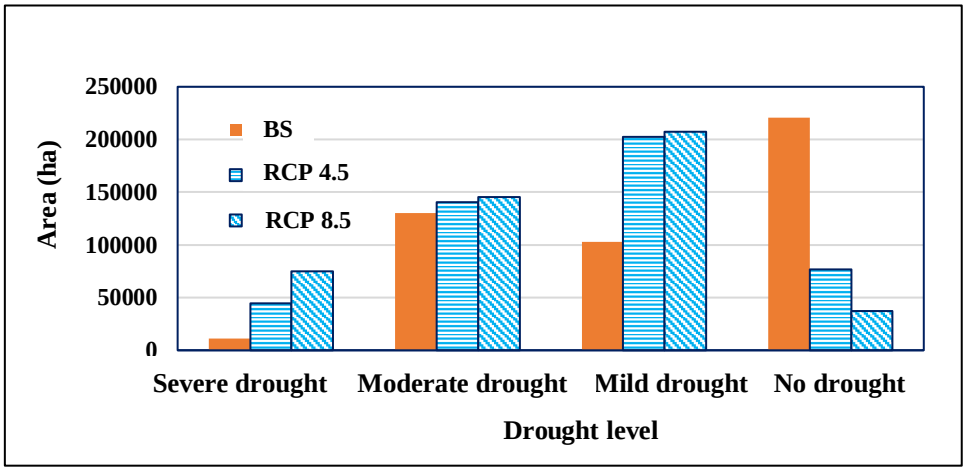


Figure 5. Forest drought area under climate change scenarios.

As agricultural drought, the no drought level area in forest also tends to decrease according to the BS, RCP 4.5 and RCP 8.5 (Figure 5). The no drought level in forest in the BS scenario is more than 220,000 ha, in the RCP 4.5 scenario is nearly 77,000 ha and the RCP 8.5 scenario is only 37,272 ha (decrease almost by 6 times). In addition, the mild drought, moderate drought and severe drought level area in forest also gradually increase according to the BS, RCP 4.5 and RCP 8.5. This shows that climate change seriously affects the level of drought in the Ba river basin. The mild drought area in the baseline scenario is just over 100,000 ha, then the area is more than doubled in the RCP 4.5 and over 207,000 ha in the RCP 8.5. The area of moderate drought in forest increases from 130,237 ha to 145,073 ha. Most notably, the area of severe drought in the RCP 4.5 and RCP 8.5 increases by 4 and 7 times compared to the area of severe drought in the baseline scenario.

4. CONCLUSIONS

Agriculture drought and forest drought have changed drastically among climate change scenarios (baseline, RCP 4.5 and RCP 8.5 scenarios). In agriculture, the no drought level area has decreasing while the moderate drought and severe drought level area has increasing. This will affect future agriculture, the trend of agricultural area can be reduced due to lack of water due to drought, especially in the upstream provinces of Ba River. In forest, the no drought level area has decreasing while the mild drought, moderate drought and severe drought level area has increasing. Severe drought seriously affects not only production but also seriously affects the supply of fresh water for daily life in the Ba river basin.

The results of this study analyzed the linking between meteorological drought and land use/land cover in the Ba river basin, which can serve as a basis for further development of other studies such as propose possible solutions to adapt to climate change, urgent actions to slow down the process of climate change, the effects of climate change on human and the environment...

5. REFERENCES

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