How can we utilize GIS to sustainability assessment of bioenergy?

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Presentation flow

GIS and the GBEP indicators

- Functions of GIS
- How we can apply GIS to sustainability assessment
- How useful GIS is to estimate GBEP indicators
- Data requirements

Examples of GIS application to sustainability assessment

- Nishiwaga, Japan
- Jintan, Jiangsu, China

Conclusions
• Three main functions of GIS

GIS

- Mapping
- Overlapping Analysis
- Distance
Mapping

- To indicate various kinds of information on a map
- Considering how much biomass is existing and how much resource is available is fundamental for sustainability assessment
- GIS can indicate location of feedstock production fields, bioenergy plants, and critical infrastructure such as roads and pipelines
- In addition, GIS is a useful tool to understand where biomass resource exists and how much we can use as bioenergy among it
Mapping and the GBEP indicators

- Mapping technique helps to assess following GBEP indicators
  - Ind. 3 (Wood resources)
  - Ind. 5 (Water use and efficiency)
  - Ind. 23 (Infrastructure and logistics)
  - Ind. 24 (Capacity and flexibility)
• To estimate area which satisfies specific conditions
• Multiple areas which have different characteristics or conditions are analyzed by GIS, and it helps to calculate area which satisfies both (all) conditions

– Topographical, land use, soil types, and environmental restrictions are analyzed by overlapping technique
By overlapping maps or information in different time points and compare them, we can understand land use change.
Overlapping analysis is applicable to following GBEP indicators

- Ind. 2 (Soil quality)
  Soil conservation area and feedstock production field

- Ind. 7 (Biodiversity)
  Biodiversity conservation area and feedstock production field

- Ind. 8 (LUC)
  Land cover in different time points
  Land use change and feedstock production field

- Ind. 9 (Land tenure)
  Area where legal tenure systems are established and feedstock production field
• To calculate distance between two or multiple points
  (one-line distance and actual distance traveled)
• GIS can easily calculate transportation distance

• How long feedstock and bioenergy should be transported is closely related to production cost (productivity) and environmental burden
Estimation of distance by GIS helps to assess the following GBEP indicators:

- Ind. 1 (GHG emission)
- Ind. 4 (Non GHG emission)
- Ind. 13 (Unpaid time for collecting biomass)
  - Walking distance to collect biomass is related to time spent
- Ind. 17 (Productivity)
- Ind. 19 (Gross value added)
• **Images**

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Sensor</th>
<th>Resolution</th>
<th>Frequency</th>
<th>Cost</th>
<th>Notes</th>
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<tr>
<td>NOAA</td>
<td>AVHRR</td>
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<td>2 times/day</td>
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<td>ASTER/TIR</td>
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<td>HRVIR–X/HRG–X</td>
<td>20/10m</td>
<td>26 days</td>
<td>High</td>
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<td>HRVIR–M/HRV–P</td>
<td>10/2.5–5m</td>
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<td>VEGETATION</td>
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<td>PRISM</td>
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<td>2.5m</td>
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– Images required depends on how GIS is applied: plant level (<10m mesh), regional (>30m mesh), or national level (>500m mesh)
Data requirements

• Positional information
  – Location of roads, plants, crop area, and conservation area etc.

• Geographical and topographical information
  – Elevation, inclination, land cover
  – Rivers and lakes, mountains, oceans
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Examples of GIS application to sustainability assessment
- Nishiwaga, Japan
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Conclusions
Examples of GIS application to sustainability assessment (1)

• Nishiwaga, Japan
  – Firewood from thinned timber
  – Indicator 1, 3, 17, 19

• GIS application
  – Mapping and overlapping (Ind. 3)
  – Transportation distance from resource extraction points and consumption points (to calculate GHG emission (Ind. 1), and cost (Ind. 17&19) )
After WW2, enormous trees (mainly Japanese Cedar: coniferous) are planted in Japan, after 60 years, now it's time to lumber, but due to recent low timber price, trees are abandoned, causing disasters like landslides and floods, lower biodiversity, and game damage.

Government are promoting sound forest management such as thinning. Utilization of thinned timber is important, energy use in household is one of the easiest options.
• How much wood resource is produced by thinning in Nishiwaga?
• And how much is unused among it?

Unused resource = Wood volume* Thinning rate* Unused rate

• Data requirements
  – Elevation data (obtained from Min. of Land)
  – Road data (obtained from Min. of Land)
  – Forest Management Block (FMB) data (location, tree type, volume, planted year etc.)
Overlapping Elevation data (10m mesh)

• How much wood resource is available among unused resources?
• Considering transportation by trucks, we exclude FMB which has inclination more than 35 degree

Available resource = Unused resource - Resource in FBM with >35 degree inclination

• Elevation data and FMB data are overlapped
Distance (to where?)

- To where should we transport wood resource?
- Assume that wood resource should be transported to center of each community.
Distance (from where to where?)

$d_1$: One-line distance from centre of FMB to the closest road

$d_2$: One-line distance from road to centre of a community

Transportation distance $= (d_1 + d_2) \times \text{detour rate}$

From calculated distance, Ind. 1 (GHG emission) and Ind. 17 & 19 (Transportation cost) are estimated
Examples of GIS application to sustainability assessment (2)

• Jintan, Jiangsu, China
  – Power generation by methane fermentation from pig waste and its residue (digested liquid)
  – Indicator 1, 17, (6: not estimated but closely related)
• As most of location data (breeding farms, rice paddies) which is needed to assess indicators is not available, we tried to utilize GIS and remote sensing
• Pig breeding in Jintan
  – Causes water pollution recently
  – Power generations from methane are installed in breeding farms to prevent water pollution
  – However, even if bioenergy is produced, once digested juice flows out to rivers, water pollution problem is not solved
  – Utilization of digested juice as fertilizer in rice farms is planned for sustainable bioenergy production
• How much digested juice is acceptable in rice farmers?
• Locations of pig breeding farms and rice fields are mapped by GIS
• How far should pig breeders have to transport digested juice?
  – One breeder has to transport around 2km (one line distance) for all produced juice to be accepted
  – 8 main routes from the breeding farm to rice fields are selected

From the results, we estimated GHG emission (Ind. 1) and its cost (Ind. 17)
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Examples of GIS application to sustainability assessment

– Nishiwaga, Japan

Conclusions
1. GIS is useful not only to map results, but also assess sustainability of bioenergy

2. GIS is applicable directly to following GBEP indicators
   - Mapping: Ind. 3, 5, 23, 24
   - Overlapping: Ind. 2, 7, 8, 9
   - Distance: Ind. 1, 4, 13, 17, 19
3. Data requirements

- Images used for analysis depend on its application level (plant, regional or national)

- GBEP indicators are mainly aimed at national or regional level assessment, images which are 500m or more mesh should be used.

- Once remote sensing technique is used, GBEP indicators are applicable even to developing countries where statistics and data for bioenergy are limited.
4. IRENA/PRIMAFF collaboration

– IRENA and PRIMAFF have initiated a collaboration work on GIS application for bioenergy

• A tool to assess biomass potential (and availability) at national level
  – Applicable even countries with restricted data accessibility
  – In the project, we will also address how GIS analysis can cover data constraint

• A sustainability assessment tool applicable to plants
  – Evaluate resource potions, energy options, technological potions at plant level
  – Holistic assessment tool like composite indicator
Thank you very much for your attention

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