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Conference

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Sierra Leone
Sugarcane Plantation Assessment

Engineering | Architecture | Design-Build | Surveying | GeoSpatial Solutions

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# Purpose

❖ To identify 50000 hectares of viable land in the Kambia District in Northwestern Sierra Leone.

❖ An executive level feasibility study concludes that approximately 42% of a given gross area in the Northwestern part of Sierra Leone is economically viable for Sugarcane production. This takes into account isolating land within a gross area for:

- Food Security
- Environmental Zones (i.e. - Forests, wetlands)
- Housing and Existing Villages / Infrastructure
- Non-arable lands

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Purpose

❖ Phase 1 is to analyze a 380 KM^2 area assigned by the government and of Sierra Leone.

❖ If approximately 16,000 hectares (which equals 42% of 380 KM^2) of land within this area are viable for sugarcane production, Phase 2 will analyze an adjacent area to achieve 50000 hectares of ultimate sugarcane production.

❖ The Phase 1 Area of Interest (AOI) is noted by the left yellow area.

❖ If 42% parameter is met in final results, proceed to design the plantation.
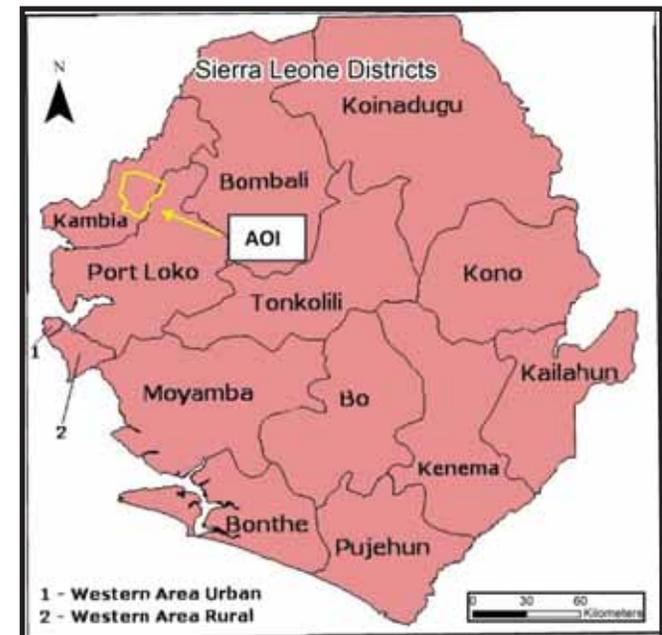
Approach

1. Contract with Digital Globe (DG) to fly the AOI with World View II to collect:

   - **Ortho Imagery -** (satellite images, Red, Green, Blue (RGB) bands) – Basic color imagery of the area of interest at 0.5 meter pixel resolution. This imagery is oriented to local coordinate system and has a positional accuracy of within 2 meters. Cloud cover was within 1% of the total area.

   - **Stereo-Pair –** The imagery was collected in a stereo pair mode which allows for topography (1 meter contours with 0.33 meter RMSE) to be photogrametrically compiled.

   - **Multispectral Imagery –** In addition to the RGB ortho-imagery bands above, five additional bands are used to determine various land and vegetation features such as land use/land cover and vegetative heath of the area.



The 8 spectral bands of WorldView-2
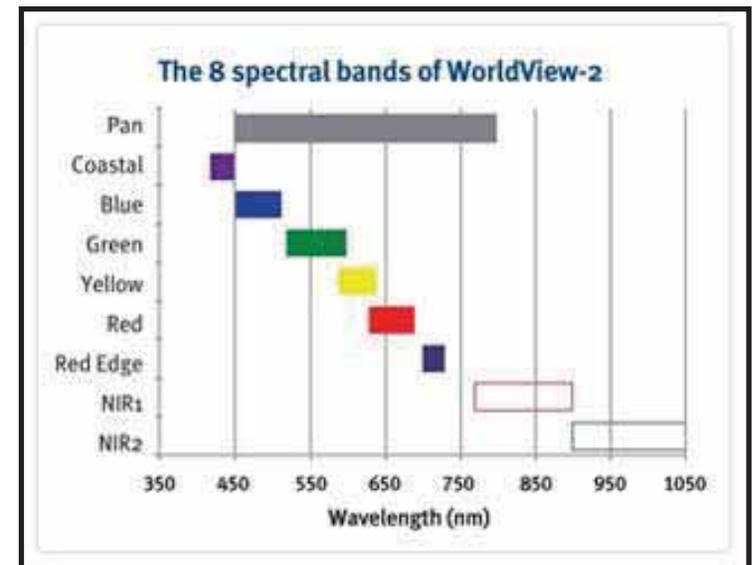
Approach

2. Send a survey team to the AOI to collect needed control to ortho-rectify the DG satellite products mentioned above. 12 control points were required and collected over a few days.

3. Perform GIS analysis of the combined DG satellite products to determine viable areas.

4. Attempt to design the plantation based on the GIS analysis. The image at the right is a sample design.

(Sample design)
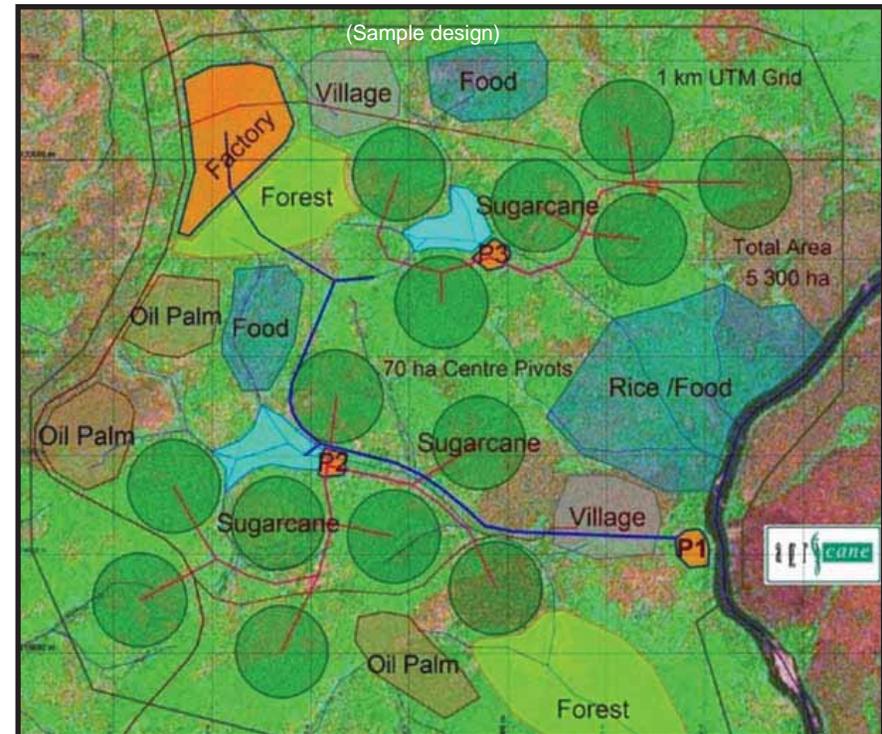
Approach

- The following criteria were derived from the DG World View II collection:

  1. Topography

  2. Hydrology / Drainage

  3. AOI Roads Network

  4. Land Use / Land Cover

  5. Vegetation Analysis

  6. Soils Analysis

  7. Processing Site Location / Housing

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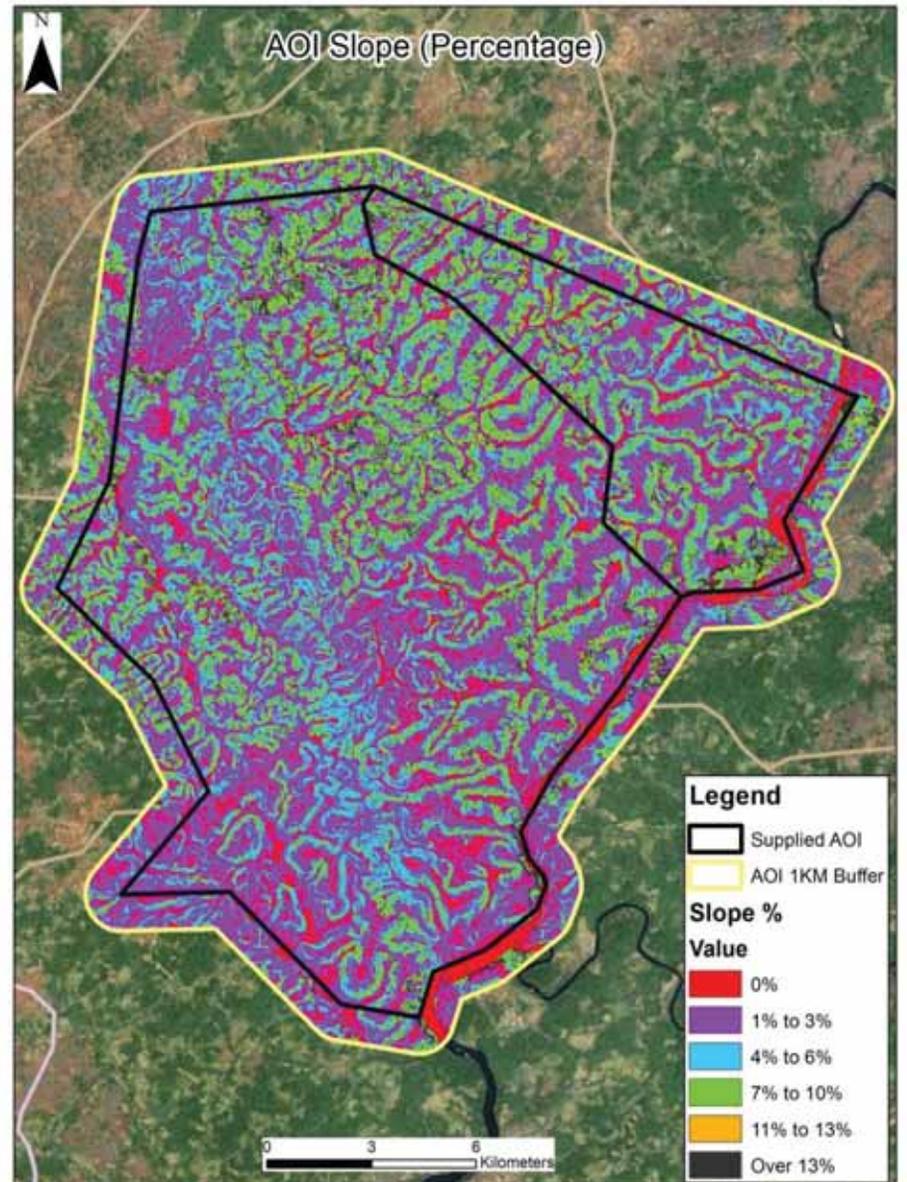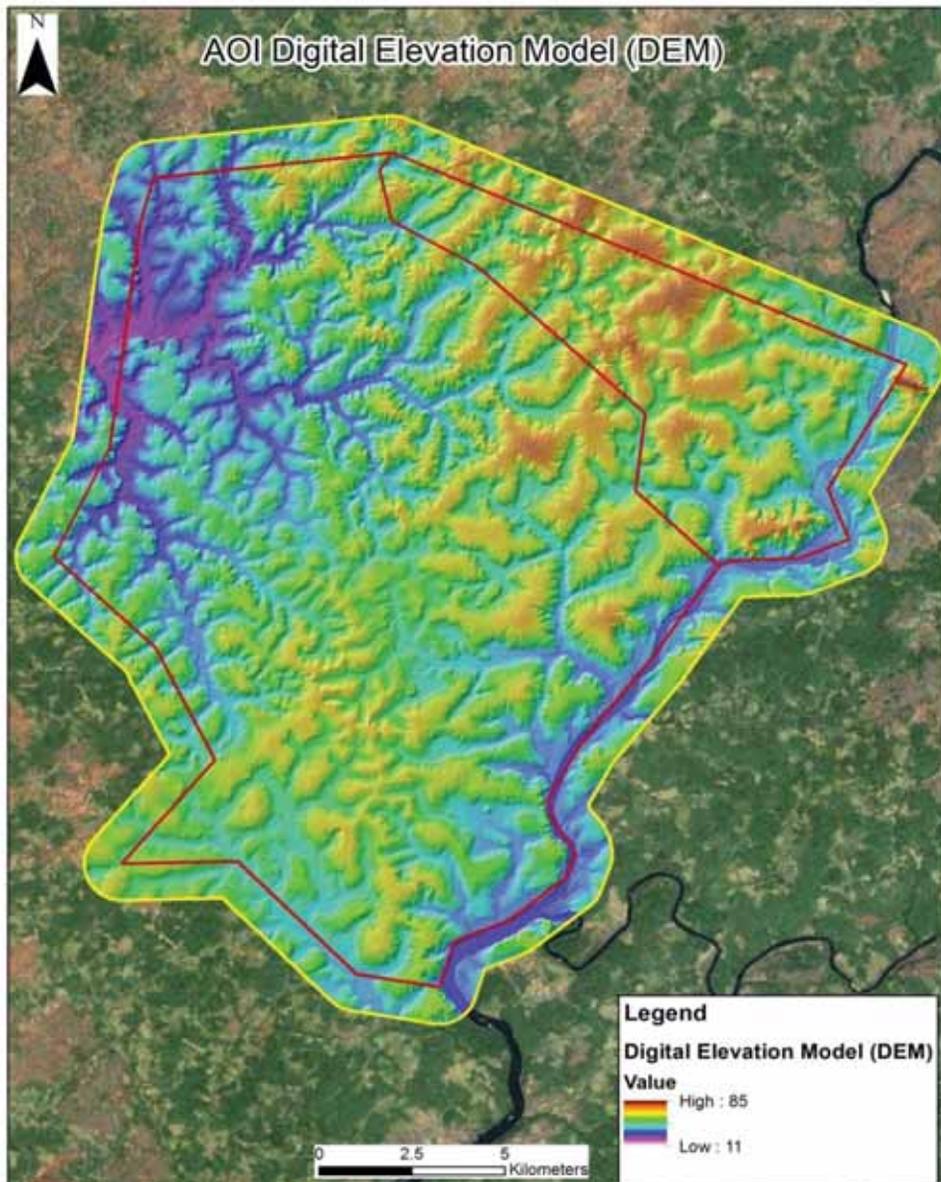
Topography

Topography

- Topography RMSE = 0.31 Meters
- Slope – Divided into 6 different classifications. Each classification represents a different category of preference for sugarcane cultivation.

|	% Slope	Slope % of entire AOI
1	0%	11.0%
2	1% to 3%	37.3%
3	4% to 6%	24.4%
4	7% to 10%	16.4%
5	11% to 13%	5.3%
6	Over 13%	5.6%

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Hydrology / Drainage

- Analyses of AOI hydrology has two purposes:

  1. To isolate areas that are prone to excessive flooding.

  2. To understand drainage within the AOI to isolate cultivation quality based on proximity to stream order.

- The right image is the primary river (Little Scarcies River) that borders the east side of the AOI.

- Using Arc-Hydro tools and simulating extreme rain events from local rain statistics, the red areas should be completely avoided for cultivation and irrigation (pump) infrastructure. Yellow areas should be approached with caution.

Most Ethanol Flood Area Delineation

Legend
Flood Zone 1
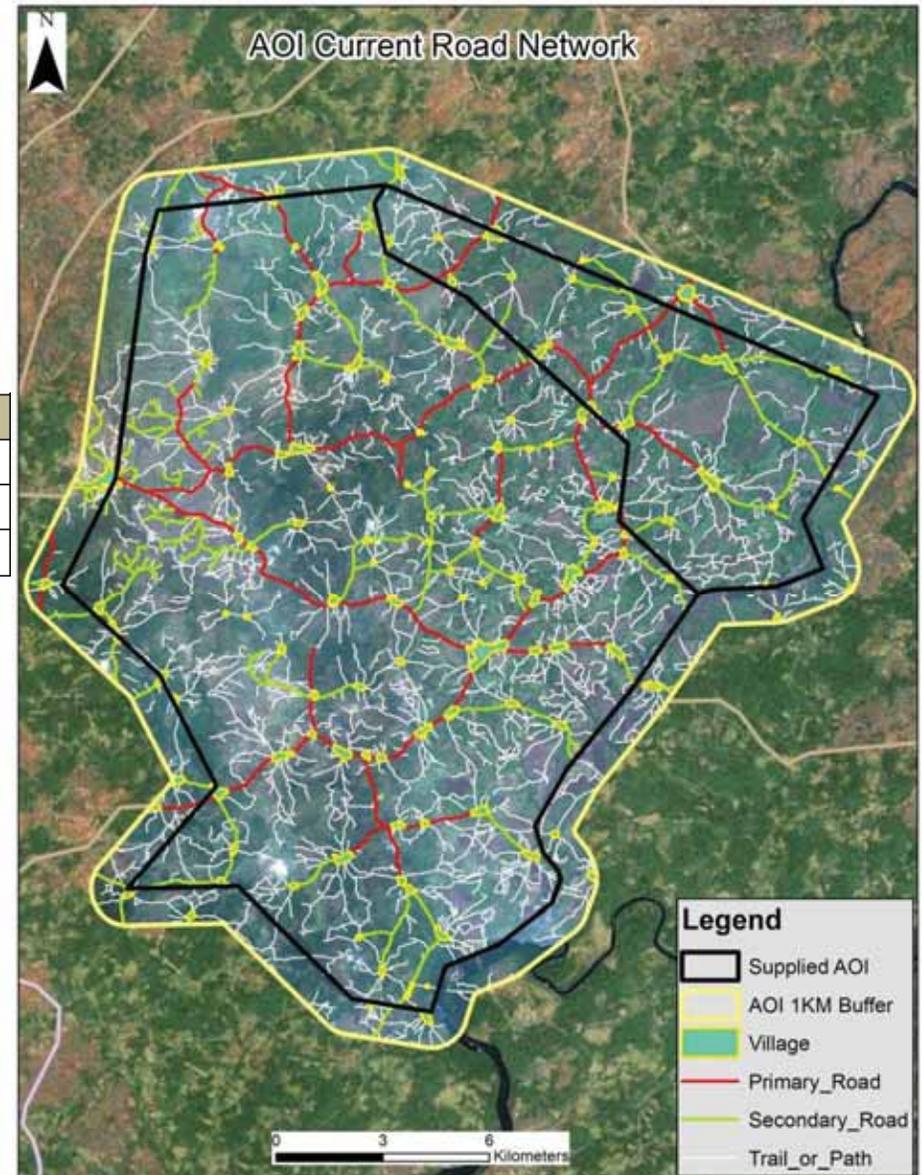Flood Zone 2
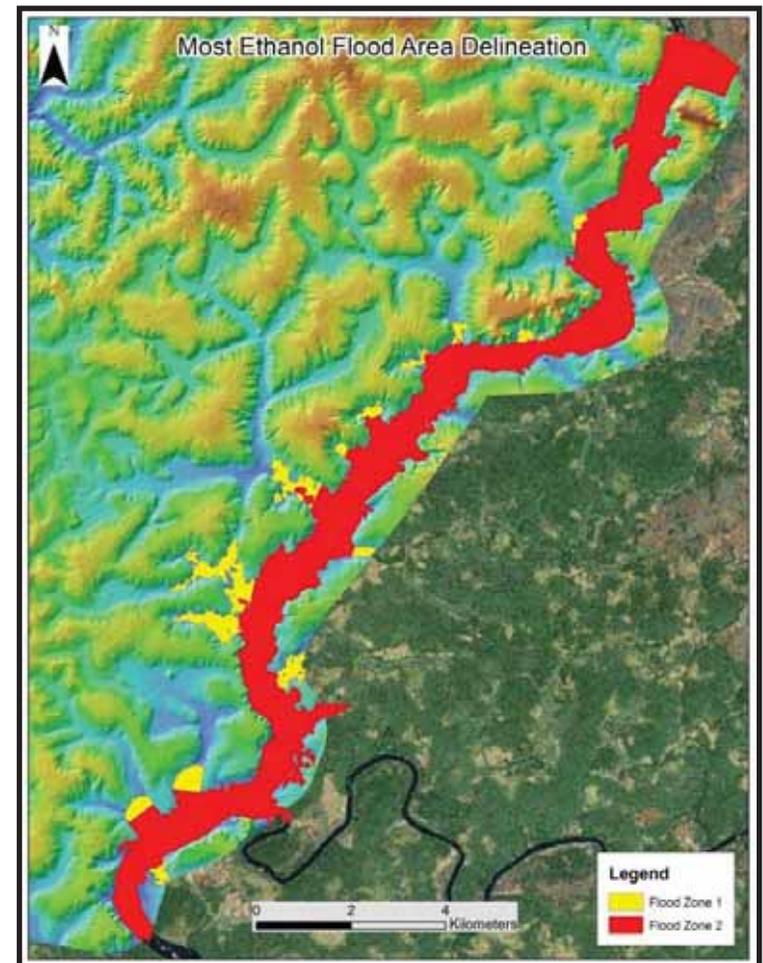
Hydrology / Drainage

- Areas of low stream order are favorable. Areas of high stream order should be avoided.

- The higher the stream order, the higher the polygon buffer width used in the final analysis.

- The Shreve methodology of ordering streams was selected to assist in visualizing areas of significant drainage.
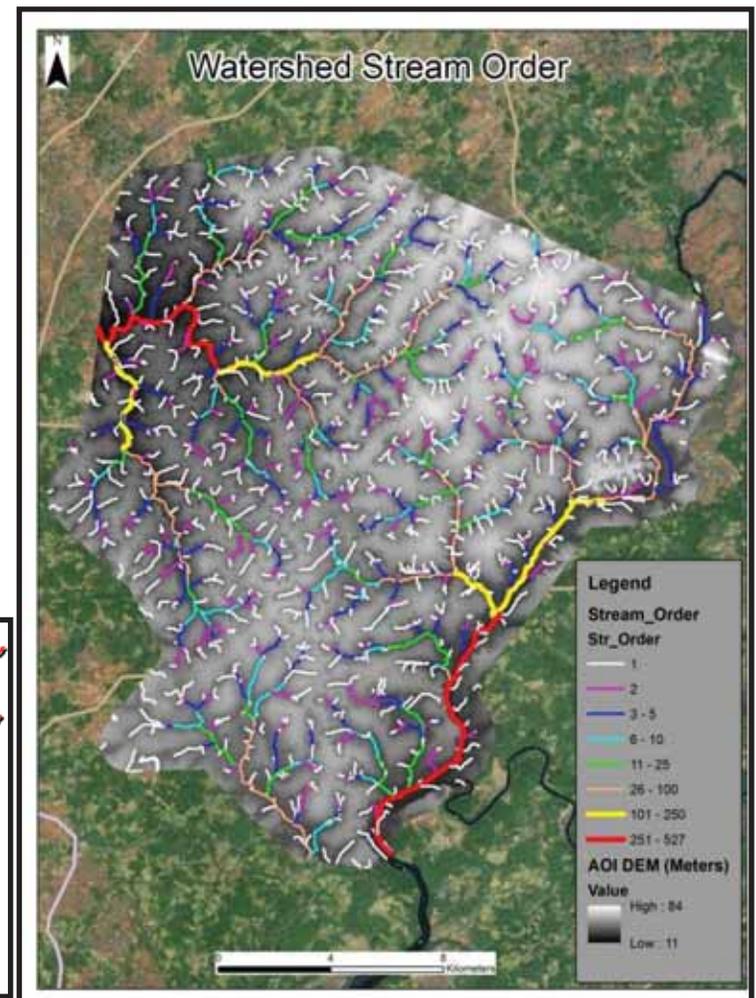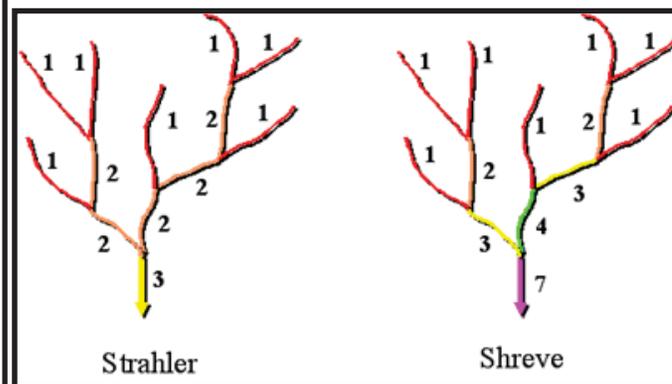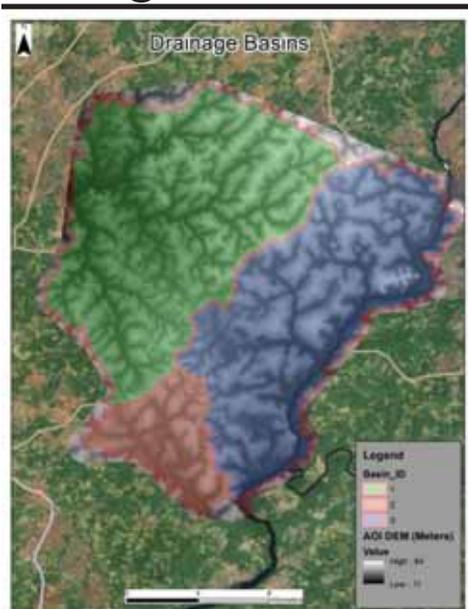
Road Network – AOI Transportation

- Road Network was digitized throughout the AOI into 3 categories: Primary Road, Secondary Road and Trail.
- After 3D analysis, 0.3% of primary and secondary segments had maximum slopes greater than 15% and 0.8% of all segments had maximum slopes between 10% and 15%.

Road Type	Total Length in KM	Percent of Entire Network
Primary Road	109.8	9.1%
Secondary Road	146.9	12.2%
Trail/Path	951.6	78.8%

AOI Current Road Network

Legend
- Supplied AOI
- AOI 1KM Buffer
- Village
- Primary_Road
- Secondary_Road
- Trail_or_Path

Road Network – AOI Transportation

AOI Current Road Network

To Conakry

To Freetown

Scarcies River Bridge

TONKO LIMBA

MASUMOBALA

Legend
Type
Primary
Secondary
Supplied AOI
1K Buffer to AOI
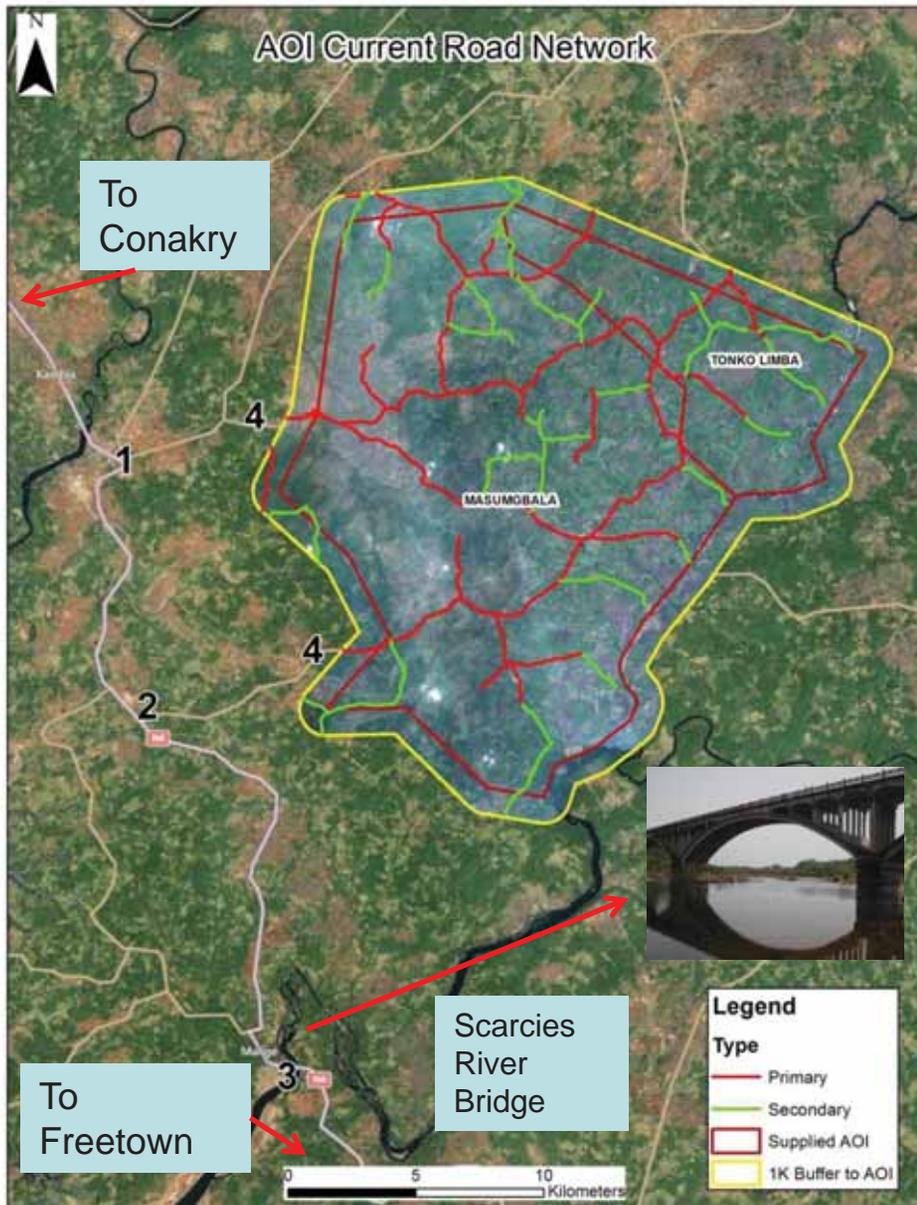
1. Town of Kambia – Major town along Freetown – Conakry Trade Route.
2. Sierra Leone Highway N4, major trade and connecting road between Sierra Leone and Guinea.
3. Major Bridge – Existing critical infrastructure for mass transport.
4. 5 km route connects AOI to main highway network.

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Soils Analysis (Preliminary)

The Harmonized World Soils Database (HWSD) (Developed through the United Nation's Food and Agriculture Organization) is likely to be the best tool available to address soils quality without onsite analysis.

The AOI falls in an area of one dominant soils (making up 40% of the area) and four other soils making up the other 60% of the AOI.
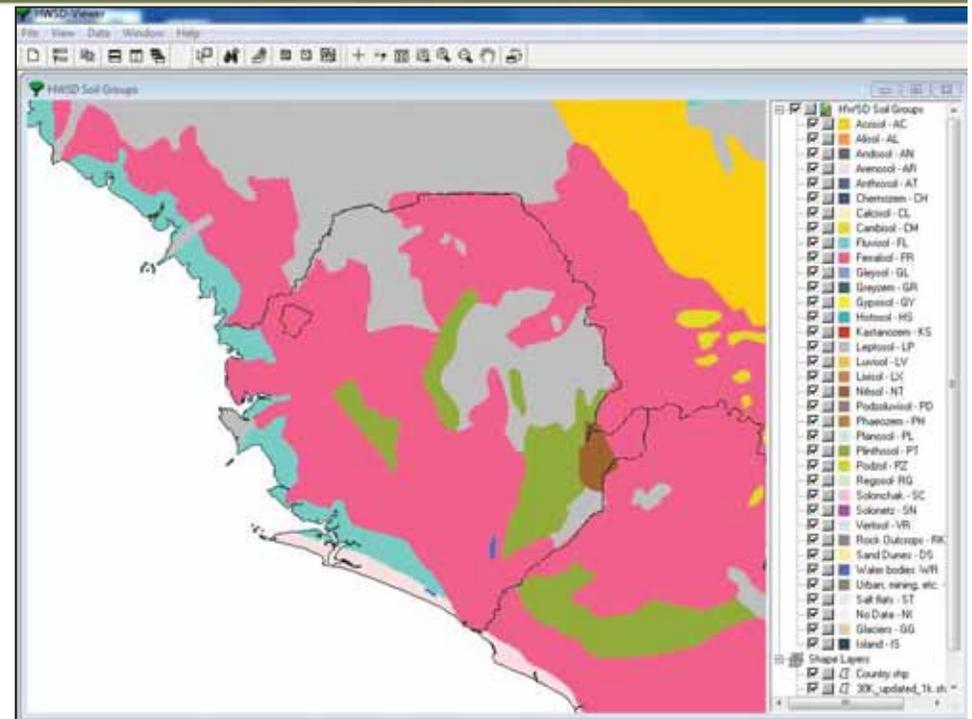

Two professors from the University of Florida – Everglades Research and Education Center indicated that the soils content listed from the HWSD do not disqualify the soils for sugarcane, however, issues related to high pH may be present and a comprehensive soils study should be performed prior to any implementation.

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Land Use and Land Cover

1. **Water** – In the AOI, this only pertains to the Little Scarcies River.

2. **Shrubbery** – Areas characterized by natural or semi natural woody vegetation with aerial stems, generally no more than a few meters tall with individual or clumps not interlocking.

3. **Herbaceous/Grassland** – Areas characterized by grassland and/or vegetation with non woody stems.

4. **Forest** – Land characterized by tree cover.

5. **Tall Forest** – Clumps of forested area significantly taller than typical forested areas.

6. **Barren** – Areas with little or no green vegetation. These areas are classified by bare sand, silt or clay, for example.

7. **Burn Area** – Areas that appear deliberately burned, likely as part of "Slash and Burn" agriculture that is practiced in Sierra Leone as well as many parts of Western Africa.

8. **Agriculture** – Areas of current agriculture use.

9. **Cloud** – Areas covered in cloud during satellite imagery collection.

10. **Villages** – Populated Areas.

AOI Land Use / Land Cover

Legend

Supplied AOI
AOI 1KM Buffer
LULC.img
LULC

Agriculture	
Barren	
Burn_Area	
Cloud	
Forest	
Herbacious/Grassland	
Shrubbery	
Tall_Forest	
Village	
Water	

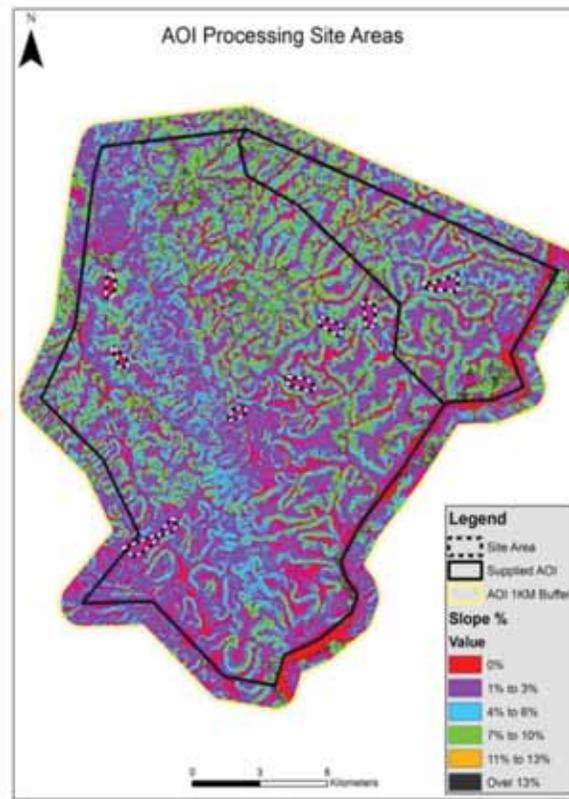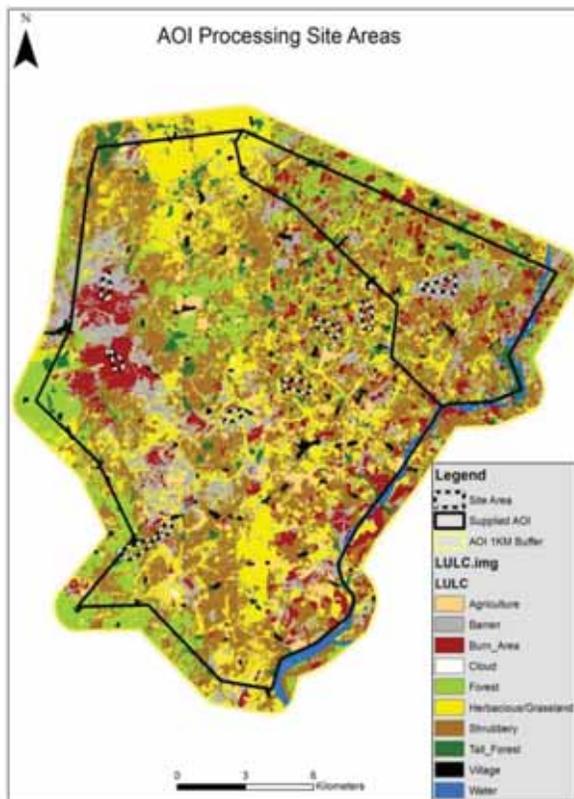| LULC Class	Percent Cover		
Shrubbery	35.0%	Village	1.6%
Barren	15.9%	Agriculture	3.4%
Herbacious/Grassland	19.8%	Cloud	0.1%
Forest	11.6%	Water	1.4%
Burn_Area	7.8%	Tall_Forest	3.5%
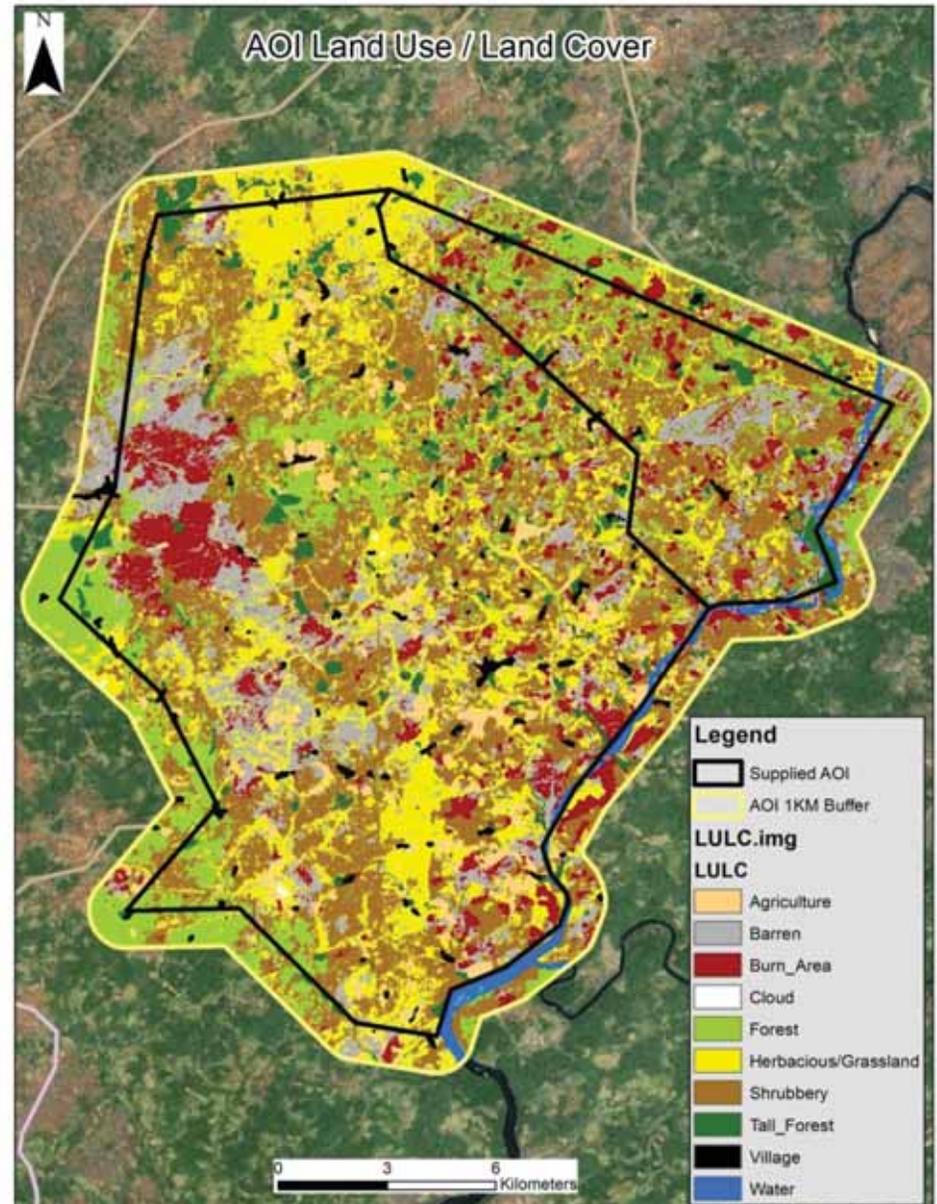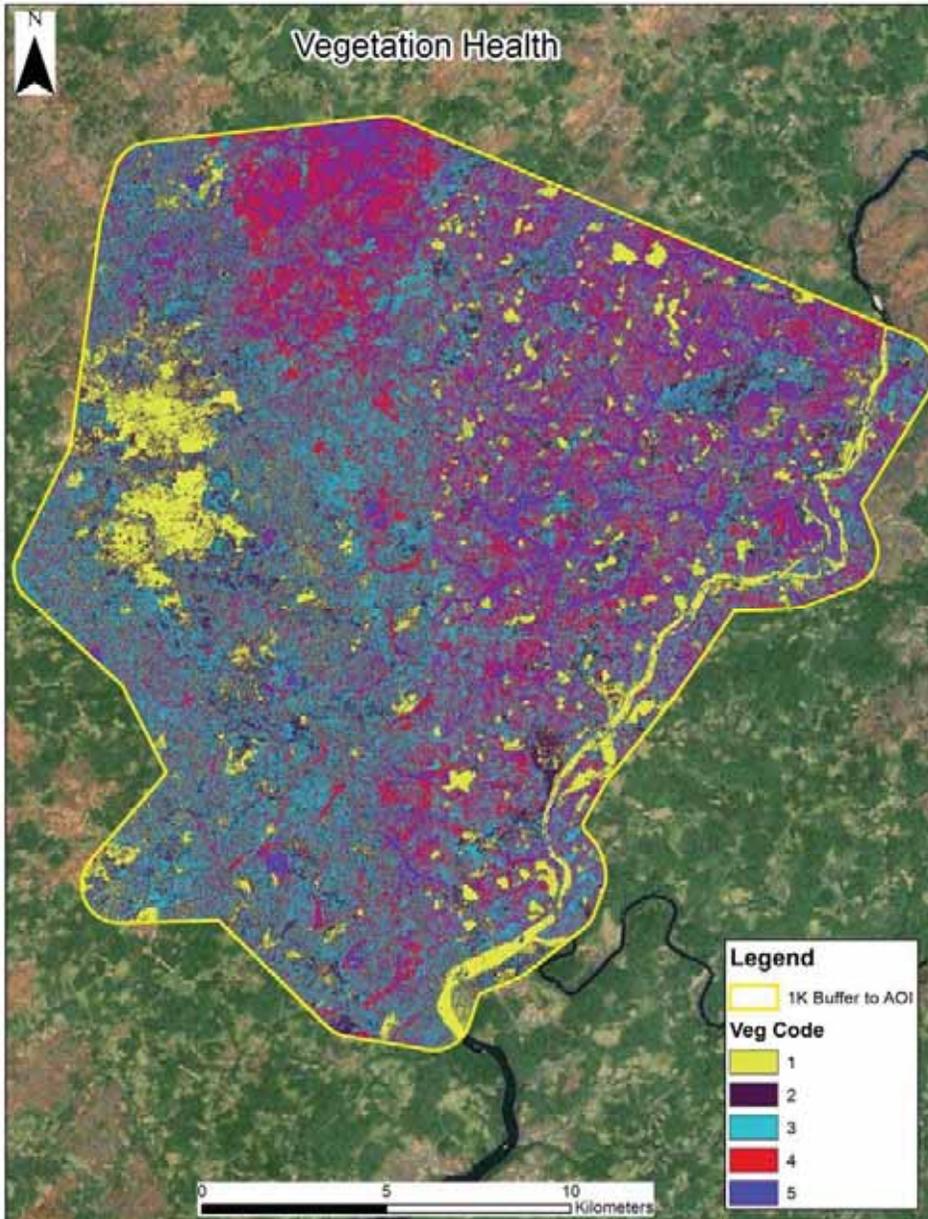
- Vegetation health of AOI derived from band #6 (Red Edge Band, World View II).
- Chlorophyll is a very strong absorber of light exclusively in the red-edge wavelength span.

Processing Site Locations

1. **Distance of Crop to Processing Facility** – Plantations should be no more than 25 miles from their processing facility.
2. **Slope** – Establishing a facility at an area of 0% slope or near 0% slope is preferred. An area of low slope reduces the likelihood that the ground will need altering (cut/fill) and minimizes runoff impact of an unforeseen event.
3. **Road Network** – The processing site will have the highest traffic due to feedstock supply and product shipping. Therefore, the site should be located adjacent to suitable primary road network.
4. **Barren Areas** – Areas classified as barren on the LU/LC are preferred due to their relative low vegetative health.

Combined Land Classification

Various criteria combined and calculated to create a combined land classification grid.
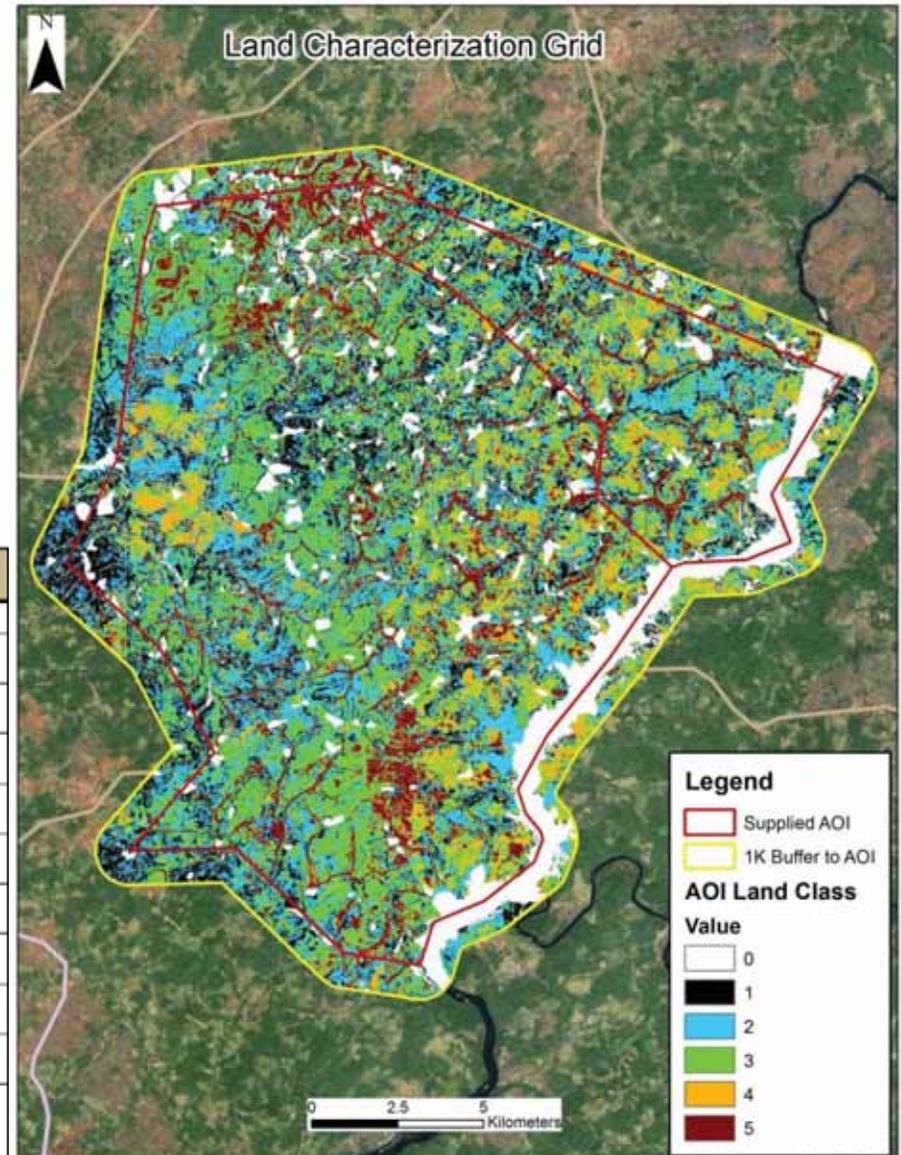
5 = Best
1 = Worst
0 = Impossible.

Land Class	Percentage
0	12.2%
1	15.5%
2	30.6%
3	16.4%
4	13.3%
5	12.0%

Slope		Land Use / Land Cover		Vegetation Health		Stream Order		Flood Area	
Over 13%	0	Water	0	Worst Health	1	251 to 527	1	Red Zone	0
11% to 13%	1	Shrubbery	3	Below Ideal Health	2	101 to 250	2	Yellow Zone	2
7% to 10%	2	Herbaceous/Grassland	5	Fair Health	3	26 to 100	3		
0%	3	Forest	1	Better Health	4	6 to 25	4		
4% to 6%	4	Tall Forest	0	Best Health	5	1 to 5	5		
1% to 3%	5	Barren	2						
		Burn Area	4						
		Village	0						
		Agriculture	1						
		Cloud	No Data						

Land Characterization Grid

Legend
Supplied AOI
1K Buffer to AOI
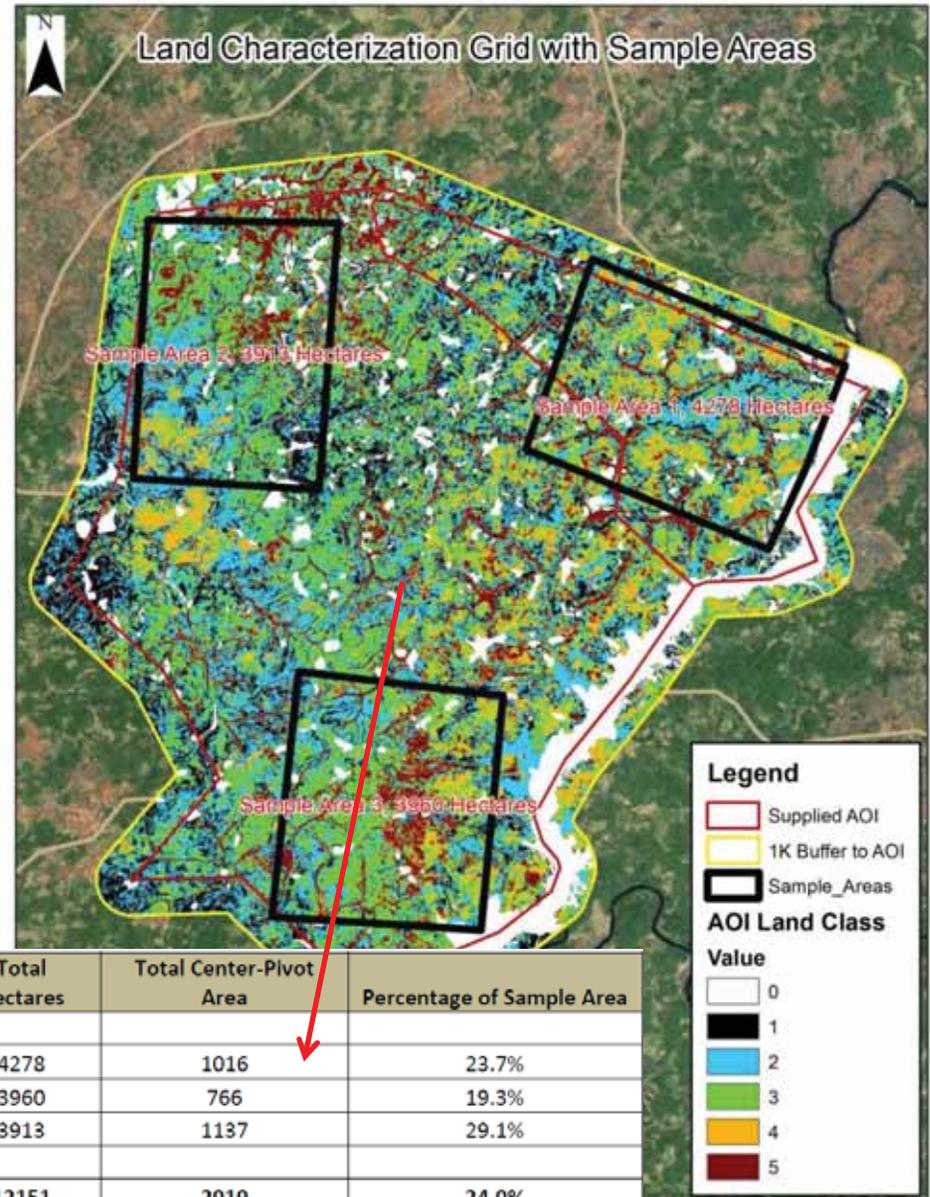
AOI Land Class Value
0
1
2
3
4
5

Irrigation Methodology - Results

- Furrow – surface system
- Impact Sprinkler
- Center Pivot
- Drip
- Rain Gun

Initial attempt to map plantation site based on a center-pivot irrigation system.


Ideal Center Pivot Layout

Land Characterization Grid with Sample Areas

Legend

- Supplied AOI
- 1K Buffer to AOI
- Sample_Areas

AOI Land Class Value

- 0
- 1
- 2
- 3
- 4
- 5

Area	Total Hectares	Total Center-Pivot Area	Percentage of Sample Area
Sample Area 1	4278	1016	23.7%
Sample Area 2	3960	766	19.3%
Sample Area 3	3913	1137	29.1%
Total	12151	2919	24.0%

Irrigation Methodology - Results
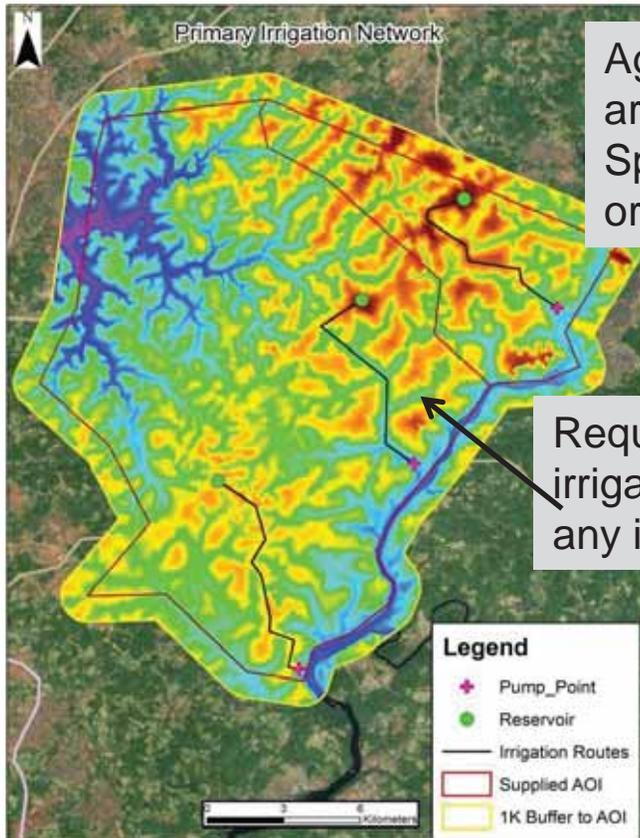
Aggregation of viable area: Areas viable for Sprinkler / Rain Gun or Drip Irrigation.

Required primary irrigation network for any irrigation method.
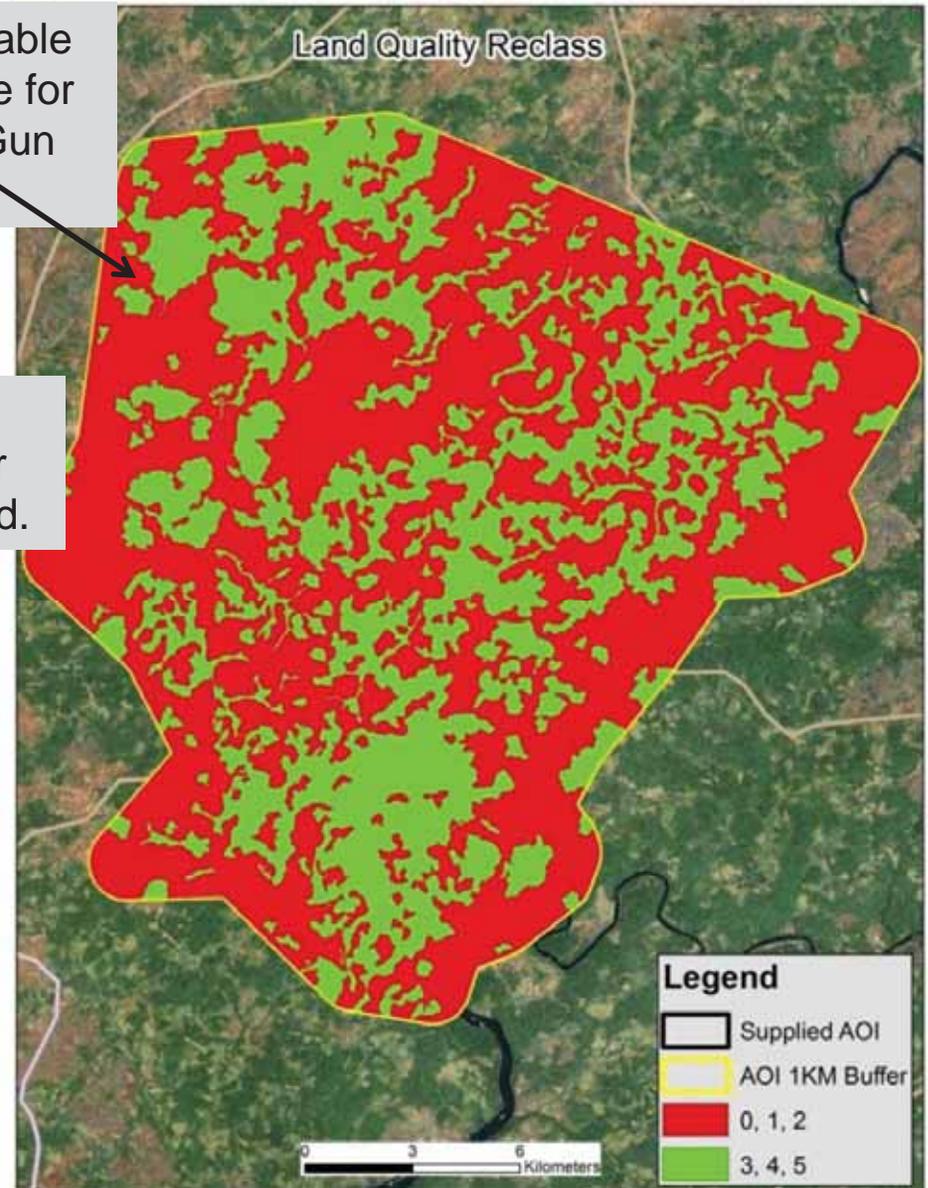
Irrigation Type	Total Area Available
Center-Pivot	24.0%
Furrow (one site only)	25.5%
Sprinkler/Rain Gun	29.6%
Drip	29.6%

Conclusion

- Based on the findings of this report, less than 30% of the AOI appears feasible for plantation areas.

- This is significantly less the 42% which Merrick's feasibility study states is typical for West African areas.

- To achieve the requested viable land, a larger tract must be purchased or the project moved to another location.

- The following elements were considered when calculating feasible plantation area:

  - Topography / Slope

  - Land Use / Land Cover

  - Vegetation Health

  - Stream Order / Hydrology

  - Flood Plain

- For the most part, the current transportation network appeared reasonable and significant alterations to the AOI road network were not necessary.

- Current soils databases indicate the soils are viable but may require treatments. Further field soils sampling should be conducted prior to implementing a project.

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