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Research Paper

Loss and damage of can tho agriculture in vietnam due to climate change

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ABSTRACT

This research used Agromeshell model combines with spatial distribution and analysis in GIS to estimate loss and damage in Can Tho agriculture, which is represented by rice productivity and cultivating land. The result indicated that Thoi Lai county has the highest loss/damage risking, gains 1448.16 billion VND in 2030 year and 1975.62 billion VND in 2050 year. Binh Thuy has the lowest loss/damage risking with 15.39 billion VND in 2050 and Vinh Thanh has the least loss/damage value in 2030 year with 9.01 billion VND by rising sea level. Thoi Lai has the highest loss/damage risking in 2050 year with 25.81 billion VND; Vinh Thanh county has the highest loss/damage risking in 2030 year with 18.35 billion VND by precipitation. Co Do County has the highest loss/damage risking in 2030 and 2050 year with 57.82 billion VND and 314.32 billion VND by temperature. Ninh Kieu county has the least loss/damage value in 2030 and 2050 year by affecting of precipitation as well as temperature in climate change. Therefore, this article revealed estimation of loss and damage risking in applying amalgamation of agromeshell model and GIS.

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1. INTRODUCTION

Science points to widespread current and future biophysical impacts of climate change [1]. Climate change refers to a long-term change in the state of the climate that can be identified by changes in the mean

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and/or the variability of its properties [2] such as temperature change, precipitation, humidity, wind patterns, extreme weather, and so on [3], [4] 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 [5] typhoon, heat wave, wildfire [6], [7].The past decade has demonstrated that the global environment has been altered by human activities [8]. It is attributed directly or indirectly to human activity that alters the composition of the global atmosphere such as burning of fossil fuels [8], land use change and agriculture that are increasing the atmospheric concentrations of greenhouse gases, and aerosols [9], [2]. According to the data from the United Kingdom's Met Office showed the rise in global average temperature in 2015 and 2016 had breached 1oC 2050 [10], in the period 1971–2010 the rate of warming is estimated at 0.26°C per decade [11] and this number will be up to 4oC in 2050 [10] leading more severe droughts and/or floods in some places and less severe droughts and/or floods in other places [9] as well as contributes to the flood intensity [12]. The IPCC indicated that global sea level has risen by between 10 and 25 cm over the past 100 years [9] and the sea level rise of 22cm by 2050 [13] as a warning for loss and damage in agriculture by climate change. Those things affect directly to people lives, rural livelihoods [14], [15], biodiversity [16], crop growth processes, loss farmland, damage transport and infrastructure [17], [18], submerge coastal land [19], and high risk of submerge salinity [20].

Loss and damage are 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 [21], [22]. There are many researches is studied to loss and damage as using loss data to make decision about disaster aid [23], [24]; using trends data in losses as a measure of policy [25]; damage assessment via flood models [26]; gaps of loss and damage emerge in human systems around the barriers and constraints to be adaption [27]; consequences of exceeding limits at differents scales of loss and damage [28]; reanalysis offlood damage database [29]; brief history and set out the central elements with WIM's function of loss and damage [30]; analyze the latest literature on land, cosystem degradation and adaption land management practices, policies preventing loss and damage [31]. 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 and are damaged by climate change. Addition to that is 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, in 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 in agriculture of Can Tho province – Vietnam 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.

2. 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 3,200 kilometers long and 70 percent of population lives in coastal areas and lowly deltas [32]; Can Tho is a province located at southern of Vietnam and far from the East Sea about 75 kilometers. Can tho is regarded as an important economy area of Vietnam because it has good land condition and weather. Therefore, Can Tho always exports of products from agriculture.

Nowadays, climate change really threatens multiple stressors on agriculture of Vietnam southern provinces, especially is Can Tho province because it does not only effect to the agriculture but also effect to economy of Vietnam. Its impacts as rising sea level, temperature, precipitation; it causes floods/droughts, salt submergence, etc. From that, this article focuses on rising sea level, temperature, precipitation to identify economic loss and damage value in Can Tho agriculture via nine counties in basic year, 2030 and

2050 year [33], 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 Can Tho province.

The formula to calculate loss and damage value is applied following as:

2.1. 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 Can Tho 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.

2.2. Loss and Damage by Rising Sea Level

From data system concluding spatial data and attributed data, these data are selected from Can Tho 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 nine counties of Can Tho 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 Agromeshelltoidentify 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 onconsideration of each factor (precipitation or temperature) in research process. The rice productivity in Can Tho province is revealed in agromeshell model [34] and Tooming G. X formula [35] as:

$$[1 - Ky(1 - \frac{ETa}{\text{WR}})]$$

Yct = Yp .

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 [36]

Rice Cultivation	K_{y1}	K_{y2}	K_{y3}	K_{y4}	$K_{yvụ}$
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:

$$\text{Yp} = \frac{\eta\text{p} \times \text{K} \times \sum\text{Q}}{q}$$

In which,

- Y_p is potential productivity (ton/ha);
- η_p iscoefficient of photosynthetic radiation factor (%);

- q is heating content can be obtained when burning 1 gram of rice dry matter (cal/g)
- ΣQ isphotosynthetic radiation (cal/cm^2)
- 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 x ET_0 (mm/day)

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

- Kc: Crop coefficient depending on plant cultivation area and growth stage
- ET_0: 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 applycation of geographic information system, this article is found out rice productivity changing for each county in Can Tho province to determind the risk of loss and damage.

3. 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:

3.1. 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 Can Tho 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 have not the loss and damage in basic year such as Cai Rang, Co Do, and Vinh Thanh county; and with two counties of Cai Rang and Co Do are still not lost/damaged on the agricultural land by rising sea level. However, with Vinh Thanh County appears risking of loss and damage on the agricultural land area and 2050 year is more loss and damage than 2030 year about 4.8 times (9.01 billion VND in 2030 year and 43.32 billion VND in 2050 year). This rising of loss and damage is happened most of counties in 2050 year versus 2030 year. Particularly, Thoi Lai county has the highest loss/damage with 1448.16 billion VND in 2030 year and 1975.62 billion VND in 2050 year; the second one is Thot Not county with 1040.9 billion VND for 2030 and 1059.59 billion VND for 2050 year; next is Phong Dien county with 330.99 billion VND in 2030 and 498.25 billion VND in 2050 year; O Mon county has loss/damage of 139.99 billion VND (2030 year) and 185.65 billion VND (2050 year); Co Do county has loss/damage of 55.51 billion VND in 2030 year and 133.45 billion VND in 2050 year; and the last county has the least loss/damage risking as Binh Thuy with 13.81 billion VND in 2030 and 15.39 billion VND in 2050. Therefore, Thoi Lai County has the most loss/damage risking on the agricultural land in 2030 and 2050 year with total about 3000 billion VND of Can Tho 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
Binh Thuy	13.17	13.81	15.39
Cai Rang	0	0	0

Co Do	46.96	55.51	133.45
Ninh Kieu	0	0	0
O Mon	118.58	139.99	185.65
Phong Dien	329.07	330.99	498.25
Thoi Lai	1397.56	1448.16	1975.62
Thot Not	1031.83	1040.9	1059.59
Vinh Thanh	0	9.01	43.32

3.2. 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 Thoi Loi, O Mon, and Thoi Lai counties; this is a reason of these counties have more loss and damage value on rice cultivating land than coastline counties. Furthermore, on the maps indicate Thoi Lai County is the most inundated as well as loss and damage on rice cultivating land in 2030 and 2050 year. Additionally, in this 2050 year, almost counties of Can Tho province are more submerged than 2030 year by sea rising. Thus, risking of loss and damage on the agricultural land of province is more increased than 2030 and basic years; and this loss/damage will achieve several thousand billion VND according to be above estimation.

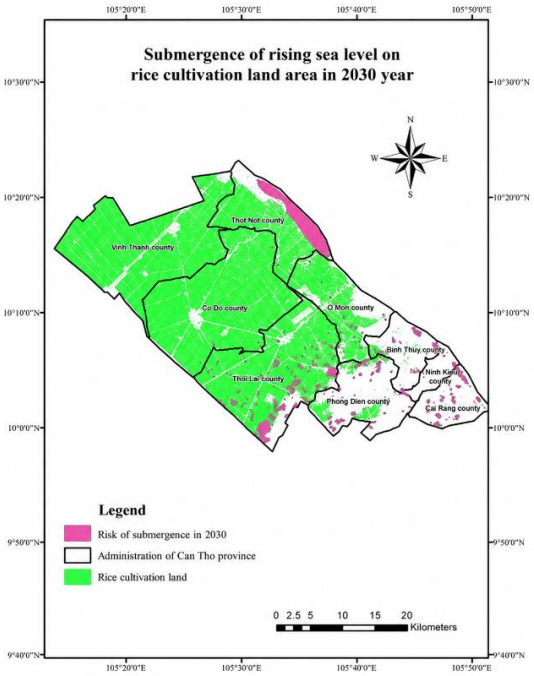

Figure 1. Submerging Distribution on can the Rice Cultivating Land in 2030 and 2050 Year

3.3. 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 Can Tho 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 Can Tho province, it reveals that the loss and damage value is from 0.0002-22.01 billion VND in 2030 year and this value is increased strongly in 2050 year, from 0.001-25.81 billion VND. Particularly, in 2030 year, Co Do county has the highest loss and damage risking with 22.01 billion VND, following distantly by Vinh Thanh county with 18.35 billion VND; Thoi Lai county is 15.35 billion VND; Thot Not county with 6.01 billion VND; O Mon county with 4.76 billion VND; Phong Dien, Binh Thuy, Ninh Kieu and Cai Rang have loss/damage value under 2 billion VND.

Addiction to that, in 2050 year, this loss and damage value also increases more times versus 2030 year such as Thoi Lai county gains 25.81 billion VND and is the county has the highest loss and damage value in 2050 year. Next is Co Do county with 12.78 billion VND; O Mon county with 7.77 billion VND; Thot Not and Phong Dien counties are 3.57 and 3.24 billion VND; Cai Rang and Binh Thuy counties have the loss/damage value under 1billion VND. Thus, Ninh Kieu county has the least loss/damage value in 2030 and 2050 year by affecting of precipitation in climate change; and Thoi Lai has the highest loss/damage risking in 2050 year with 25.81 billion VND. However, this highest value in 2030 year belongs to Vinh Thanh county with 18.35 billion VND.

Table 4. Loss and Damage Value of can tho 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)	Changing of rice productivity versus basic year (ton)	Risk of damage (Billion VND)
Binh Thuy	2081.58	49.54	0.24	47.95	0.64
Cai Rang	1.93	0.05	0.0002	0.06	0.001
Co Do	208383	4480.19	22.01	951.82	12.78
Ninh Kieu	0.99	0.02	0.0001	0.03	0.0004
O Mon	42776.86	969.08	4.76	578.45	7.77
Phong Dien	10377.2	247.12	1.21	241.62	3.24
Thoi Lai	138351.37	3124.01	15.35	1922.16	25.81
Thot Not	57016.5	1223.81	6.01	265.8	3.57
Vinh Thanh	177888.01	3736.21	18.35	343.08	4.61

3.4. Loss and Damage of Rice Productivity by Temperature

Similarly, estimation of loss and damage in Can Tho agriculture through affecting of temperature factor is presented by its value in Table 5 indicated that Ninh Kieu County has still the lowest loss/damage value with 0.0003-0.002 billion VND in both of 2030 and 2050 year. However, this value is increasingly with other counties of Can Tho province in 2030 and 2050 year. Particularly, Co Do county has the highest loss/damage risking in 2030 and 2050 year with 57.82 billion VND and 314.32 billion VND; and this value is more loss/damage than in 2030 year about 6 times. Next is Vinh Thanh county as 49.71 billion VND in 2030 and 268.17 billion VND in 2050; it is higher than about 6.2 times. The loss/damage value of Thoi Lai county in 2050 year (210.83 billion VND) is more than 2030 year (38.36 billion VND) about 5.8 times. Thot Not county has loss/damage risking with 15.78 billion VND in 2030 and 86.1 billion VND in 2050 (5.9 times); following by Phong Dien county is 2.84 billion VND for 2030 and 15.97 billion VND in 2050 year; Binh Thuy county is 0.56 billion VND in 2030 and 3.2 billion VND in 2050; Cai Rang county has loss/damage value under 1 billion VND. Consequently, the highest loss/damage value by affecting of temperature in climate change belongs to Co Do county in both of 2030 and 2050 year; and the least one is Ninh Kieu county. The loss/damage risking value in 2050 is more than 2030 from 5 to 6 times for several counties.

Table 5. Loss and Damage of can tho 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)	Changing of rice productivity versus basic year (ton)	Risk of damage (Billion VND)
Binh Thuy	2081.58	114.96	0.56	238.4	3.2
Cai Rang	1.93	0.11	0.001	0.22	0.003
Co Do	208383	11770.6	57.82	23411.06	314.32
Ninh Kieu	0.99	0.05	0.0003	0.11	0.002
O Mon	42776.86	2385.12	11.72	4851.5	65.14
Phong Dien	10377.2	577.7	2.84	1189.19	15.97
Thoi Lai	138351.37	7810.28	38.36	15703.47	210.83
Thot Not	57016.5	3213.54	15.78	6412.69	86.1
Vinh Thanh	177888.01	10120.22	49.71	19973.77	268.17

3.5. Difference from Loss and Damage by Climate Change Factors

The below Figure 2 is three factors are considered and have relation to loss and damage of Can Tho agriculture (rice productivity and cultivating land) in 2030 and 2050 year shows that loss and damage value due to rising sea level in Can Tho province of Thoi Lai and Thot Not counties is higher than other counties more times (hundred times). Addition to that, it is almost the loss/damage risking of counties in 2050 year is more than 2030 and basic year because the temperature increases leading sea level rises as well. Risking of loss/damage in Can Tho province changes in each counties, but generally the agricultural land in Can Tho province are damaged significantly by climate change. Particularly, Thot Not and Thoi Lai counties are damaged several thousands billion VND for 2030 and 2050 year by rising sea level.

The loss/damage risking by precipitation of counties in 2030 and 2050 year is most increasingly than basic year, in which Thoi Lai has the highest loss/damage risking in 2050 year and Vinh Thanh county has the most loss/damage risking in 2030 year. This growth of loss and damage risking is also presented clearly by effecting of temperature, such as Vinh Thanh, Co Do, and Thoi Lai counties has the loss/damage value in 2050, is more increasingly than 2030 year about 6 times. However, the highest loss/damage risking in 2030 and 2050 year by temperature belongs to Co Do county. This is different point of loss/damage risking by temperature versus risking of loss/damage from precipitation and rising sea level on Can Tho agriculture land.

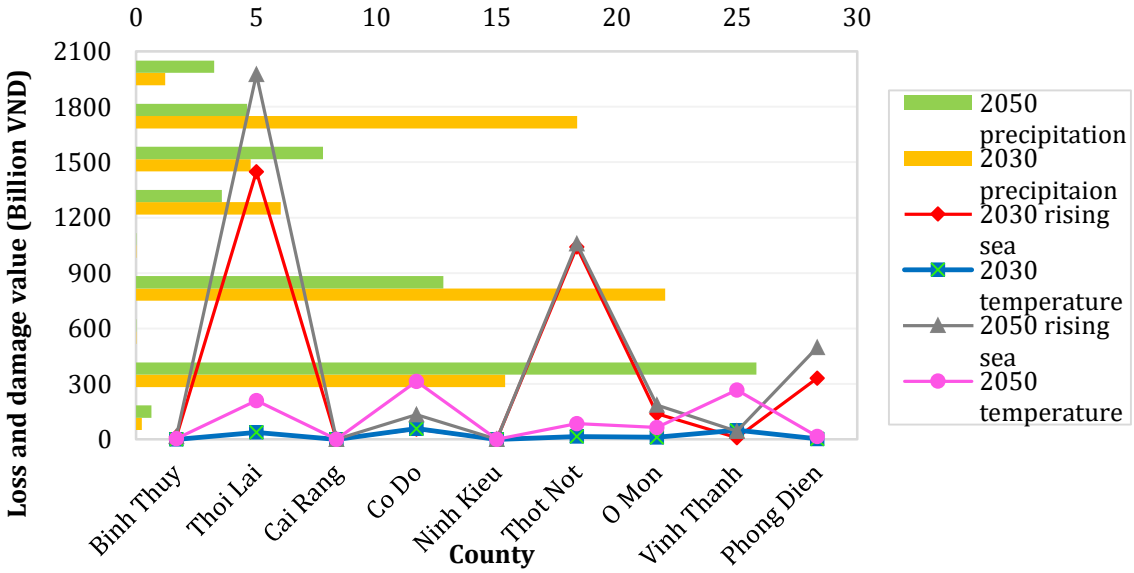

Figure 2. Loss and Damage Risking of can though Agriculture in 2030 and 2050

4. CONCLUSION

Climate change not only affects to Can Tho 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 Can Tho 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 spatial analysis in geographic information system, this article took out the loss and damage value on Can Tho rice agriculture in basic, 2030 and 2050 year. It is drawn following as:

Loss and damage in 2030 and 2050 year are higher than basic year, in which in 2050 year is more loss and damage than 2030 year. Thoi Lai County has the highest loss/damage risking, gains 1448.16 billion VND in 2030 year and 1975.62 billion VND in 2050 year. Binh Thuy has the lowest loss/damage risking with 13.81 billion VND in 2030 and 15.39 billion VND in 2050. Especially, in some counties, the loss/damage value is more than other counties about hundred times in the same year due to sea level rising, such as Thoi Lai and Thot Not County.

With effecting of precipitation in climate change, Thoi Lai has the highest loss/damage risking in 2050 year with 25.81 billion VND; and Vinh Thanh County has the highest loss/damage risking in 2030 year with 18.35 billion VND.

However, the loss/damage value in 2050 year is caused by effecting of temperature is more than 2030 year about 6 times for most counties in Can Tho province, such as Co Do county has the highest loss/damage risking in 2030 and 2050 year with 57.82 billion VND and 314.32 billion VND or Vinh Thanh county is 49.71 billion VND in 2030 and 268.17 billion VND in 2050.

Ninh Kieu county has the least loss/damage value in 2030 and 2050 year by affecting of precipitation as well as temperature. Vinh Thanh has the least loss/damage value in 2030 year and this least value belongs to Binh Thuy county in 2050 year by rising sea level owing to climate change.

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Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Minh Thu Nguyen	✓	✓		✓	✓	✓		✓	✓	✓		✓		✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this article.

Informed Consent

All participants were informed about the purpose of the study, and their voluntary consent was obtained prior to data collection.

Ethical Approval

Not Applicable.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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