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Effects of Sea Level Rise in Florida

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Abstract

The Sea level rise issue associated with climate change is a growing concern and major number of research work is carried out to evaluate the impact and for future prediction. This study helps to understand the level of threat to the coastal Florida and to visualize potential impacts from sea level rise for different scenarios using the data available in the form of Digital Elevation Models available online such as SRTM and Aster DEM data. The area of impact is calculated and its performance is compared between datas using ArcGIS software.

Keyword: Sea level rise, Florida, SRTM, GDEM, Area of impact.

Introduction

Sea level rise is a major environmental issue associated with global climate change. Sea level rise affects coastal land use such as settlements, forest, ecosystem and infrastructure. For effective coastal zone management it is important to know about the susceptibility of shoreline to sea level rise. Various methods have been adopted to access how vulnerable the coastal areas due to sea level rise. The sea level rise was predicted by IPCC 2007, that the sea level rise affects tropical countries more negatively; based on IPCC report an average of various model projections relating the change in surface temperature as and hence the value for sea level rise is obtained as shown in figure-1. Also there are various other models showing different projection values for sea level rise for melting Greenland ice sheet, Antarctic ice sheet[1].

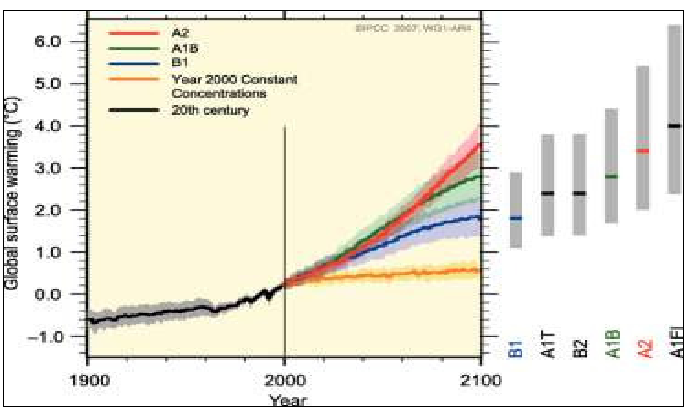

Figure-1
Multi Model Averages and Accessed ranges for Surface warming[1]

Where A1B, A1F, A1T, A2, B1, B2 are the various scenarios of sea level rise for change in surface temperature on influence of emission (based on IPCC special report emission scenarios). They are given in table-1.

Table-1
Projected Average Surface warming and Sea level rise on a Global Scale at the end of 21st century[1]

	Temperature Charge (°C at 2090-2099 relative to 1980-1999)[a]		Sea Level Rise (m at 2090-2099 relative to 1980-1999 Model-based range excluding future rapid dynamical changes in ice flow
	Best estimate	Likely range	
Constant Year 2000 concentrations[b]	0.6	0.3 – 0.9	NA
B1 scenario	1.8	1.1 – 2.9	0.19 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1Fl scenario	4.0	2.4 – 6.4	0.26 – 0.59

These are estimated from a hierarchy encompassing simple Climate-Carbon feedback models, Earth System models, and Atmosphere-Ocean general circulation models.

A1- the emission considered as due to rapid introduction of new and more efficient technologies (A1F1 fossil intensive, A1T non fossil energy source, A1B balance across all sources).

A2- describing emission from a heterogeneous world with preservation of local identities and increase in population.

B1- about emission due to environmental sustainability, economic and social with additional climate initiatives.

B2- it focuses on local and regional levels of emission.

The models suggest that contribution of Greenland Ice Sheet after 2100 to be up to 7 meters similarly a palaeoclimate study shown a sea level rise of 4-6m on reduction of polar ice. The model studies relating Antarctic Ice sheet suggest that there will not be much changes in the ice sheet and it will remain too cold for wider surface melting and hence it is projected that there will be increase in mass due to increase in snowfall[1].

Study Area: Florida peninsula lies on between Gulf of Mexico, Atlantic Ocean and the strait of Florida located on 28.0908° N latitude, 81.9604° W longitude. Florida has the longest coastline in contiguous of United States[2]. The total area of Florida is 151,939 sq.km, in which land occupies upto 140,256 sq.km and waterways 11,683 sq km. Florida its maximum North to South and East to West extent is 719 km and 581 km. Approximately 95 percent of Florida's population is living within 56 km of coastal areas. Environmental sensitive areas such as the everglades, coral reefs, beaches are located within this area[3]. Sea level rise will increase flooding and it will affect the developed areas. It will also cause beach erosion and major environmental sensitive areas such as everglades could completely submerged by sea level rise. Barrier lands in the south Florida prevents storm surge. Due to sea level rise, barrier land would be reduced[4].

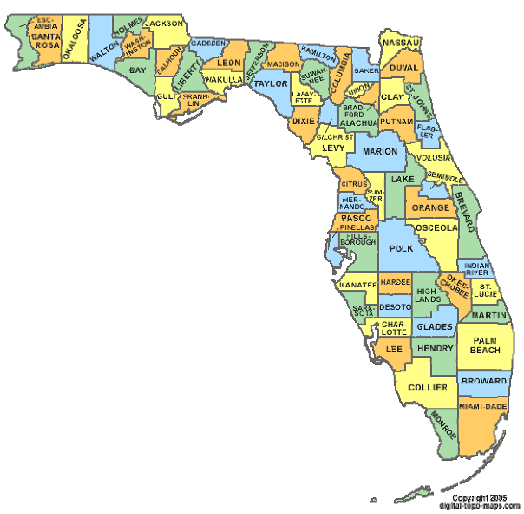

Figure-2
Study Area-Florida

Climate: Florida is having different kinds of climate, where North and Central Florida and South Florida has humid subtropical climate and tropical climate. The major factors that governs climate in Florida are ocean circulation, latitude, water and land distribution prevailing windstorms, and pressure systems. In the winter, average temperature throughout Florida was between 39°F to 65°F and during summer maximum temperature was around 83°F (Charles, 1984). Florida was receiving an annual precipitation rate of 54 inches per year.

Most of them fall it as rain, even though snow falls periodically in Florida[5]. Florida is called as "Sunshine states" and highly suitable for solar energy production. The wettest part in Florida was Southeastern Florida and Pan Handle. Cape Canaveral and Florida keys are the driest portions in the Florida. The pan handle has two wettest seasons, so it receives more rainfall during summer and winter. The summer rainfall is due to convective heat forces. Florida Keys receives lower rainfall due to poor convectional heat[5].

El-Nino and La-Nino plays an important role in Florida's Climate. 30 to 40 percent of total rainfall intensity in Florida brings by El-Nino and also cooler temperature to Florida during winter. La-Nina causes periodic drought in Florida and it brings a warmer and much drier than normal winter and spring. During El-Nino event, strong jet streams prevent the arctic air intrusion which brings cold temperature to Florida. La-Nina causes different jet streams pattern which moves the colder air to the north. Florida State is highly susceptible to hurricanes. Florida experience more hurricanes per ten thousand miles than any state in the nation[6].

Methodology

Based on the flow chart shown in figure-3, i. Calculate statistics tool is used to ignore elevation values less than zero. ii. Reclassification of SRTM raster data and GDEM data helps to extract sea level inundation for 0.38m, 0.43m, 0.45m, 0.48m,0.51m,0.59m, 6m, 7m scenarios based on IPCC 2007 report[1]. iii. Inundation area is calculated using Zonal geometry as table, which is available in the toolbox. iv. The raster dataset was converted into polygon shape file, which includes inundation polygons for each scenario. v. It is then overlaid and an inundation map can be obtained for different scenarios based on IPCC 2007 in a single map image[1].

Results and Discussion

Figure-4 and figure-5 shows the possible area of inundations based on the Digital Elevation Model data.

The present study helps to understand the level of threat to the coastal areas in Florida due to different level of sea level rise scenarios. As the study area has broad range of economic activities and densely populated it is important to identify the potential impacts along the coast of Florida for seal level rise, which is one of the most vulnerable areas in the United States. Table-2 represents the extent of inundation for various SLR scenarios. From the obtained results the obvious impact of sea level rise can be clearly differentiated by overlapping the inundations values for various scenarios, which indicates the vulnerable area to get affected by sea level rise. The inundation affects most of the coastal regions and wetland of Florida in 7m rise of sea level was as expected. But the difference between the values obtained from the output using SRTM data and Aster GDEM data could be because of the resolution. From this the results the total area of 148173.16 sq.km is much nearer to the value of total area 151939 sq.km as mentioned before. Hence Aster GDEM data provides much better accuracy than SRTM.

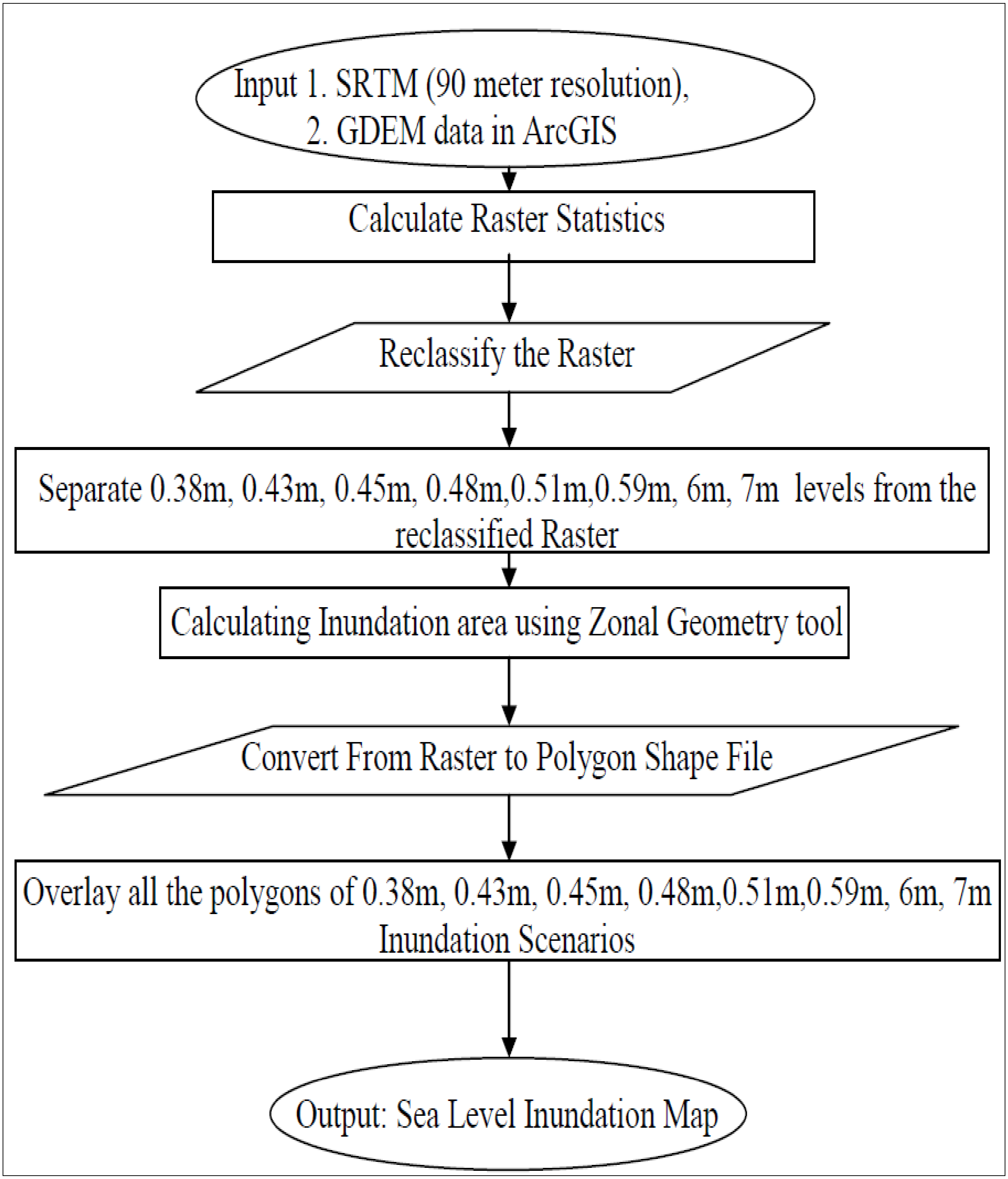

Figure-3
Methodology flow chart

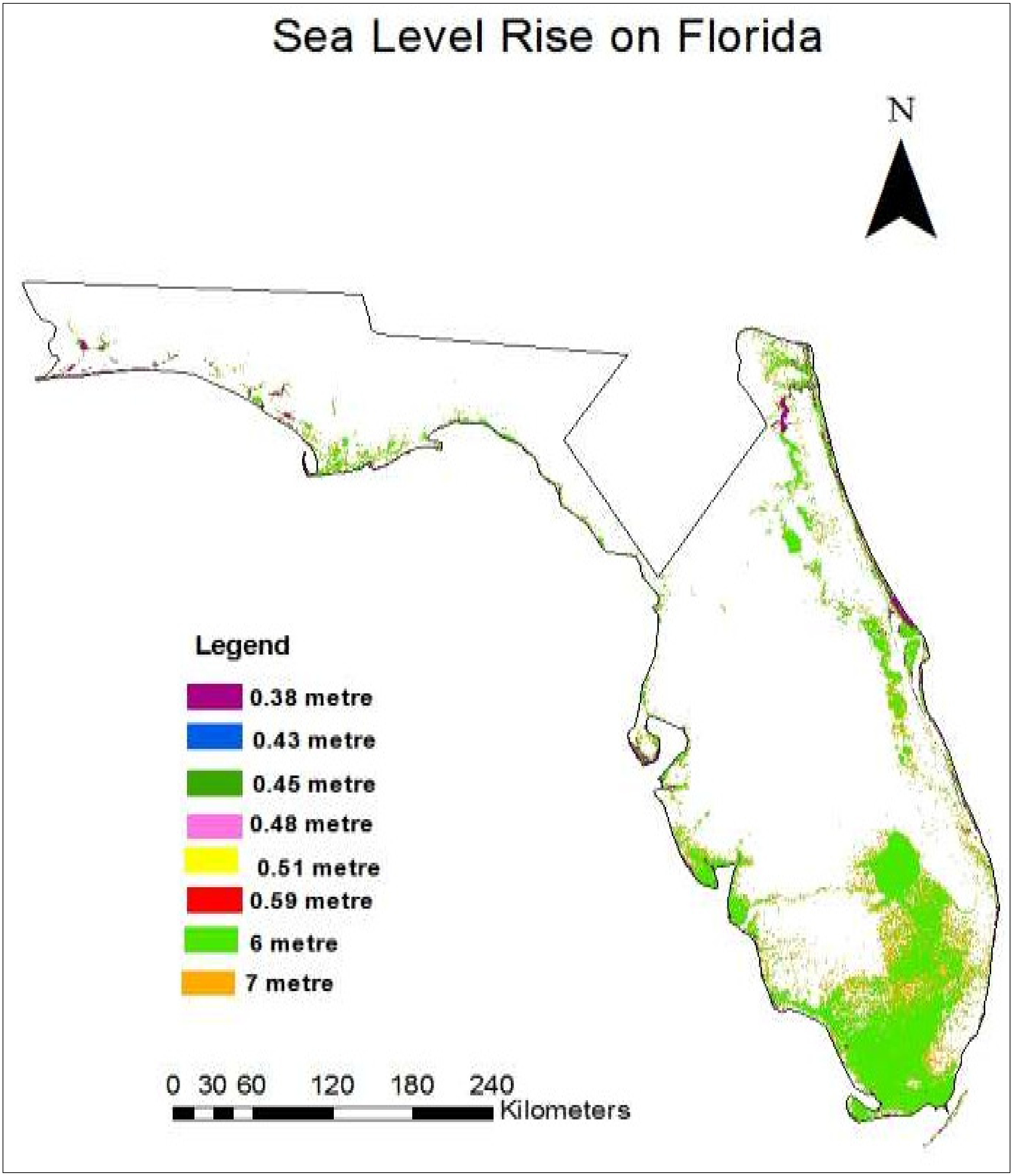

Figure-4
Sea Level Rise Impact Area output from SRTM data

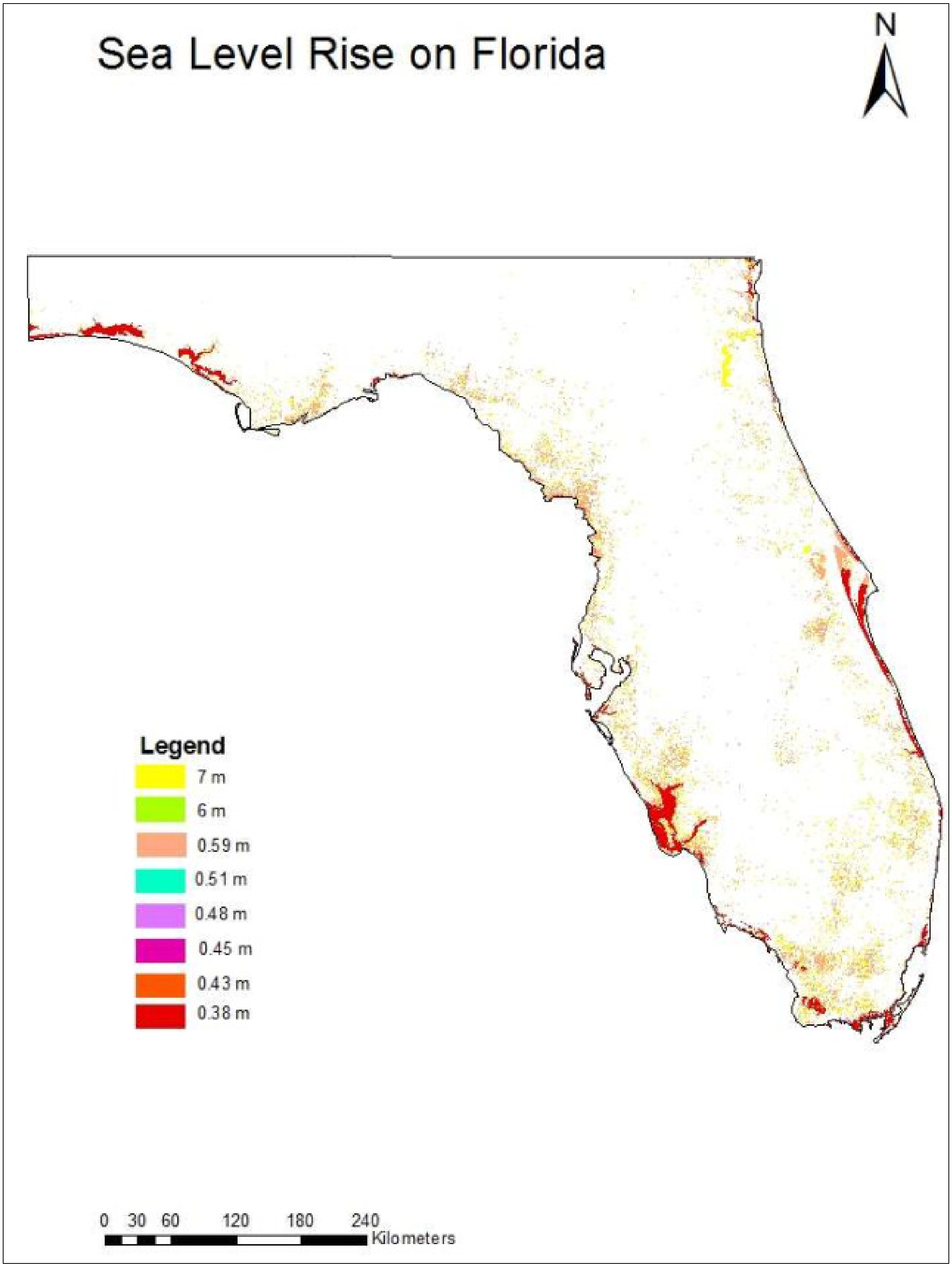

Figure-5
Sea Level Rise Impact Area output from Aster GDEM data

Submergence of land area is calculated for each scenario using the ArcGIS software. The results are given in table-2.

Table-2
Submergence Area in (sq.km)

S.No	**SLR (m)**	**Area of submergence Sq.Km (from SRTM data)**	**Area of submergence Sq.Km (from Aster GDEM data)**
1.	0.38	1724.018 (1.31%)	3124.34 (2.11 %)
2.	0.43	1737.181 (1.31%)	3124.34 (2.11 %)
3.	0.45	1737.181 (1.31%)	3124.34 (2.11 %)
4.	0.48	1737.181 (1.31%)	3124.34 (2.11 %)
5.	0.51	1737.181 (1.31%)	3124.34 (2.11 %)
6.	0.59	1737.181 (1.31%)	3124.34 (2.11 %)
7.	6	19687.37 (15.05%)	31696.66 (21.39%)
8.	7	24563.82 (18.78%)	39547.75 (26.69%)

Total area measured (using SRTM data) = 130769.78 sq.km, Total area measured (using GDEM data) = 148173.16 sq.km.

Conclusion

The most precise value for submerged area can be obtained from Aster GDEM data as, i. 3124.34 sq.km for 0.38, 0.43, 0.45, 0.48, 0.51, 0.59 meters, ii. 31696.66 sq.km for 6m, iii. 39547.75sq.km for 7m of sea level rise.

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