

Climate change: Estimation of loss and damage in BAC Lieu agriculture

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ABSTRACT: This research used agromeshell combines with spatial distribution and analysis in geographic information system to estimate loss and damage in Bac Lieu agriculture, which is represented by rice productivity and cultivating land. The result indicated that risking of loss and damage in Bac Lieu agriculture almost occurs in two future years more than basic year, in which Phuoc Long is a county, has the most loss and damage value in 2030 and 2050 year due to effect of temperature and precipitation factors, respectively with 30.8 billion VND in 2030 year and 222.09 billion VND in 2050 year by precipitation; 70.18 billion VND in 2030 year and 556.25 billion VND in 2050 year by temperature. Moreover, Gia Rai county has the most loss and damage value in 2030 year, obtains 326.75 billion VND and Hong Dan county has the biggest loss and damage risking in 2050 year as 660.23 billion VND by effecting of sea level rising. Besides, the research also indicates the loss and damage value in 2050 year is higher than 2030 year about 2-3 times with sea level rising factor; 5-7 times with precipitation factor; and 7-8 times in temperature factor. Additionally, Dong Hai county has the lowest loss and damage risking in the whole province: 1.11 billion VND in 2050 year by sea level rising, 0.82-3.21 billion VND due to effect of precipitation, and 1.82-14.46 billion VND by effect of temperature. Therefore, this article revealed estimation of loss and damage risking in applying amalgamation of agromeshell model and geographic information system, this meaning will be aided environmental manager to be able to take out timely response solutions with climate change.

KEYWORDS: Climate Change, loss and damage, Bac Lieu, Agromeshell, Geographic information system.

I. INTRODUCTION

Science points to widespread current and future biophysical impacts of climate change

[11]. Climate change refers to a long-term change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties [14] such as temperature change, precipitation, humidity, wind patterns, extreme weather, and so on [13,15] and they make alteration of the energy balance of the climate system lead to increasing risk of vector born diseases, widespread damage of natural ecosystem, loss of biodiversity, increase the frequency of extreme events like droughts, floods [27] typhoon, heat wave, wildfire [22, 25]. The past decade has demonstrated that the global environment has been altered by human activities [30]. It is attributed directly or indirectly to human activity that alters the composition of the global atmosphere such as burning of fossil fuels [30], land use change and agriculture that are increasing the atmospheric concentrations of greenhouse gases, and aerosols [12, 14]. According to the data from the United Kingdom's Met Office showed the rise in global average temperature in 2015 and 2016 had breached 1°C 2050 [26], in the period 1971–2010 the rate of warming is estimated at 0.26°C per decade [21] and this number will be up to 4°C in 2050 [26] leading more severe droughts and/or floods in some places and less severe droughts and/or floods in other places [12] as well as contributes to the flood intensity [7]. The IPCC indicated that global sea level has risen by between 10 and 25 cm over the past 100 years [12] and the sea level rise of 22cm by 2050 [31] as a warning for loss and damage in agriculture by climate change. Those things affect directly to people lives, rural livelihoods [1, 35], biodiversity [18], crop growth processes, loss farmland, damage transport and infrastructure [6, 33], submerge coastal land [23], and high risk of submerge salinity [29].

Loss and damage as the actual and/or potential manifestation of impacts associated with climate change that negatively affect human and natural systems, including impacts from flooding,

drought, sea level rise, glacial retreat, and etc [36, 16]. There are many researches is studied to loss and damage as using loss data to make decision about disaster aid [9, 34]; using trends data in losses as a measure of policy [8]; damage assessment via flood models [5]; gaps of loss and damage emerge in human systems around the barriers and constraints to be adaption [3]; consequences of exceeding limits at different scales of loss and damage [17]; reanalysis offlood damage database [24]; brief history and set out the central elements with WIM's function of loss and damage [19]; analyze the latest literature on land, cosystem degradation and adaption land management practices, policies preventing loss and damage [4]. However, they are merely assessment and analysis about understanding of loss and damage signification that they have not completely revealed about estimating of loss and damage value by money, especially in application of geographic information system to find out the loss of rice cultivating land area via deluge due to impact of rising sea level and using Agromeshell model combines with geographic information system to identify the damage level in agriculture through rice productivity owing to impact of temperature as well as precipitation. Therefore, this article uses a new method, which is spatial analysis in geographic information system and Agromeshell model in order to estimate the loss and damage of Bac Lieu agriculture in climate change devastating consequences via rising sea level, temperature, and precipitation factors in basic year, and predicting of loss and damage risk for 2030, 2050 year.

II. METHODOLOGY

Vietnam has both a tropical climate zone and a temperate climate zone; temperature normally at the southern is higher than northern with two seasons, in which rainy season brings heavy rainfall, also is one of the major natural risks facing is riverside and coast flooding. Vietnam's coastline is 3,200kilometers long and 70 percent of population lives in coastal areas and lowly deltas [32]; Bac Lieu is a province locating at this coastal are and has mainly rice agricultural development. Climate change really threatens multiple stressors on agriculture of Vietnam southern provinces, and Bac Lieu is suffered this effecting as well by rising sea level, temperature, and precipitation factors in climate change. From that, the article focuses on these factors to identify economic loss and damage value in Bac Lieu agriculture via seven counties in basic year, 2030 and 2050 year [20], in which rice cultivation is regarded as representation because rice has a particularly vital role and is mainly food in

Vietnam agriculture as well as Bac Lieu province. The formula to calculate loss and damage value is applied following as:

$$\text{Loss and damage} = S * P$$

In which,

S is scope of suffering loss and damage

P is price for each loss and damage suffering objective

With the cost of rice productivity is calculated depending on the rice cost due to Department of Bac Lieu Agriculture and Rural Development published for basic year, and slippage value is counted following Joint Circular No.23/2016/TTLT-BTC-BNNPTNN due to Ministry of Finance and Ministry of Agriculture and Rural Development issued about guiding of investigated and produced rice cost calculation methods. In the price of rice cultivating land-use is applied by the issued decision of provincial people's committee about costing of land types.

Loss and damage by rising sea level: From data system concluding spatial data and attributed data, these data are selected from Bac Lieu administrative offices and Bureau of surveying and cartography. In this research used map overlay methodology in geographic information system to find out deluge on rice cultivating land area. After map edition process is completed, the research is published the whole inundated area data and maps in order to calculate the loss on rice cultivating land-use in seven counties of Bac Lieu province. The relevant factors such as topographic change or geological uplift, subsidence by groundwater extraction, coastline change, tide changing or hurricanes, acid raining, biodiversity, non-economic damage, extreme weather, and etc will not be considered in this article.

Loss and damage by precipitation and temperature: Wind speed, temperature, precipitation, radiation, humidity, sowing season, and soil data are original ones, are used in Agromeshell to identify rice productivity in basic year, and these original data is regarded as no changing in predicted years that it is only changed by temperature or precipitation factor depending on consideration of each factor (precipitation or temperature) in research process. The rice productivity in Bac Lieu province is revealed in agromeshell model [2] and Tooming G. X formula [28] as:

$$Y_{ct} = Y_p \cdot \left[1 - K_y \left(1 - \frac{ETa}{WR} \right) \right]$$

In which,
Yct is the productivity can be achieved (ton/ha)
Yp is potential productivity (ton/ha)

Eta is total realistic evaporation (mm)
WR is potential evaporation content (mm)
Ky is coefficient of productive diminishing

Table 1 Coefficient of rice productive diminishing [10]

Rice cultivation	K _{y1}	K _{y2}	K _{y3}	K _{y4}	K _{yvnu}
Water rice	1,0	2,0	2,5	1,0	2,0
Dry rice	0,4	0,9	1,5	0,5	1,25

And potential productivity is used by Tooming X. G formula:

$$Y_p = \frac{\eta_p * K * \sum Q}{q}$$

In which,
Y_p is potential productivity (ton/ha);

η_p is coefficient of photosynthetic radiation factor (%);
q is heating content can be obtained when burning 1 gram of rice dry matter (cal/g)
ΣQ is photosynthetic radiation (cal/cm²)
K is coefficient of rice productivity determination

Table 2 Coefficients of rice cultivation in Tooming X.G method

η _p	1,6-3,5
K	0,5

Potential evaporation content is calculated in Cropwat model as:

$$WR = Kc \times ET_0 \text{ (mm/day)}$$

And, $ET_0 = C [W \times Rn + (1-W) \times f(u) \times (ea-ed)]$
(Penman- Monteith, mm/day)

Kc: Crop coefficient depending on plant cultivation area and growth stage

ET₀: Evaporation is calculated by Penman-Monteith formula

C: Adjusted coefficient of wind speed and solar radiance

W: Coefficient is related to elevation of irrigation area and temperature

Rn: realistic radiation

f(u): Relationship function with wind speed

(ea-ed): Difference from saturated vapor pressure and realistic vapor pressure

From that, the research is gained rice productivity changing of 2030 and 2050 year versus basic year.

Via application of geographic information system, this article is found out rice productivity changing for each county in Bac Lieu province to determine the risk of loss and damage.

III. RESULTS AND DISCUSSION

Basing on spatial analysis in geographic information system combines with using Agromeshell model in the research process. The results are presented as follows:

Loss and damage of rice cultivating land area by rising sea level

After calculating process in geographic information system about economic loss and

damage on Bac Lieu rice cultivating land area. Table 3 is presented that risk of loss and damage in 2030 and 2050 year is almost more than basic year due to extension in submerging area of sea level rising. There are some counties, which has not the loss and damage in basic year such as Hong Dan, Phuoc Long, and Dong Hai County, but in 2030 year, risking of loss and damage presents 241.4 (Hong Dan county) and 161.96 billion VND (Phuoc Long county). This damage rises also 1.5-3 times versus 2030 year (660.23 billion VND for Hong Dan; 270.64 billion VND for Phuoc Long). Dong Hai is a county has the least loss and damage risking in Bac Lieu province as 1.11 billion VND in 2050 year while this county does not appear the loss and damage in basic and 2030 year. Nevertheless, the county has the most loss and damage risking in Bac Lieu province belongs to Hong Dan country in 2050 year with 660.23 billion VND, next is Gia Rai County with 643.59 billion VND. Although, Gia Rai has 2nd ranking of loss and damage risking in 2050 year, but it has the first loss and damage risking in 2030 year with 326.75 billion VND, and the second ranking is Vinh Loi County with 264.6 billion VND. Thus, the loss and damage by sea level rising is indicated clearly in table 3 with its value is from 0-278.04 billion VND with total value as 565.76 billion VND in basic year; 0-326.75 billion VND with total value as 1115.3 billion VND in 2030 year (rising more 2 times versus basic year); and 1.11-660.23 billion VND with total value as 2261.77 billion VND in 2050 year (rising about 4 times versus basic year).

Especially, Gia Rai county has the highest loss and damage risking in 2030 year and Hong Dan county has the highest loss and damage risking in 2050 year although it did not appear submergence by sea

level rising in basic year. Moreover, Dong Hai County has the least loss and damage risking in Bac Lieu province.

Table 3 Loss and damage value of rice cultivating land by sea level rising
(Unit: Billion VND)

County name	Basic year	2030 year	2050 year
Gia Rai	278.04	326.75	643.59
Hoa Binh	38.21	38.21	114.49
Hong Dan	0	241.4	660.23
Phuoc Long	0	161.96	270.64
Bac Lieu city	66.65	82.38	107.8
Vinh Loi	182.86	264.6	463.91
Dong Hai	0	0	1.11

Spatial distribution of submerged area on rice cultivating land

Showing on two maps of 2030 year and 2050 year presents clearly inundated area due to rising sea level is distributed the whole province, in which coastline counties is more submerged than other ones. However, in coastline counties have not a lot of rice cultivating land area. Therefore, the loss and damage in these coastline counties almost belongs to other land-use types such as resident land, urban land or aquaculture land, and so on. While counties locate beside coastline counties have more rice cultivating land area as Phuoc

Long, Gia Rai and Hong Dan County, this is a reason that these counties have more loss and damage value on rice cultivating land than coastline counties. Furthermore, on the maps indicate Gia Rai County is the most inundated as well as loss and damage on rice cultivating land in 2030 year, and this value increases about two times in 2050 year. And also in this 2050 year, Hong Dan and Gia Rai County is two counties have been more loss and damage, in which loss and damage value of Hong Dan County is more than Gia Rai County as 16.64 billion VND.

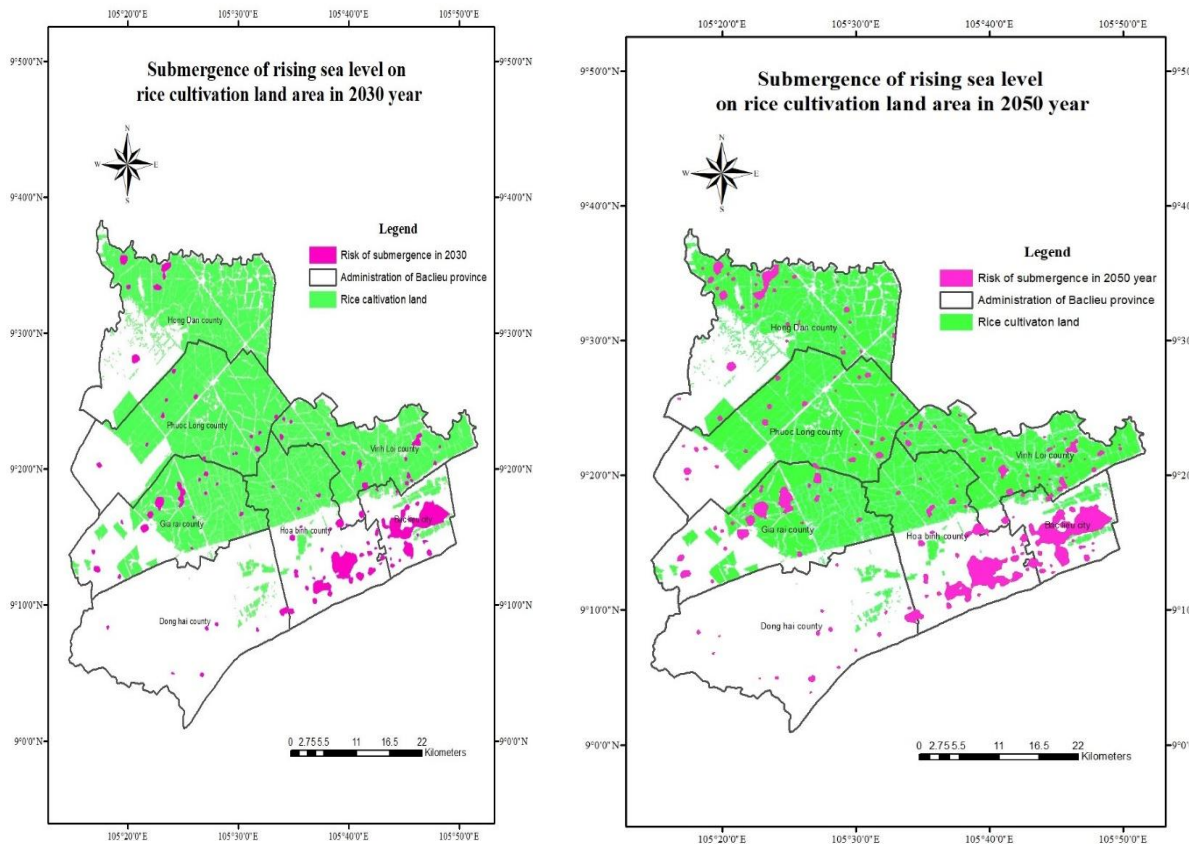


Fig.1. Submerging distribution on Bac Lieu rice cultivating land in 2030 and 2050 year

Loss and damage of rice productivity by precipitation

Our country in recently has rapid economic growth and depending on agriculture that the most productivity in agriculture is rice plant. Or another speaking as rice agriculture is represented for Vietnam, and Bac Lieu province has a lot of rice cultivating area, which is covered almost by counties in province. This point shows that if the loss and damage on rice agriculture happens, it means will be affected so much to people life and economic development. From applying Agromeshell model combines with spatial analysis in geographic information system, this research indicates out the loss and damage due to precipitation via rice productivity changing in 2030 and 2050 year versus basic year. Table 4 is total loss and damage risking of seven counties in Bac Lieu province, it reveals that the loss and damage value is from 0.82-30.8 billion VND in 2030 year and this value is increased strongly in 2050 year, from 3.21-222.09 billion VND. Particularly, in 2030 year, Phuoc Long county has the highest loss

and damage risking with 30.8 billion VND, following distantly by Hong Dan county with 25.08 billion VND; Vinh Loi county is 21.82 billion VND; Gia Rai county with 18.95 billion VND; Hoa Binh county with 12.85 billion VND; Bac Lieu city is 2.03 billion VND; and the least is Dong Hai county with 0.82 billion VND. Addition to that, in 2050 year, this loss and damage value also increases more times versus 2030 year such as Phuoc Long county gains 222.09 billion VND and is the county has the highest loss and damage value. Next is Vinh Loi county with 167.76 billion VND; Hong Dan county with 154.49 billion VND; Gia Rai county with 148.76 billion VND; Hoa Binh county is 101.13 billion VND; Bac Lieu city and Dong Hai county have the smallest loss and damage risking, respectively as 16.25 billion VND and 3.21 billion VND. Thus, Phuoc Long is a county, which has the highest the loss and damage risking and Dong Hai has the lowest one in 2030 and 2050 year of Bac Lieu province by affecting of precipitation in climate change.

Table 4 Loss and damage value of Bac Lieu rice productivity by precipitation

County name	Basic year	2030 year	2050 year		
	Rice productivity (ton)	Changing of rice productivity versus basic year (ton)	Risk of damage (Billion VND)	of	Risk of damage (Billion VND)
			Changing of rice productivity versus basic year (ton)		
Gia Rai	130430.77	3422.44	18.95		6845.64
Hoa Binh	86051.72	2320.83	12.85		4653.70
Hong Dan	181029.48	4529.63	25.08		7109.19
Phuoc Long	216385.71	5563.63	30.80		10219.93
Bac Lieu city	13433.12	367.09	2.03		747.92
Vinh Loi	146262.85	3942.38	21.82		7720.03
Dong Hai	5568.88	148.15	0.82		147.75

Loss and damage of rice productivity by temperature

Similarly, estimation of loss and damage in Bac Lieu agriculture through affecting of temperature factor is presented by its value in table 5: Risking of loss and damage occur the biggest at Phuoc Long County with 70.18 billion VND and 556.25 billion VND in 2030 year and 2050 year versus the whole province. Next is Hong Dan county with 58.31 billion VND and 461.12 billion VND; Vinh Loi county is 46.32 billion VND and 378.75 billion VND; Gialai county is 42.6 billion VND and 337.57 billion VND; 27.65 billion VND

and 223.6 billion VND belongs to Hoa Binh county; Bac Lieu city gains 4.26 billion VND and 34.96 billion VND; and Dong Hai county has the least loss and damage value with 1.82 billion VND and 14.46 billion VND in two years (2030 year and 2050 year). The result indicates Phuoc Long county suffers the most loss and damage in two years, 2030 and 2050 year. While Dong Hai county presents the least loss and damage in the whole Bac Lieu province via affecting of temperature factor in climate change.

Table 5 Loss and damage of Bac Lieu rice productivity by temperature

County name	Basic year	2030 year	2050 year		
	Rice productivity (ton)	Changing of rice productivity versus basic year (ton)	Risk of damage (Billion VND)	of	Risk of damage (Billion VND)
			Changing of rice productivity versus basic year (ton)		
Gia Rai	130430.77	7695.44	42.60		15534.17
Hoa Binh	86051.72	4994.79	27.65		10289.43
Hong Dan	181029.48	10532.02	58.31		21219.34
Phuoc Long	216385.71	12677.87	70.18		25597.17
Bac Lieu city	13433.12	768.66	4.26		1608.92
Vinh Loi	146262.85	8367.53	46.32		17428.90
Dong Hai	5568.88	328.58	1.82		665.61

Difference from loss and damage by climate change factors

The below figure is three factors are considered and have relation to loss and damage of Bac Lieu agriculture (rice productivity and cultivating land) in 2030 and 2050 year shows that

loss and damage value due to rising sea is high, especially in Hong Dan and Gia Rai county. Particularly, loss and damage value in 2050 year (pink line) almost more increasing than 2030 year when comparison with the same type, respectively about 2-3 times. Besides, the value of loss and

damage owing to precipitation although in 2050 year (royal blue line) is higher than 2030 year, but it is revealed in ordinary gap (5 times) except for Phuoc Long county has the most loss and damage value in 2050 year and more than 2030 year about 7 times. Nevertheless, the value of loss and damage due to temperature in 2050 year (lime green line) almost is higher than 2030 year and in big gap,

typically Phuoc Long, Hong Dan, and Gia Rai county has loss and damage value is riser than 2030 year about 7-8 times. Therefore, from figure 2 indicates the risking of loss and damage in Bac Lieu agriculture by climate change factors is not small, and if climate change continues occurring, the loss and damage in Bac Lieu agriculture also is more increasing.

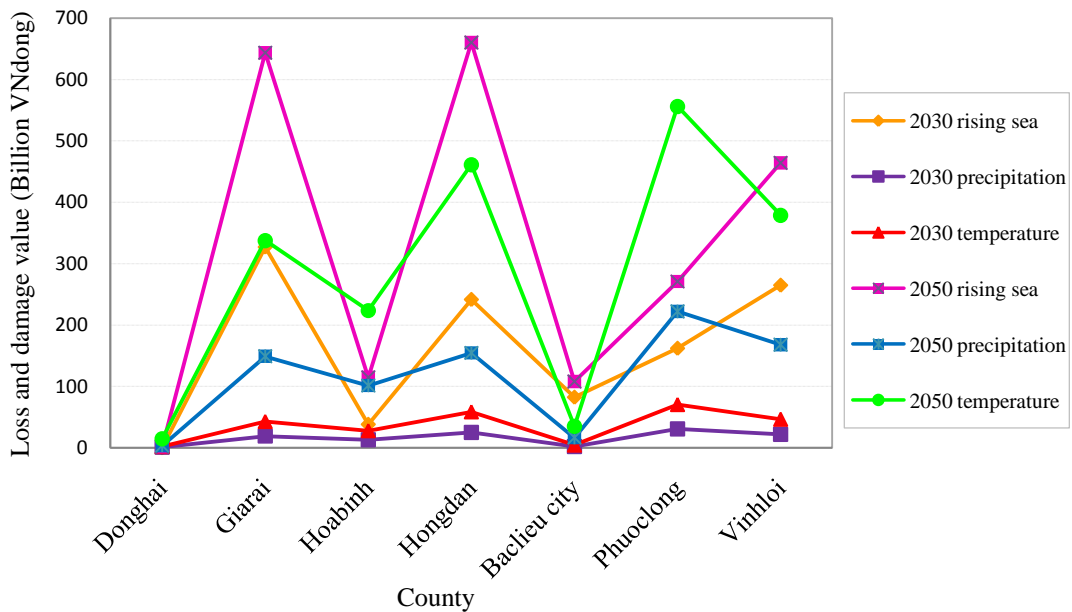


Fig.2. Loss and damage risking of Bac Lieu agriculture in 2030 and 2050

IV. CONCLUSION

Climate change not only affects to Bac Lieu rice cultivating land area as diminishing rice cultivation land area in agriculture, but also impacts directly to agricultural outcome growth and rice productivity leading to be shortage of rice and reducing rice export potentiality. Estimation of loss and damage in Bac Lieu agriculture is regarded as a pre-warning about climate change how to affect and damage to rice agriculture in order to be able to take out response solutions on time. From agromeshell model combines with geographic information system, this article took out the loss and damage value on Bac Lieu rice agriculture in basic, 2030 and 2050 year. It is drawn following as:

Loss and damage in 2030 and 2050 year is higher than basic year, in which in 2050 year is more loss and damage than 2030 year about 2-3 times in some counties such as Hong Dan and Gia Rai county, gains 643.59-660.23 billion VND

while Gia Rai county has the most loss and damage value in 2030 year, obtains 326.75 billion VND due to effect of sea level rising.

Risking of loss and damage in 2050 is higher than 2030 year about 5 times, especially Phuoc Long County is 7 times owing to effect of precipitation. Moreover, Phuoc Long and Hong Dan county has the most loss and damage value in 2030 year, obtains 25.08-30.8 billion VND while Vinh Loi and Phuoc Long county achieve loss and damage value as 167.76-222.09 billion VND in 2050 year.

Owing to effect of temperature, loss and damage value in 2050 year is more than 2030 year with big gap (7-8 times). Phuoc Long County has the most loss and damage risking; it gains 70.18 billion VND in 2030 year and 556.25 billion VND in 2050 year.

Dong Hai County has the lowest loss and damage value in the whole province: 1.11 billion VND in 2050 year by sea level rising, 0.82-3.21

billion VND due to effect of precipitation, and 1.82-14.46 billion VND by effect of temperature.

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