

APPLICATION OF GIS TECHNOLOGY TO ASSESS THE AFFECT OF SEA LEVEL RISE ON AGRICULTURAL LAND. CASE STUDY OF NGHIA HUNG DISTRICT, NAM DINH PROVINCE

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Abstract. Global sea levels are rising and this change is expected to accelerate in the coming century due to anthropogenic global warming. Any rise in sea level promotes land loss, increased flooding and salinisation. The impacts of and possible responses to sea-level rise vary at the local and regional scale due to variation in local and regional factors.

The coastline of Vietnam is more than 3,260 km and stretches across from north to south. Here occur a series of interactive processes between the land and the sea, between the dynamic force of rivers and the sea, between the natural and human processes, etc. Recently, sea level rise due to climate change is serious global threat.

Therefore, a study to assess the impact of sea level rise on agricultural land fills a critical need. In this paper, we focus on the application of GIS technology to analyze and predict the impact of sea level rise on agricultural land use of this coastal district. The results will help managers and policy makers to make the right decisions in agricultural land use and adaptation strategies for climate change.

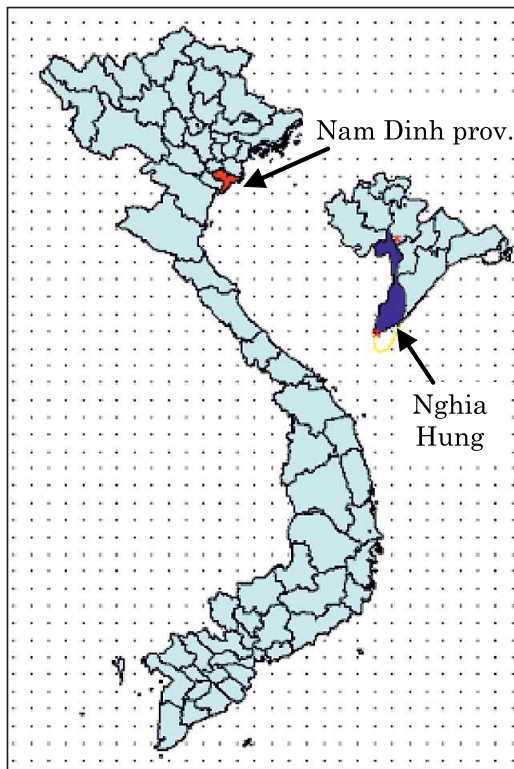
Key words: sea level rise, land use, GIS

INTRODUCTION

Climate change is happening all around the world, not only at a region level where Vietnam is located in, but also at a global level, due to the excessive emission of greenhouse gases into the atmosphere by the human activities. Climate change will seriously impacts on the production, living condition and the environment across the world. This issue has made a thorough and profound change on the process of development and global security such as food security, water, energy, and safety issues of social, cultural, foreign Affairs and Trade.

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Being one of the most severely affected countries by climate change, Vietnam has considered the way to cope with the problem of climate change as a vital issue. Scenarios of climate change and sea level rise are necessary which will become a preliminary basis to assess the level and impact of climate change to the different aspects, sectors and localities. From that, the effectively respond with climate change will be set out.



Nghia Hung district locates in the southern coast of Nam Dinh province in Vietnam. It had a total natural land area of 26,190.54 hectares in 2012, in which, area of agricultural land was 19 536.04 hectares. Agricultural land was used for rice cultivation, annual crops, perennial crops, for production of salt, aquaculture, for soil-protection forest and other unused land.

In Nghia Hung, communes that have the largest agricultural land are Rang Dong (1025.81 hectares), Nam Dien (5366.60 hectares), Nghia Thanh (1192.96 hectares), Nghia Hong (1006.07 hectares), and Nghia Son (1009.41 hectares). Meanwhile, communes that have the lowest agricultural land are Lieu De (262.76 hectares), Nghia Phuc (117.31 hectares), Nghia Loi (305.1 hectares). The decrease in agricultural land area of Nghia Hung in recent years has a direct effect to the efficiency, and sustainability of land use.

Therefore, it is necessary to studies this issue,

assess the impact of sea level rise on agricultural land to provide solutions to deal with this situation.

Nowadays, information technology develop dramatically, the application of information technology is widely used in social life. Geographic information system (GIS) is an effectively supporting tool in the management of environment and natural resources of many countries in the world. In 2004, Andre Zerger and Stephen Wealands have research linking GIS for flood risks management in far-north coastal Australia. Results show that GIS tool helped decision support system for flood management. GIS contributes to the assessment the current status, analysis, modeling and forecasting, etc., through the process of data collection, management, query, analysis and integration the information associated with the background of consistent geometry based on the coordinates of the input data. In 2000, A Ertug Gunes and Jacob P. Kovel have been using GIS in Emergency Management Operations such as flooding, common disaster [Gunes and Kovel 2000] Therefore, the application of geographic information system is necessary, providing a suitable tool for assessing the impact of sea level rise on the use of agricultural land in the coastal areas of our country.

METHODOLOGY

Survey was used to collect socio-economic data and information on the situation of natural conditions in Nghia Hung district, Nam Dinh province, especially for considering, terrain analysis and geomorphology of coastal areas.

Spatial analysis functions of ArcGIS software was exploited to build a database of land, including data layer maps on the current status of land use, maps of land, using IDW interpolation method to construct digitized elevation models (DEM) from topographic maps.

Sea level rise scenarios of the Ministry of Natural Resources and Environment in 2012 was also used as a reference information in this study.

This research used the spatial analysis functions of GIS, based on sea level rise scenarios of the Ministry of Natural Resources and Environment, and determine the study sites to choose the most appropriate scenarios. From the suitable scenarios that consistent with the study sites, the study established the scenario maps of three types: low level (B_1), medium level (B_2), and high level (A_1F_1) of water rise yearly, stacking the layers to build maps of the effects of sea level rise on the area of agricultural land use in Nghia Hung district, Nam Dinh province according to those three scenarios.

GIS can also be used to provide information as a basis to propose solutions to cope with climate change.

RESULTS

Data Collection

The data collected includes:

- + administrative boundary map of Nghia Hung district;
- + the map of current status of agricultural land use in Nghia Hung district;
- + background topographic map of Nghia Hung district;
- + map of residential distribution;
- + map of current levee system in Nghia Hung district.

Establishment of database

Database were classified into layers:

- layers of administrative boundary;
- layers of the current status of land use;
- layers of **contour**;
- layers of dikes;
- layers of resident.

Building digital elevation model (DEM)

DEM was built based on the contour lines from the background of terrain, using the 3D analysis functions of ArcGIS software. DEM was the basis to calculate the impact of sea level rise on the agricultural land use in Nghia Hung district.

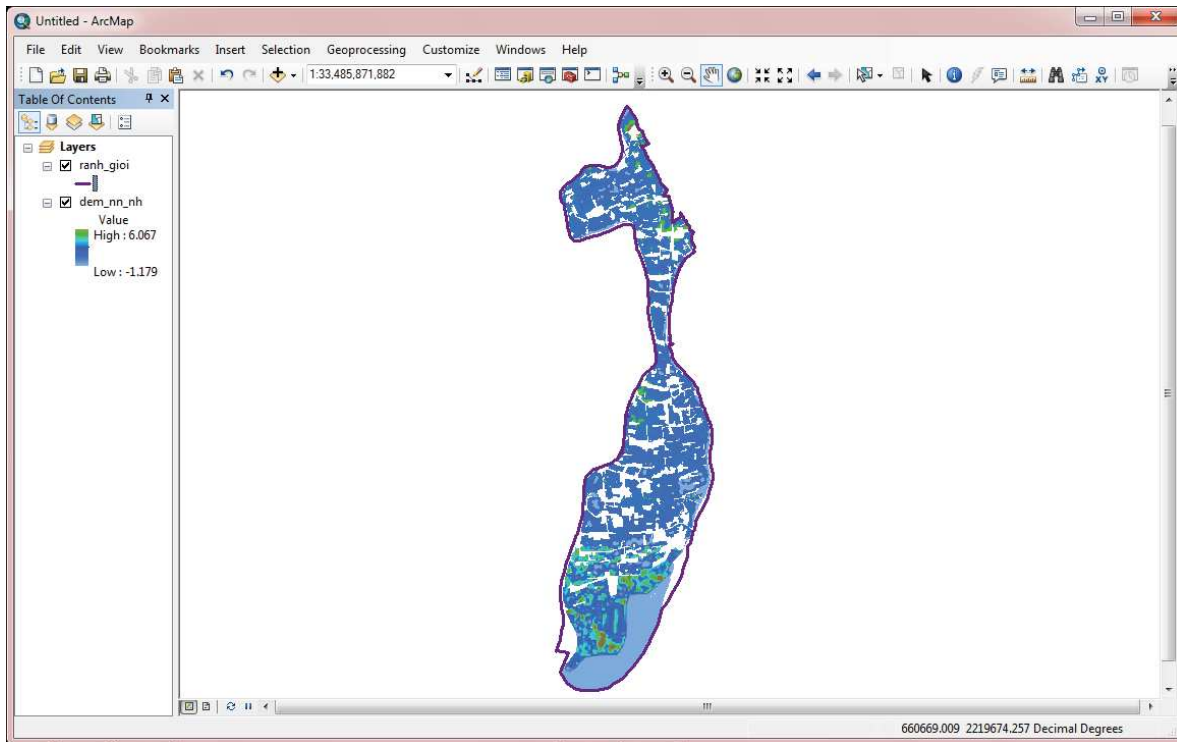


Fig. 1. DEM in Nghia Hung district, Nam Dinh Province

Assessment of sea level rise on agriculture land use

Using functions of layers, three scenarios of sea-level rise maps were estimated as shown in Table 1.

Table 1. Scenarios of wetland layers

	Scenario B_1	Scenario B_2	Scenario $A_1 F_1$
Flood zone [m]	-1,179–0,120	-1,179–0,130	-1,179–0,140
Normal zone [m]	0,120–6,067	0,130–6,067	0,140–6,067

Results of terrain layers according to three scenarios are presented in Figure 2.

With the functions of spatial analysis of GIS, the study performed stacking the terrain layers maps with the maps of current status of land use to build maps of flooded agricultural land. The results are presented in Figure 3.

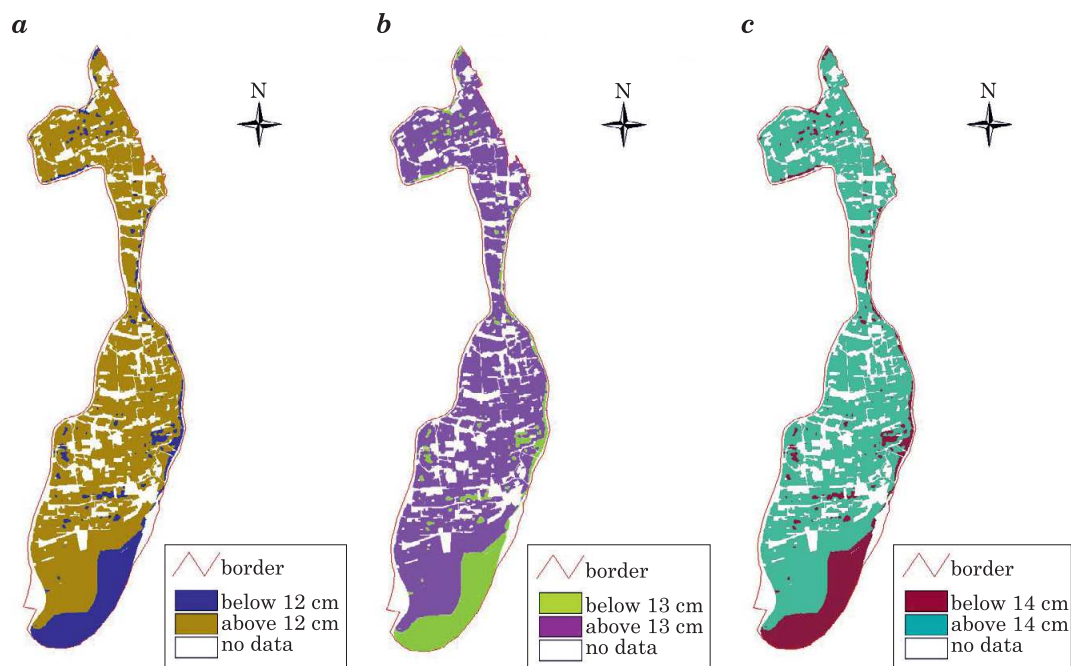


Fig. 2. Results of three scenarios of wetland layers: *a* – scenario B_1 ; *b* – scenario B_2 ; *c* – scenario A_1F_1

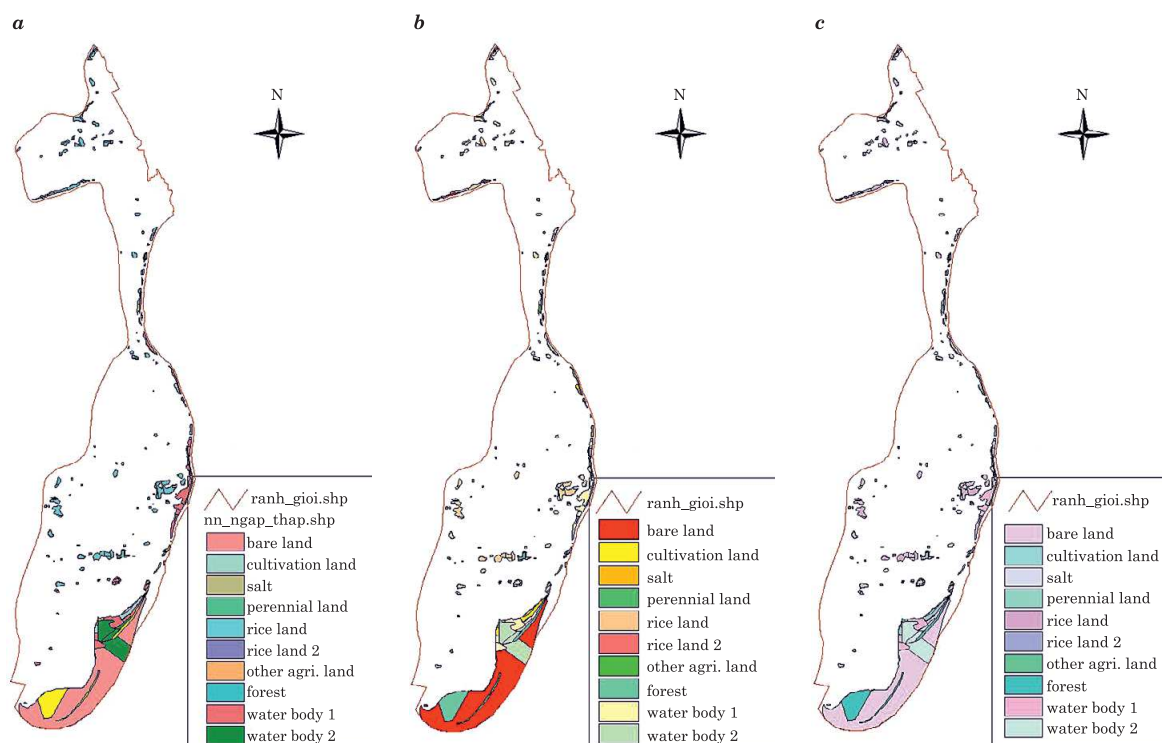


Fig. 3. Maps of flooded agricultural land according to three scenarios *a* – B_1 ; *b* – B_2 ; *c* – A_1F_1

The scenario B_1 predicts that in 2030, total area of flooded agricultural land in Nghia Hung district will be 3191.91 hectares. Flooded agricultural land will appear in 22 over 23 communes in this district. Coastal and estuaries communes will suffer from the largest area of food such as Rang Dong (47.99 flooded hectares), Nam Dien (2293.97 hectares), Nghia Binh (205.37 hectares), Nghia Son (76.12 hectares), Nghia Thang (72.82 hectares) ect., meanwhile the communes have the least flooded land will be Phu Nghia (2.23 hectares), Trung Nghia (2.12 hectares), Nghia Tan (9.89 hectares), Nghia Minh (5.00 hectares), Nam Thai (13.66 hectares). Agricultural land in the Lieu De town will not be affected by sea level rise.

The types of agricultural land use that is flooded the most will be LUC (540.54 hectares), RPT (338.24 hectares), TSL (389.29 hectares), TSN (337.47 hectares), BCS (1423.78 hectares). BCS is formed by the silt from the estuary where the terrain is low, therefore it is flooded the most.

The scenario B_2 forecasts that in 2030, total area of flooded agricultural land in Nghia Hung district will be 3196.79 ha.

Comparison between the area of flooded agricultural land due to sea level rise in 2030 of scenarios B_1 and B_2 by the communes, we noticed that in scenario B_2 , the area of flooded agricultural land in some communes and towns tends to increase such as Rang Dong (increase 1.55 ha of flooded agricultural land compared to that of the scenario B_1 in the same year), Nam Dien (increase 3.33 hectares compare to that of the scenario B_1), etc.

The types of agricultural land use that is flooded the most will be LUC (540.86 hectares, increase 0.32 hectares compared to that of scenario B_1 in the same year), RPT (339.4 hectares), TSL (390.85 hectares, increase 1.56 hectares compared to that of scenario B_1), TSN (337.47 hectares), BCS (1425.36 hectares).

According to the scenario A_1F_1 , in 2030, the total area of flooded agricultural land in Nghia Hung district will be 3199.14 hectares. Flooded agricultural land will also appear in 22 over 23 communes in this district. Communes and towns with the largest area of flooded agricultural land will be Rang Dong (50 hectares of flooded), Nam Dien (2299.25 hectares), Nghia Binh (205.37 hectares), Nghia Son (76.12 hectares), Nghia Thang (72.82 hectares)... The communes with the least flooded land area will be Phu Nghia (2.23 hectares), Nghia Trung (2.12 hectares), Nghia Tan (9.89 hectares), Nghia Minh (5.00 hectares), and Nam Thai (13.66 hectares). Agricultural land in the Lieu De town will also not be affected by sea level rise.

Comparison between the area of flooded agricultural land of the most effected communes due to sea level rise in 2030 of scenarios B_2 and A_1F_1 , we found that in scenario A_1F_1 , the area of flooded agricultural land in some communes and towns tends to increase such as Rang Dong (increase 0.46 ha of flooded agricultural land compared to that of the scenario B_2), Nam Dien (increase 1.95 hectares compared to that of the scenario B_2).

The types of agricultural land use that is flooded the most will also be LUC (increase 0.46 hectares of flooded agricultural land compared to that of the scenario B_2 in the same year), RPT (340.29 hectares of flooded area), TSL (increase 0.53 hectares of flooded agricultural land compared to that of the scenario B_2 in the same year), TSN (337.47 hectares of flooded area), BCS (1425.86 hectares of flooded area).

The area of flooded agricultural land due to sea level rise according to the three scenarios are presented in Figure 4.

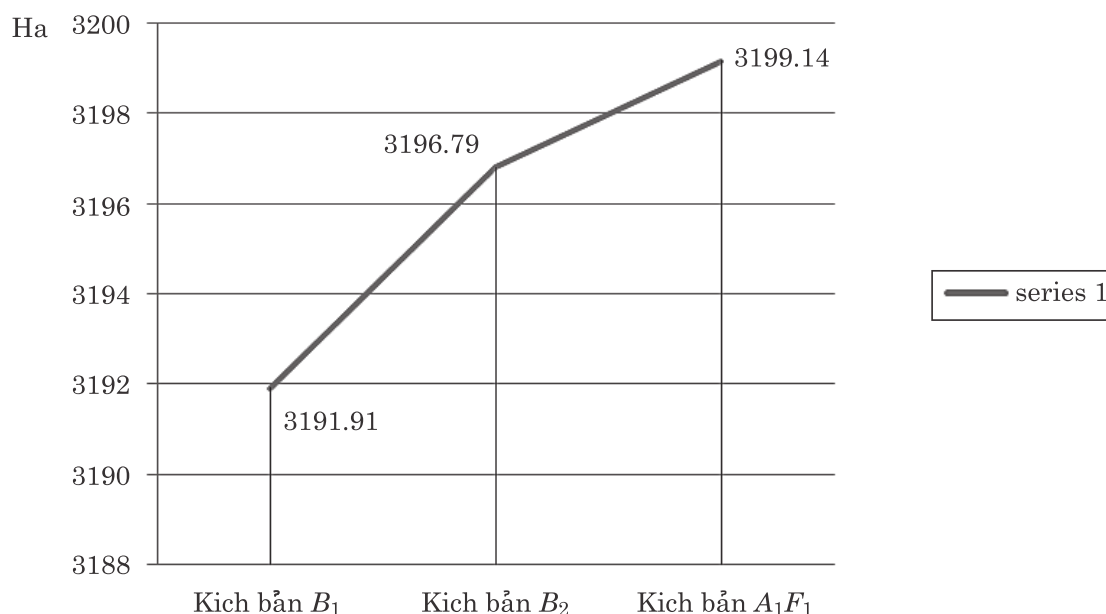


Fig. 4. Three scenarios of flooded agricultural land

CONCLUSION

Nghia Hung district locates in the south coast of Nam Dinh province and had a total natural land area in 2012 of 26 190.54 hectares; of which, agricultural land was 17 828.76 hectares, non agricultural land was 6654.5 hectares, and unused land was 1707.28 hectares. In recent years, due to the effects of climate change, sea level rise, this district recognized and had a statistic that agricultural and unused land diminished over the years (in 2008, the total agricultural land and unused land was 19803.04 hectares, but in 2012, this land area decreased to 19 536.04 hectares). However, this district has not established the prediction maps of flooded agricultural and unused land under scenarios of climate change and sea level rise of the Ministry of Natural Resources and Environment (in 2012) according to the timeline of the 21st century.

This research has applied GIS to establish maps of flooded agricultural land in 2030 under the scenario B_1 , B_2 , A_1F_1 , based on the scenario of climate change and sea level rise of the Ministry of Natural Resources and Environment in 2012 and obtained the following results:

1. Establishment of the prediction maps of flooded agricultural land and types of flooded agricultural land in 2030 under three scenarios B_1 , B_2 , and A_1F_1 .

2. Forecast the total area of flooded agricultural land in 2030.

In 2030, the total area of flooded agricultural land under scenario B_1 will be 3191.91 hectares, in scenario B_2 will be 3196.79 hectares, and in scenario A_1F_1 will be 3199.14 hectares.

3. Forecast the area and type of flooded of agricultural land by the communes.

This research has solved problems of flooding by the intuitive modeling, easy to update, clearly display and detail in every position, can overlay, and compare according to the different flood levels. Our building maps bring the visual results, can provide the most adequate and accurate information. The local authorities and residents can recognize the flooded zone of agricultural land and prepare preventive measures to minimize the impact of sea level rise on land use.

GIS applications are one of the most convenient technical tools to solve the problems for data processing programs, normally based on remote sensing, satellite or expensive software or calculate by the professional, complex, costly hydrologic and hydraulic software.

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ZASTOSOWANIE TECHNOLOGII GIS DO OCENY ODDZIAŁYWANIA WZROSTU POZIOMU MORZA NA TERENY UŻYTKOWANE ROLNICZO STUDIUM PRZYPADKU NA PRZYKŁADZIE PROWINCJI NAM DINH (OBSZAR NGHIA HUNG, WIETNAM)

Streszczenie. Obserwuje się wzrost poziomu morza o zasięgu globalnym. Zjawisko to będzie postępować w nadchodzącym stuleciu na skutek antropogenicznego globalnego ocieplenia. Każdy wzrost poziomu morza skutkuje utratą ziemi, coraz częstszymi powodzią oraz zasoleniem. Skutki i możliwe reakcje na wzrost poziomu morza różnią się w skali lokalnej i regionalnej ze względu na różnice w czynnikach lokalnych i regionalnych. Linia brzegowa Wietnamu wynosi ponad 3260 km i rozciąga się z północy na południe. W jej obrębie występuje wiele procesów interaktywnych między lądem a morzem, między dynamicznym życiem rzek i morzem, między zjawiskami naturalnymi i antropogenicznymi itp. W ostatnim czasie wzrost poziomu morza na skutek zmian klimatu stanowi poważne globalne zagrożenie. Dlatego też badania mające na celu ocenę wpływu wzrostu poziomu morza na grunty rolne są bardzo potrzebne. W artykule skupiono się na wykorzystaniu technologii GIS do analizy i przewidywania wpływu wzrostu poziomu morza na użytkowanie gruntów rolnych w nadmorskiej dzielnicy Nam Dinh. Otrzymane wyniki mogą wspomóc procesy decyzyjne właściwych menadżerów i decydentów oraz tworzenie strategii adaptacyjnych terenów rolnych w kontekście zmian klimatycznych.

Słowa kluczowe: wzrost poziomu morza, użytkowanie gruntów, GIS

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