GLOBAL BIO-ENERGY PARTNERSHIP (GBEP)  
SUSTAINABILITY INDICATORS FOR GHANA: PILOT STUDY ON SELECTED SUB-INDICATORS

CSIR-IIR GBEP PROJECT TEAM  
PRESENTATION AT ECOWAS/GBEP WORKSHOP  
MINISTRY OF FOREIGN AFFAIRS  
PRAIA, CAPE VERDE

PRESENTER: MAWUENA AGGEY (CSIR-IIR)

7TH/8TH NOVEMBER 2013
THE TEAM AND COLLABORATORS

CSIR-IIR GBEP PROJECT TEAM

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COLLABORATORS/SUPPORTERS

• GLOBAL BIOENERGY PARTNERSHIP (GBEP)
• THE DUTCH GOVERNMENT
• ECOWAS REGIONAL CENTRE FOR RENEWABLE ENERGY & ENERGY EFFICIENCY (ECREEE)
• GHANA CSIR-SECRETARIAT
• GHANA ENERGY COMMISSION
• PARTNERS FOR INNOVATION BV
PRESENTATION OUTLINE

• BACKGROUND
• INTRODUCTION
• OBJECTIVES OF CSIR-IIR STUDY
• STUDY APPROACH
• FINDINGS
  – CALCULATED VALUES (Productivity, Procession Efficiency, Net energy Balance, Logistics)
• LESSONS
  – APPROACH, DATA COLLECTION, DATA ASSESSMENT, BASELINE VALUES
• RECOMMENDATIONS
• NEXT STEPS
BACKGROUND

JUSTIFICATION:

 Much biomass used as energy
 Unsustainable traditional biomass harvesting;
 Unsustainable fossil energy production and use;
 Negative impact on livelihoods, economies, environment;
 Huge opportunity for modern-sustainable bio-energy production
 Increasing GLOBAL INCLINATION TO utilization of modern bio-energy and other re-newables

 APPROPRIATE COMPREHENSIVE INDICATORS REQUIRED TO MEASURE/MONITOR AND FACILITATE SOUND NATIONAL POLICY DECISIONS FOR ADOPTING MODERN BIOENERGY
GBEPSI:
• 24 Measures/ values of quantitative/qualitative attributes of bioenergy resource production, delivery and use
• Indicator Groups –
  Environmental (8), Social (8), Economic (8)

Utility:
• Measure state of bioenergy resource;
• Forecast trends in state of bioenergy resource;
• Benchmark/baseline criteria definition;
• Monitor Country movement to or from bioenergy resource sustainability (Changes in indicators between periods)
• Comprehensive bioenergy policy formulation
BACKGROUND
PILOT STUDIES

- GBEP Pilot studies launched to test:
  - Calculation
  - Application
  - Relevance

Japan, Indonesia, Netherlands, Germany, USA, Colombia.

- Ghana pilot - May/June-November, 2012:
  - 36 working days - GHC18,600
  - Results/Lessons
  - Input to policy/programmes
  - Share with ECOWAS
INTRODUCTION
ECONOMIC PILLAR INDICATORS

Indicator 17 Productivity (BASELINES = 4)
• 17.1 Productivity of bioenergy feedstocks
• 17.2 Processing efficiencies
• 17.3 Amount of bioenergy end product
• 17.4 Production cost per unit of bioenergy

Indicator 18 Net energy balance (BASELINES = 4)
• 18.1 feedstock production,
• 18.2 processing of feedstock into bioenergy,
• 18.3 bioenergy use; and/or
• 18.4 lifecycle analysis

Indicator 19 Gross value added (BASELINES = 0)
• 19.1 Gross value added per unit of bioenergy produced
• 19.2 GVA as percentage of gross domestic product
INTRODUCTION
ECONOMIC PILLAR INDICATORS

Indicator 20 Change in consumption of fossil fuels and traditional use of biomass (BASELINES = 2)
• 20.1-6 Substitution of fossil fuels with domestic bioenergy
• 20.7-12 Annual savings of convertible currency
• 20.13-18 Substitution of traditional use of biomass with modern domestic bioenergy

Indicator 21 Training and re-qualification of the workforce
• 21.1 Share of trained workers in the bioenergy sector out of total bioenergy workforce
• 21.2 Share of re-qualified workers out of the total number of jobs lost in the bioenergy sector (BASELINES = 0)

Indicator 22 Energy diversity (BASELINES = 0)
• 22.1 Change in diversity of total primary energy supply due to bioenergy
INTRODUCTION
ECONOMIC PILLAR INDICATORS

Indicator 23 Infrastructure and logistics for distribution of bioenergy (BASELINES = 2)
• 23.1 Number routes for critical distribution systems
• 23.2 capacity of routes for critical distribution systems
• 23.3 proportion of the bioenergy associated with route

Indicator 24 Capacity and flexibility of use of bioenergy (BL = 0)
• 24.1 Ratio of capacity for using bioenergy compared with actual use for each significant utilization route
• 24.2 Ratio of flexible capacity which can use either bioenergy or other fuel sources to total capacity

TOTAL INDICATORS = 8
TOTAL SUB-INDICATORS = 36
TOTAL BASELINE VALUES = 12
## INTRODUCTION

CSIR-IIR PRIORITY INDICATORS

CSIR-SECRETARIAT → Policy Stakeholder Group (PSG)

• Selection/Priority → 29 from 36 sub-indics -12/12 BL

### Economic pillar

<table>
<thead>
<tr>
<th>Priority</th>
<th>Indicator</th>
<th>Number of Sub-indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17) Productivity</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>20) Change in the consumption of fossil fuels and traditional use of biomass</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>23) Infrastructure and logistics for distribution of bio-energy</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>18) Net energy balance</td>
<td>4</td>
</tr>
</tbody>
</table>
OBJECTIVES OF STUDY

- Objectives of pilot study:
  - Collect most appropriate available data, to calculate SUB-indicators (Task 1);
  - Assess usefulness, availability, quality of data (Task 2);
  - Make recommendations to improve data collection, creation and use (Task 3); and
  - Propose baseline values for most important (sub) indicators (Task 4).

- Exploratory Study focus on existing data
- No actual measurements, tests or surveys
CSIR-IIR Study Approach

• Team Formation
  – Energy, Environment, Economist

• Orientation
  – PSG member

• Brainstorm
  – Country energy profile scan
  – Country bioenergy profile scan
  – Selection Criteria

Criteria:
Representative Mix of Biofuel States/Forms
  - Solid - Liquid - Gas

Furthest/Longest Conversion Pathway
  - for insight into all possible bottlenecks

Primary state to Used state
CSIR-IIR Study Approach

- Basket of Biofuel Conversion Pathways
- Selection
- Review of Definitions, Methodologies & Calculation Formulae
- Search Data/Information - Compilation
- Analysis & Calculations
- Filling In the Template
- Report Write-Up
- Technical Backstopping
# Ghana Biofuel Conversion Basket

<table>
<thead>
<tr>
<th>USED FORM</th>
<th>SOLID</th>
<th>LIQUID</th>
<th>GAS</th>
<th>NON MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>USED FORM EXAMPLES</td>
<td>CHARCOAL</td>
<td>BIODIESEL</td>
<td>BIOGAS (METHANE)</td>
<td>FACTORY ELECTRICITY HEAT</td>
</tr>
<tr>
<td>PRIMARY FORM EXAMPLES</td>
<td>FUELWOOD (FIREWOOD)</td>
<td>SEEDS: JATROPHA SUNFLOWER</td>
<td>HUMAN EXCRETA COW DUNG WASTE FROM: Hospital Theatre Slaughter House Kitchen MIXTURES</td>
<td>FUELWOOD (FIREWOOD) RESIDUE: SAW MILL FOREST CROP</td>
</tr>
<tr>
<td>Replacement for:</td>
<td>Firewood Saw mill residue Forest residue Farm residue Crop Residue - E. P. Bunch - spiklets/fibre - shells/cobs - straw/stalks</td>
<td>Fossil fuels</td>
<td>Charcoal Fuelwood Firewood Kerosene stoves</td>
<td>Fossil Fuels Hydro Electricity Thermal Electricity</td>
</tr>
</tbody>
</table>

**11/11/2013**
CSIR-IIR SELECTED LINES OF INVESTIGATION

SELECTED BIOENERGY PATHWAYS:

- Solid, Liquid and Gas bioenergy pathways:
  - Woodfuel
  - Sunflower plant
  - Jatropha plant
  - Human excreta
  - Mixed Household Waste
  - Charcoal
  - Biodiesel
  - Biogas

SELECTED SUB-INDICATORS & CONVERSION TECHNOLOGY
Understand, Calculate, Data available in short time

ATTEMPT ALL
SELECTED (SUB) INDICATORS

- **PRODUCTIVITY:**
  - Productivity of bioenergy feedstocks by farm/plantation;
  - Processing efficiencies by technology, by feedstock;
  - Amount of bioenergy end product by mass, volume, energy content/ha/year;
  - Production cost per unit of bioenergy.

- **CHANGE IN CONSUMPTION**
  - Substitution of fossil fuels with domestic bioenergy;
  - Annual savings of convertible currency
  - Substitution of traditional use of biomass use by modern domestic bioenergy
SELECTED (SUB) INDICATORS

- Infrastructure and logistics
  - Number of critical routes
  - Capacity of routes
  - Assessment of proportion of bioenergy associated with each route

- Energy balance
  - Feedstock production
  - Processing feedstock
  - Bioenergy use
  - Life cycle analysis

FOR SINGLE CONVERSION PATH WITH SINGLE TECHNOLOGY
SELECTION/PRIORITY: 29 from 36 sub-indicators (12/12 BL)
CALCULATED VALUES: 26 from 29 sub-indicators (0/12 BL)
## FINDINGS – INDICATOR 17: PRODUCTIVITY

### SUB-INDICATOR 17.1 – PRIMARY YIELD

<table>
<thead>
<tr>
<th>Indicator 17.1A:</th>
<th>1.44 tonne/ha/yr</th>
<th>Firewood Fuelwood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator 17.1B:</td>
<td>8.75 tonne/ha/yr</td>
<td>Jatropha seed</td>
</tr>
<tr>
<td>Indicator 17.1C:</td>
<td>2.05 tonne/ha/yr</td>
<td>Sunflower seed</td>
</tr>
<tr>
<td>Indicator 17.1D:</td>
<td>0.55 m³ per capita/yr</td>
<td>Fresh excreta (human)</td>
</tr>
<tr>
<td>Indicator 17.1E:</td>
<td>0.22 tonne/capita/yr</td>
<td>Mixed Household waste</td>
</tr>
</tbody>
</table>
## FINDINGS - INDICATOR 17: PRODUCTIVITY

### SUB INDICATOR 17.2 – PROCESSING EFFICIENCY

<table>
<thead>
<tr>
<th>Indicator 17.2A</th>
<th>Value</th>
<th>Description</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator 17.2B1</td>
<td>0.28</td>
<td>MJ charcoal/MJ wood</td>
<td>TRADITIONAL MOUND TECHNOLOGY</td>
</tr>
<tr>
<td>Indicator 17.2B2</td>
<td>0.60</td>
<td>MJ oil/MJ jatropha seed</td>
<td>Average high &amp; low efficiency technology</td>
</tr>
<tr>
<td>Indicator 17.2C1</td>
<td>0.62</td>
<td>MJ biodiesel (jatropha)/MJ crude jatropha oil</td>
<td></td>
</tr>
<tr>
<td>Indicator 17.2C2</td>
<td>0.50</td>
<td>MJ oil/MJ sunflower seed</td>
<td>Average high &amp; low efficiency technology</td>
</tr>
<tr>
<td>Indicator 17.2D</td>
<td>0.53</td>
<td>MJ biogas/MJ excreta</td>
<td>Anaerobic</td>
</tr>
<tr>
<td>Indicator 17.2E</td>
<td>0.90</td>
<td>MJ biogas/MJ kitchen waste</td>
<td>Anaerobic</td>
</tr>
</tbody>
</table>
FINDINGS - INDICATOR 17: PRODUCTIVITY

SUB-INDICATOR 17.3 – AMOUNT OF BIOENERGY END PRODUCT

<table>
<thead>
<tr>
<th>Indicator 17.3A</th>
<th>1,788,000</th>
<th>TONNE/YR</th>
<th>Charcoal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator 17.3C</td>
<td>1</td>
<td>Tonne biodiesel/yr</td>
<td>Sunflower</td>
</tr>
<tr>
<td>Indicator 17.3DE</td>
<td>579,620</td>
<td>M³ biogas/yr</td>
<td>Biogas</td>
</tr>
</tbody>
</table>
## FINDINGS - INDICATOR 17: PRODUCTIVITY

### SUB-INDICATOR 17.4 – PRODUCTION COST VALUES

<table>
<thead>
<tr>
<th>Indicator 17.4</th>
<th>Value</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator 17.4A</td>
<td>0.001</td>
<td>USD/MJ</td>
<td>CHARCOAL</td>
</tr>
<tr>
<td>Indicator 17.4C</td>
<td>0.016</td>
<td>USD/MJ</td>
<td>biodiesel from sunflower oil</td>
</tr>
<tr>
<td>Indicator 17.4D</td>
<td>NA</td>
<td>USD/MJ</td>
<td>Biogas from Human Excreta</td>
</tr>
</tbody>
</table>
FINDINGS - INDICATOR 18 - ENERGY BALANCE: Ratio

- SUB-INDICATOR 18.1 – FEEDSTOCK PRODUCTION
- SUB-INDICATOR 18.2 - PROCESSING FEEDSTOCK
- SUB-INDICATOR 18.3 - BIOENERGY USE
- SUB-INDICATOR 18.4 - LIFE CYCLE ANALYSIS

<table>
<thead>
<tr>
<th>Sub Indicator</th>
<th>Process</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator 18.1A:</td>
<td>Fuelwood production</td>
<td>11.31</td>
</tr>
<tr>
<td>Indicator 18.2A:</td>
<td>Processing fuelwood to charcoal</td>
<td>0.55</td>
</tr>
<tr>
<td>Indicator 18.3:</td>
<td>Bioenergy use</td>
<td>NA</td>
</tr>
<tr>
<td>Indicator 18.4:</td>
<td>Life cycle analysis</td>
<td>NA</td>
</tr>
</tbody>
</table>
### FINDINGS - INDICATOR 20: Bioenergy Production/Substitution

<table>
<thead>
<tr>
<th>Sub-Indicator</th>
<th>Bioenergy type/Pdn</th>
<th>TJ/yr</th>
<th>TOE Pdn National</th>
<th>Fossil fuel subst (TOE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator 20.1</td>
<td>Total bioenergy</td>
<td>104.0</td>
<td>6,617,510.5</td>
<td>2,510.5</td>
</tr>
<tr>
<td>Indicator 20.2</td>
<td>Liquid fuels</td>
<td>0.04</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Indicator 20.3</td>
<td>Gaseous fuels</td>
<td>0.3</td>
<td>33.3</td>
<td>33.3</td>
</tr>
<tr>
<td>Indicator 20.4</td>
<td>Solid fuels</td>
<td>6,615,000.0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Firewood</td>
<td></td>
<td>2,870,000.0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Charcoal</td>
<td></td>
<td>3,745,000.0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Indicator 20.5/6</td>
<td>Electricity, Heating and Cooling</td>
<td>103.7</td>
<td>2,476.3</td>
<td>2,476.3</td>
</tr>
<tr>
<td>Co-generation (Timber Farms)</td>
<td></td>
<td>57.0</td>
<td>1,358.6</td>
<td>1,358.6</td>
</tr>
<tr>
<td>Co-generation (Oil palm Farms)</td>
<td></td>
<td>46.7</td>
<td>1,117.8</td>
<td>1,117.8</td>
</tr>
</tbody>
</table>
### FINDINGS - INDICATOR 20: Annual Savings from Bioenergy

<table>
<thead>
<tr>
<th>Sub-Indicator</th>
<th>Biofuel type</th>
<th>Million USD/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>1.6655</strong></td>
</tr>
<tr>
<td>Indicator 20.7:</td>
<td>Liquid fuels:</td>
<td>0.0006</td>
</tr>
<tr>
<td>Indicator 20.8:</td>
<td>Gaseous fuels:</td>
<td>0.0218</td>
</tr>
<tr>
<td>Indicator 20.9:</td>
<td>Solid fuels:</td>
<td><strong>1.6431</strong></td>
</tr>
<tr>
<td>Indicator 20.10:</td>
<td>Co-generation: Timber firms</td>
<td>0.8892</td>
</tr>
<tr>
<td>Indicator 20.11:</td>
<td>Co-generation: Oil palm firms</td>
<td>0.7316</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
FINDINGS - INDICATOR 23: INFRASTRUCTURE/LOGISTICS

SUB-INDICATOR 23.1: Number of critical routes:

<table>
<thead>
<tr>
<th>Subindicator</th>
<th>Critical routes</th>
<th>Bioenergy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator 23.1a</td>
<td>2</td>
<td>charcoal</td>
</tr>
<tr>
<td>Indicator 23.1b</td>
<td>0</td>
<td>biodiesel</td>
</tr>
<tr>
<td>Indicator 23.1c</td>
<td>0</td>
<td>biogas</td>
</tr>
</tbody>
</table>

SUB-INDICATOR 23.3: Proportion associated with routes (charcoal):

<table>
<thead>
<tr>
<th>Indicator 23.3</th>
<th>1.0%</th>
<th>Charcoal/seaport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator 23.4</td>
<td>0.2%</td>
<td>Charcoal/railway</td>
</tr>
</tbody>
</table>
LESSONS : Study Approach

• Team Formation
  – Agronomist
  – Bioenergy experts
  – All relevant expertise defined/included

• Orientation
  – PSG only
  – Detailed /Firm Orientation for Team

• Backstopping Focus
  – definitions, calculations, methods (AT START OF STUDY)
    • Boost confidence/reduce uncertainty in Team members
  – Template filling & Report format (AT MIDDLE OF STUDY)
    • Will minimize misconceptions/confusion in draft report
LESSONS : DATA COLLECTION

1.1 SELECTION OF SUB-INDICATORS

SINGLE FEEDSTOCK; SINGLE PATHWAY; SINGLE TECH

Selection/Priority: 29 from 36 subs; (12 from 12 BL) Calculated Values: 26 from 29 subs; (0/12 BL)

- FEEDSTOCK/TECHNOLOGY VARIETY INCREASE MATRIX: Are there weighted baseline values?
- Why baselines excluded for Indicators 19, 21, 22, 24?
- CONCEPT OF CAPACITY OF PORTS/RAILWAY TO CARRY CHARCOAL NOT CLEAR: Original purpose not CHARCOAL

1.2 SCOPE

- Geographic: National /Average Data scarce
  District/locality/Specie specific data for national;
- Feedstock: Fuelwood varieties wide BUT data not specific
- Year Valid; Sunflower valid for 2012; Data not updated for fuelwood, jatropha and human excreta
LESONS : DATA COLLECTION

1.3 SELECTION OF UNITS - Followed template

- Sub-Indicator 17.1 – Feedstock Productivity;
  “Tonnes ha per year” - (Tonne/ha/year or Tonne/ha-year)?
  Same Units as 17.3 end product

- Indicator 17.2; Processing Efficiency;
  “MJ/tonne” - But Ratio = Charcoal (MJ/T)?
  Fuelwood (MJ/T)

- Single year or Moving Average data?

1.4 DATA SOURCES

- Readily accessible on internet, institutions, companies nationwide and by telephone and email: 42 sources cited
  - 57% (2007-2012)
  - 14% (1998-2006)
  - 29% undated
LESSONS : DATA ASSESSMENT

2.1 METHODOLOGICAL APPROACH:
Secondary data:
- International/National/district level reports & literature, telephone interviews /email/internet;
- Physical constants (Calorific value) & conversion factors from standard reference

Primary data:
- Not clear if recommended methods used
- Recommended methods appropriate for Ghana

2.2 CALCULATIONS
- Standard mathematical, material and energy balance calculations necessary;
- Data not directly available for some sub-indicators
LESSONS: DATA ASSESSMENT

2.3 DATA AVAILABILITY

- Requirements generally met (17-80%)
- Deviations – Partially old; one off data; could not confirm data accuracy

2.4 EASE: Easy to collect secondary from internet, documents, Some primary data from personal visits & telephone calls

HISTORICAL: No historic trend data for most; one time estimates/measurements referenced in documents, Trend figures available for fuelwood and charcoal

INSTITUTIONS, MANDATE, CAPABILITIES & RESOURCES:
Energy Commission, Forestry Commission, CSIR, have mandate others don’t; Resources and capacities need to be improved
LESSONS: DATA ASSESSMENT

2.5 DATA QUALITY:
- Accuracy: Except for physical constants, accuracy of some cannot be confirmed.
- Precision: Cannot be established for data.
- Geographical coverage: National surveys were scarce, local/district values assumed for national.

2.6 OVERALL ASSESSMENT
- Usefulness: Very useful (8 rating) for 3 indicators; 4 for one.
- Availability: Concept new (3 to 5).
- Quality: Calculated sub-indicators affected by quality of input data – Quality rating of calculated figures (5 to 7.5).
LESSONS: BASELINE VALUES


- No Sub indicator baseline value established
  - National baseline survey for current authentic datum data
  - Similar to standards; appropriate stakeholder consultations
  - Resolve calculation of averages & data scope
  - Net energy balance calculations problematic
  - Critical route capacity calculations problematic
  - Benchmark values from other countries
Conclusions

• Provides very sound, fundamental and comprehensive framework for bioenergy resource measurement, monitoring and management;

• Possible to extract critical set of indices through factor analysis and other methods;

• Pilot study exploratory/tentative; requires critical review and scale-up studies to:
  – Identify & fill actual data gaps
  – Set up the full matrix of sub-indicator values
  – Simplify the matrix
RECOMMENDATIONS
3.1: IMPROVE DATA USEFULNESS, AVAILABILITY & QUALITY

• Priorities:

  Consistent/Comprehensive data collection; Regular updates for historic trends; Adequate resources: Relevant to Ghana context

• Collection methodology:
  ▪ Best practice data collection strategy and protocol for each sub-indicator to be outlined, agreed and disseminated to stakeholder countries and Organizations;
  ▪ Periodic data collection, update frequency/time to be defined
  ▪ Reference should be made to GBEP methodology but can be simplified
RECOMMENDATIONS
3.2: IMPROVE DATA USEFULNESS, AVAILABILITY & QUALITY

- Human/Institutional Capacity:
  - Define data collection needs clearly & comprehensively
  - Clearly identify and mandate data collection Institutions;
    Eg Ghana Statistical Service, Energy Commission, EPA, MEST, CSIR, Universities
  - Train staff in data collection techniques, protocol and equipment use
RECOMMENDATIONS

- Technology/Equipment required:
  - Identify and approve appropriate equipment and instruments for data collection;
  - Ensure uniformity and comparability for accuracy

- Policy/regulatory changes:
  - Review existing policy, regulatory framework and mandate of identified data collection institutions
  - Modify appropriately to accommodate new objectives for sub-indicators

- Financial resources:
  - Detailed financial requirement to be done by cost centre for each sub-indicator by consultants/appropriate institutions
  - Stakeholders to provide resources
Next steps

• CSIR-IIR desires to extend Indicator study:
  - Critical review of GBEP pilot steps covering all 8 indicators in Environment Pillar, identify & confirm all data gaps
    – map out situational analysis with authentic primary data (include energy diversity indicator);
    – Establish indicator bench-mark values for Ghana;
  – Local evidence based comparative advantages among conversion pathways, energy /food crops, waste stream bio-feedstocks
    – Integrate indicator studies into on-going IIR projects
      ❖ 2nd Generation Biofuels Project
      ❖ Sustainable Products from Waste Project
  – Collaborative comparative ECOWAS country studies
Thank you.