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Consequences of DEM Choice in a Land Use Application

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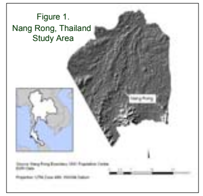
Introduction

This research explores the implications of different digital elevation models (DEM)s in the United States and elsewhere, for select areas of **Shuttle Radar Topography Mission (SRTM) C-band, SRTM X-band, Light Detection and Ranging (LiDAR), and National Elevation Dataset (NED)** data. The Nang Rong, Thailand district was selected as an international location to explore the SRTM C-band and SRTM X-band. Based on similar topographic, land cover, and land use properties, two locations where NED, SRTM, and LiDAR-derived DEMs were available were selected in **Louisiana**. An agricultural model was identified as an appropriate application to explore in both the Thailand and Louisiana contexts given their similar surface characteristic. This type of application highlights how the use of terrain models can play a vital role in agricultural models worldwide.

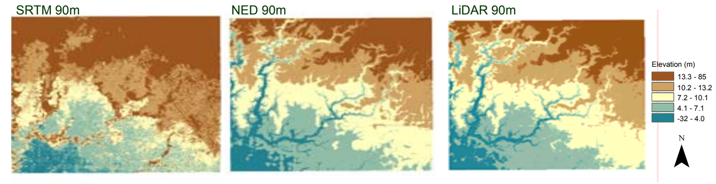
Study Areas



Extent was based on the availability of SRTM X-band.

Figure 2. Louisiana Study Areas

Figure 3. Data Sources: Example Acadia Study Area



The NED (30m) and LiDAR (5m) were resampled to 90m resolution using the Nearest Neighbor Method.

Background

Since agriculture is a main land use of both areas, criteria were created based on flat topography (slope 0-1 degrees) and topographic position, in order to examine how the DEMs distinguished these characteristics. The low locations on the landscapes would be locations of likely flow accumulation. Thus, the locally low locations on the landscape are considered suitable for rice cultivation or other agriculture activity. The aims of this application are to assess differences in model results due to the use of different DEMs.

Methods: Figure 4. Cartographic Model

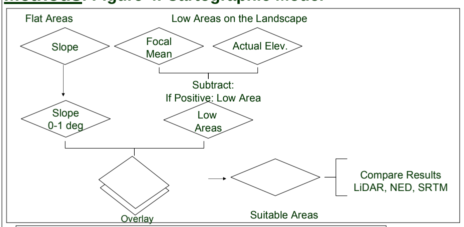


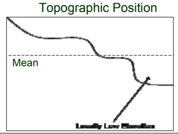
Figure 4 indicates the cartographic model employed on the LiDAR 90 m DEM, NED 90 m, and SRTM 90 m DEM for the Acadia and Webster Study Areas. Similarly for the Nang Rong Study Area, the model was used with the SRTM C-90 m, SRTM X-25 m, and SRTM X-90 m DEMs. The multiplication of the suitable slope locations and the suitable low locations on the landscape would indicate the locations where the appropriate criteria were found for both of these variables.

Suitable Slope = { 0 if Slope > 1; 1 if Slope = 0-1 }

Suitable Low Position = { 0 if Mean Elevation - Actual Elevation ≤ 0; 1 if Mean Elevation - Actual Elevation > 0 }

Figure 5. Land Use Formulas used for the Application. This shows how slope or position can be suitable or unsuitable. Figure 6 indicates how the land use application was interested in only lower areas on the landscape.

Figure 6. Schematic of Low Topographic Position



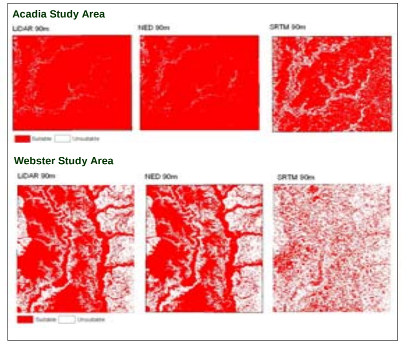


Figure 7. The shaded areas indicated suitable slopes.

Suitable Low Slope Areas: Acadia/ Webster Study Areas

The slope was reclassified for the LiDAR 90 m, NED 90 m, and SRTM 90 m DEMs. To determine the locally low elevations, a circular focal mean of a 900 m radius (10 cells at 90 m resolution) was used in the focal operation. This decision was based on observation of the semivariogram of the SRTM 90 m for Nang Rong, Thailand DEM. For consistency, this distance was applied to all DEMs compared in the application analysis. The actual elevation in each cell was subtracted from the smoothed focal mean elevation. If the difference is positive, the focal mean is greater than the actual, and the cell is a low location in the landscape.

Topographic Position Criterion

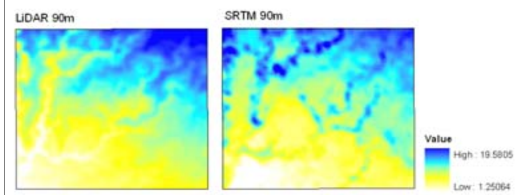
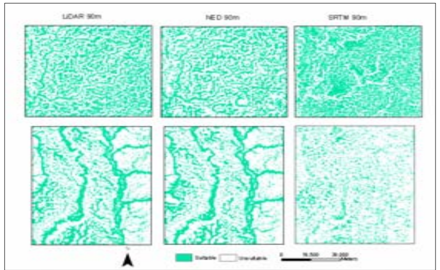


Figure 8. Focal Operation: Topographic position was highly dependent on the characteristics of the focal mean output for the study areas. The focal mean of the Acadia Study Area indicate a much smoother depiction of the mean elevation characteristics of the study area. The focal mean depicts the lower elevation in the southwest compared to the higher elevations in the northeast. The focal mean operation produced a surface, which was smoothed in terms of elevation; however, once differenced with the actual elevations the low locations on the surface could be identified.

Results

Figure 9. Final Application Results: Acadia/ Webster Study Area



Similarities are noted between the NED and LiDAR DEMs. The SRTM DEM indicated a greater overall suitable area for the Acadia Study Area compared to the Webster Study Area.

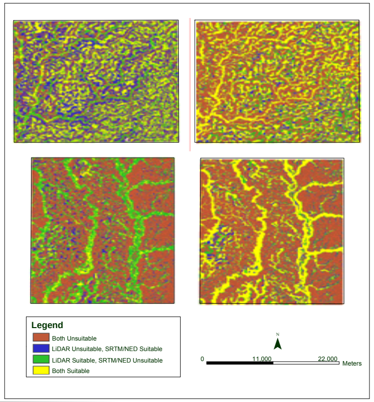
Table 1. Summary of Suitable Areas

	Acadia Study Area		Webster Study Area	
	Cell Counts	Area (km²)	Cell Counts	Area (km²)
LiDAR 90 m	110,540	895	58,689	475
NED 90 m	102,917	834	56,592	458
SRTM 90 m	136,684	1,107	31,411	254

More suitable areas were identified in the Acadia study area than the Webster study area.

Figure 10.Comparative Examination

The unsuitable and suitable cells for each DEM were recoded with a different value, so that when added together, each cell could be 1 of 4 different values. The cell counts were recorded for each combination. In addition to determining areas found suitable by all DEMs, contingency tables were made using the LiDAR 90 m as reference in relation to the NED and SRTM application results.



Acadia Study Area

Table 2. Comparison of SRTM 90m and LiDAR 90m

		LiDAR			
		Unsuitable	Suitable	Row Total	User's Accuracy
SRTM	Unsuitable	64,173	47,179	111,352	0.6
	Suitable	71,749	63,257	135,006	0.5
	Column Total	135,922	110,436	246,358	
	Producer's Accuracy	0.5	0.6		
	Overall Accuracy	51.7%			
	Kappa Coefficient	0.04			

Table 3. Comparison of NED 90m and LiDAR 90m

		LiDAR			
		Unsuitable	Suitable	Row Total	User's Accuracy
NED	Unsuitable	109,155	35,810	144,965	0.7
	Suitable	26,767	74,626	101,393	0.7
	Column Total	135,922	110,436	246,358	
	Producer's Accuracy	0.8	0.7		
	Overall Accuracy	74.6%			
	Kappa Coefficient	0.4			

Webster Study Area

Table 4. Comparison of SRTM 90m and LiDAR 90m

		LiDAR			
		Unsuitable	Suitable	Row Total	User's Accuracy
SRTM	Unsuitable	106,048	44,019	150,067	0.7
	Suitable	16,647	14,670	31,317	0.5
	Column Total	122,695	58,689	181,384	
	Producer's Accuracy	0.9	0.3		
	Overall Accuracy	66.6%			
	Kappa Coefficient	0.1			

Table 5. Comparison of NED 90m and LiDAR 90m

		LiDAR			
		Unsuitable	Suitable	Row Total	User's Accuracy
NED	Unsuitable	106,998	17,191	124,189	0.9
	Suitable	15,313	41,217	56,530	0.7
	Column Total	122,311	58,408	180,719	
	Producer's Accuracy	0.9	0.7		
	Overall Accuracy	82.0 %			
	Kappa Coefficient	0.6			

Discussion/ Conclusions

The SRTM did not identify the wetland areas as flat since the forests on the landscape give the SRTM a raised appearance in these areas, unlike the LiDAR 90 m and NED 90 m. The LiDAR 90 m and the NED 90 m output contained many linear-like features, which may be a result from the focal mean operation. In the Acadia study area, the *kappa coefficient* was 0.5 for the LiDAR/NED comparison, while the LiDAR/SRTM comparison had a much lower kappa coefficient of 0.04. These kappa coefficients indicate greater classification accuracy for the NED-based application than for the SRTM-based application. Similarly, for the Webster study area, the kappa coefficient was lower for the SRTM/LiDAR comparison compared to the SRTM/NED comparison. In the Webster study area, there are some noticeable rectangular patterns to the result, which may be attributed to the rectangular patterns of forests.

Figure 11. Nang Rong Study Area Final Results

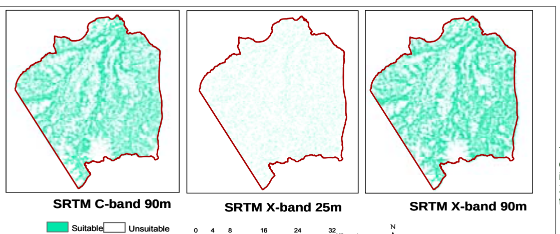


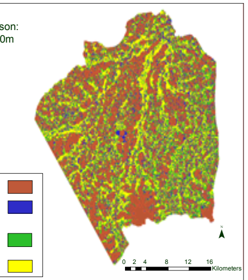
Table 6. Nang Rong Study Area Summary of Suitable Areas

	Suitable Cells	Suitable Area (km²)
SRTM C- 90 m	42,469	344
SRTM X-25 m	51,914	32
SRTM C-90 m	48,733	395

The Nang Rong application illustrated how the constraints of flat topography and low topographic position would result in similar areas between the SRTM C-90 m and the SRTM X-90 m. The SRTM X-25 m DEM identified much less area than the SRTM C-90m and SRTM X-90m.

Figure 12. Suitability Comparison: SRTM C-90m and SRTM X-90m

The SRTM X-90 m was used as reference to the SRTM C-90 m. Brown and yellow indicate correspondence between DEMs.



Both Unsuitable
SRTM X-90m Unsuitable/ SRTM C-90m Suitable
SRTM X-90m Suitable/ SRTM C-90m Unsuitable
Both Suitable

Table 7. Comparison of SRTM C-90m and SRTM X-90m

		SRTM X-90 m			
		Unsuitable	Suitable	Row Total	User's Accuracy
SRTM C-90 m	Unsuitable	57,243	21,919	79,162	0.7
	Suitable	16,260	26,192	42,452	0.6
	Column Total	73,503	48,111	121,614	
	Producer's Accuracy	0.8	0.5		
	Overall Accuracy	68.6 %			
	Kappa Coefficient	0.3			

Nang Rong Study Area

The overall accuracy indicates that there was high overall agreement between the SRTM X-90 m and SRTM C-90 m. However, the kappa coefficient was 0.3, which accounts for agreement between the SRTM C-90 m and the SRTM X-90 based on chance. Much of the agricultural area was identified as unsuitable for both the SRTM C-90 m and SRTM X-90 m. There were isolated locations (i.e. single cells) identified as unsuitable for the SRTM X-90 m and suitable by the SRTM C-90 m.

Data Sources/ References:

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