BEFS
Bioenergy and Food Security Projects

# The Bioenergy and Food Security Approach of FAO

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RENEWABLE ENERGY TRAINING PROGRAM , MODULE 8 | BIOENERGY
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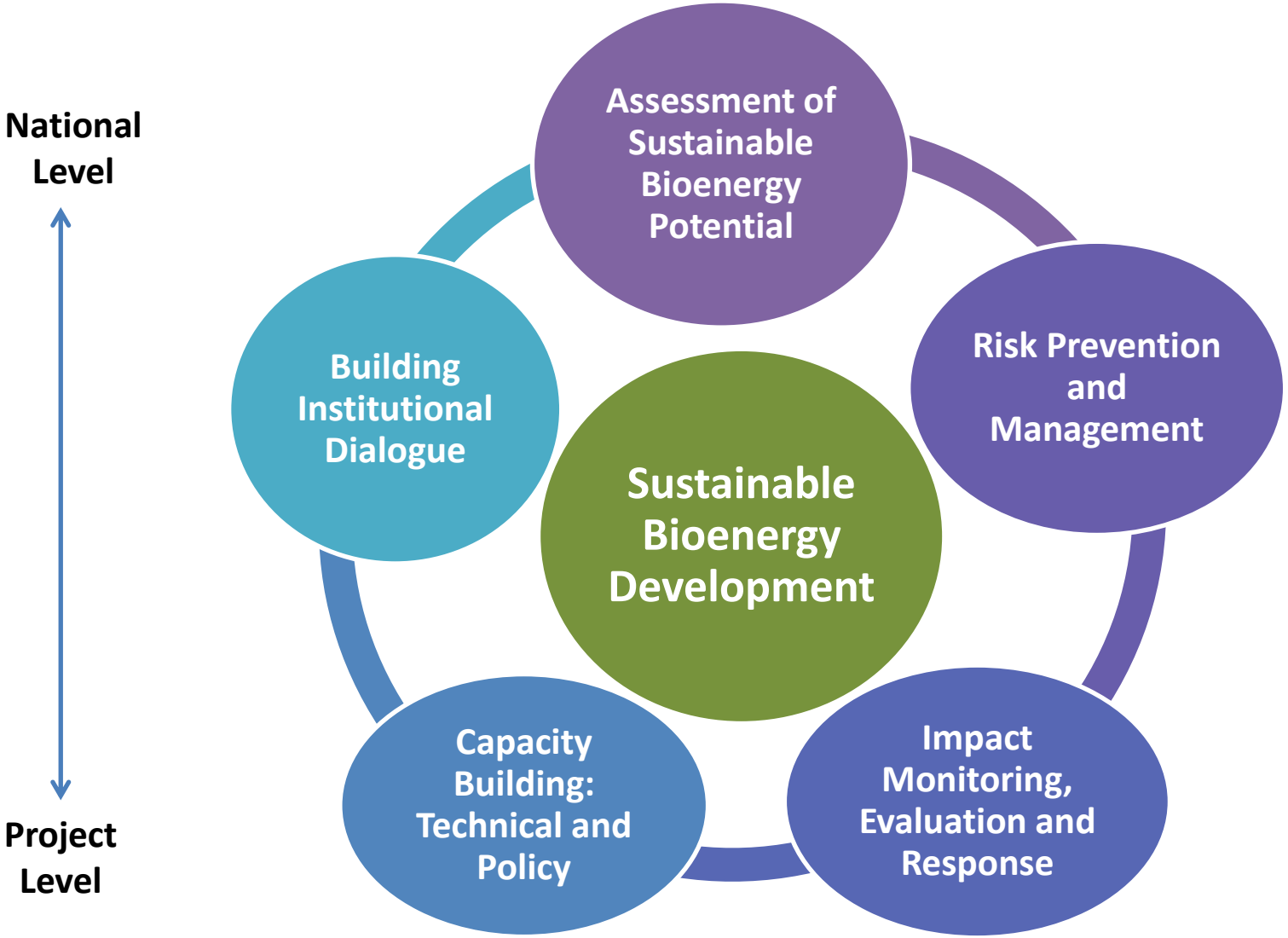
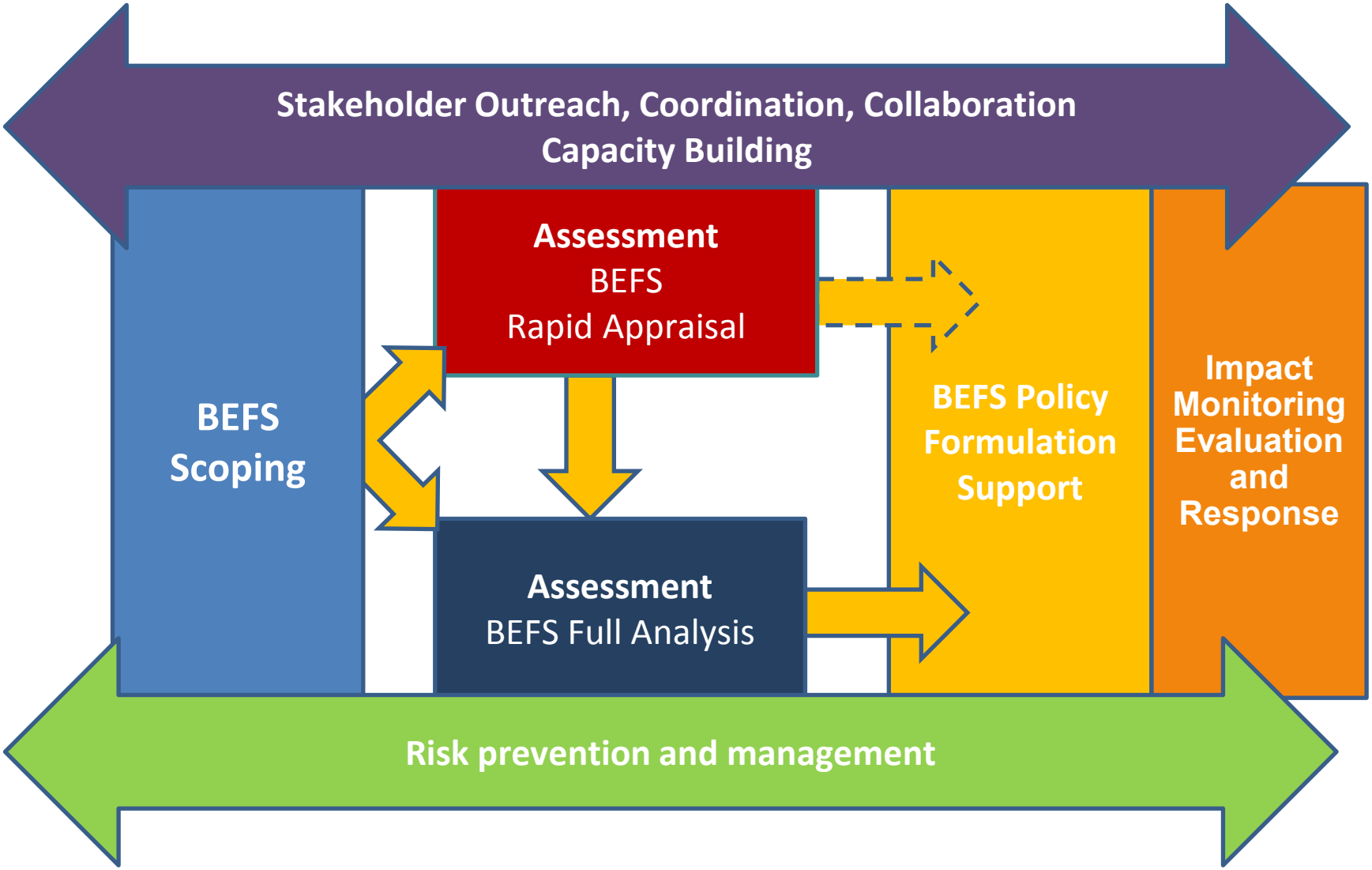
# Outline

- The BEFS Approach
- The BEFS Analytical Framework
- BEFS Operator Level Tool

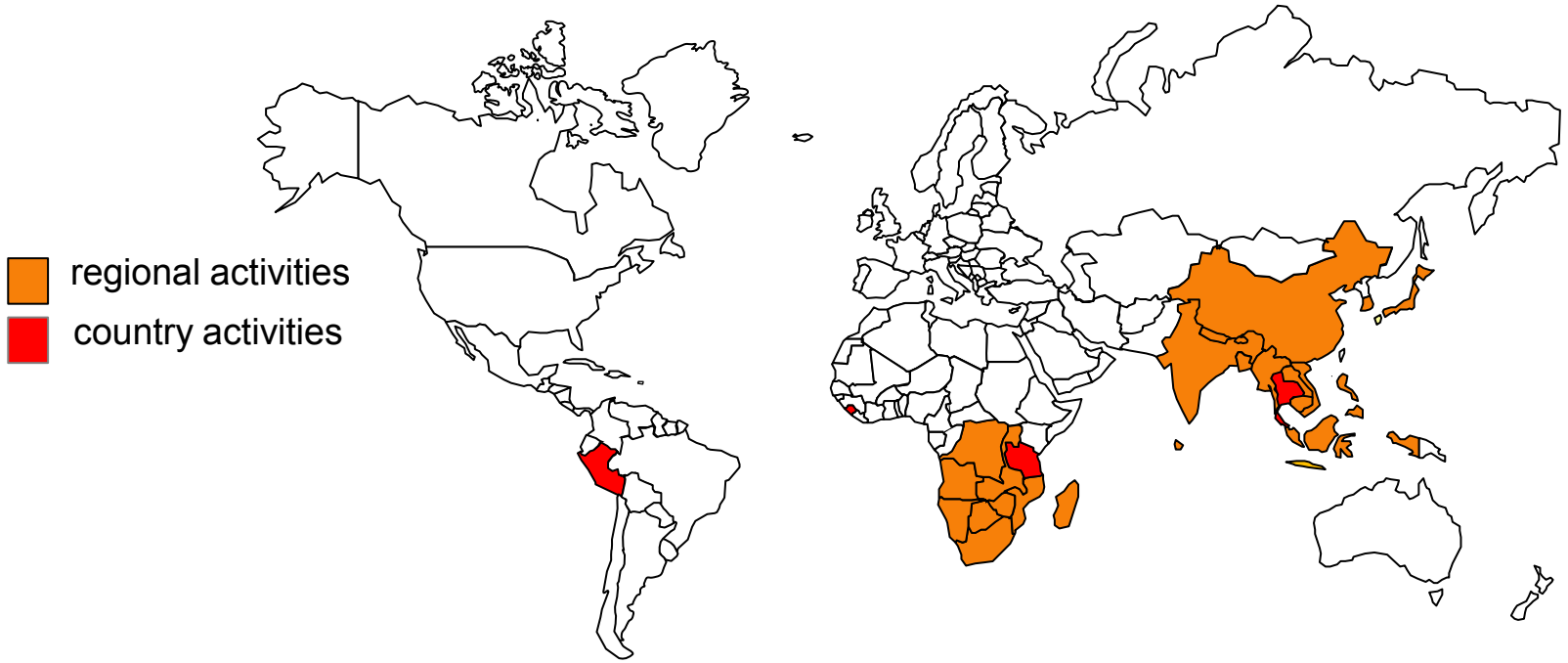
# Sustainable Bioenergy Development: What is needed
# The BEFS Approach



# BEFS Approach: Components

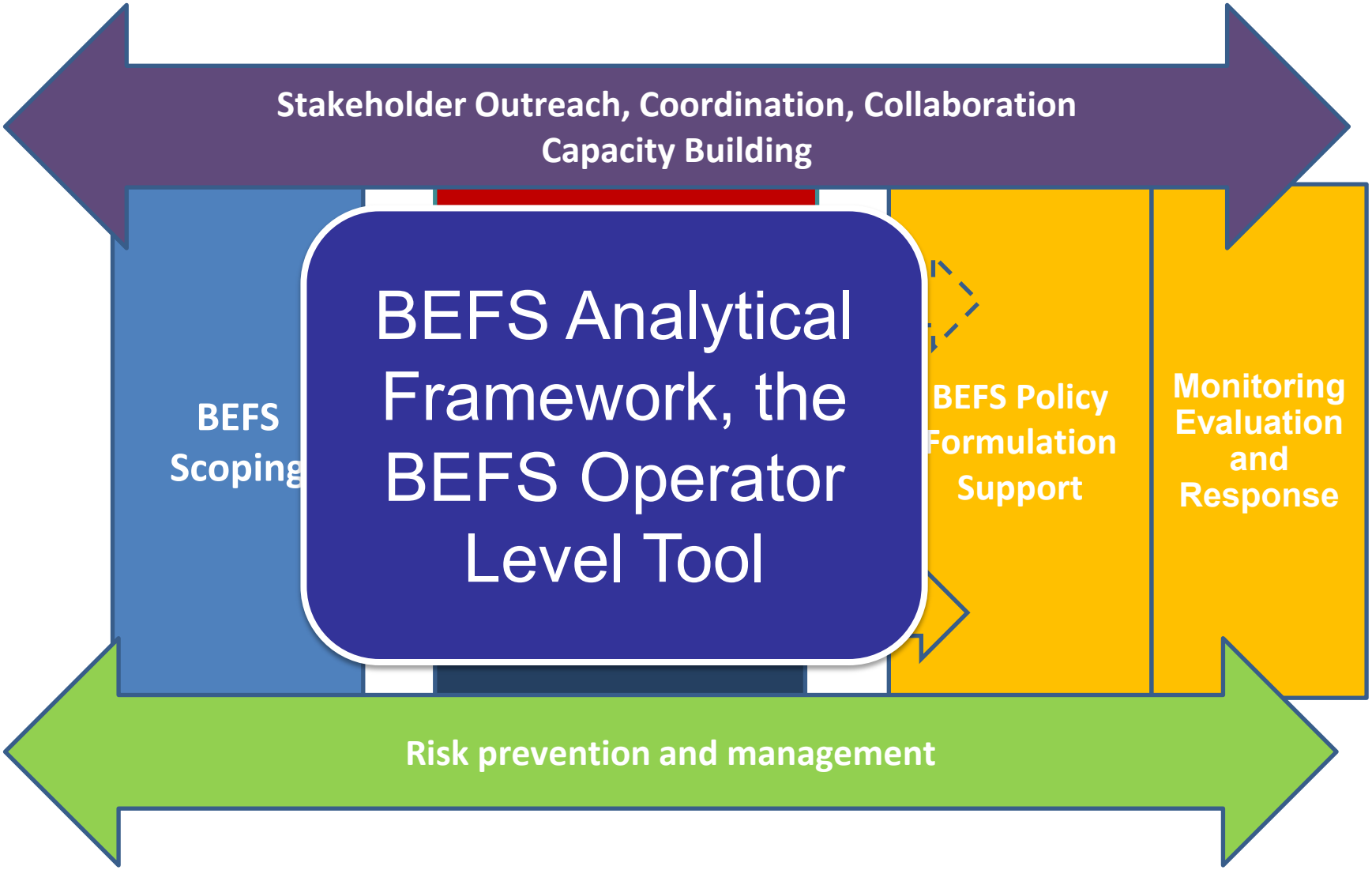


# BEFS country work to date




| BEFS Activities | Countries |
|---|---|
| Detailed BEFS Analysis | Peru, Tanzania, Thailand |
| Scoping activities | Sierra Leone, Malawi (starting now), Nepal, Butan, Sri Lanka |
| Regional activities | SADC, ASEAN |
| Pending country requests | Botswana, Zimbabwe, Indonesia, Bolivia, follow up Sierra Leone |

# BEFS Approach: Components



# The BEFS Analytical Framework
# Country level evidence

**Diagnostic Analysis**

- What is the current agricultural baseline?
- What is the current agricultural market outlook?

**Natural Resources**

- What is the feedstock availability for bioenergy in country? Crops, livestock and forestry…
  - Resource availability and constraints?

**Techno-economic aspects**

- Can biofuels be produced profitably and competitively?
- To what degree can smallholders be involved?
  - What might the tradeoffs be?
- Greenhouse gas emissions

**Socio-economic aspects**

- What are the national level impacts? Labour, growth, poverty?
- What are the household level impacts and who are the vulnerable?



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# Starting point: which are the key crops and feedstock within the country?

- Country specific analysis and data
  - Food security crops
  - Potential bioenergy feedstock
    - Crops
    - Woody biomass
    - Residues (crops, agroprocessing, livestock and forestry)

# Starting point: Tanzania

- **Food security** staples:
  **Maize** (33.4 %) and **Cassava** (15.2 %)

- **Potential bioenergy crops**

  Sugar cane, molasses, sweet sorghum, **cassava**, palm oil, sunflower, jatropha

| Ranking | Commodity | Calorie Share (%) |
|---|---|---|
| 1 | Maize | 33.4 |
| 2 | Cassava | 15.2 |
| 3 | Rice (Milled Equivalent) | 7.9 |
| 4 | Wheat | 4.0 |
| 5 | Sorghum | 4.0 |
| 6 | Sweet Potatoes | 3.3 |
| 7 | Sugar (Raw Equivalent) | 3.3 |
| 8 | Palm Oil | 3.0 |
| 9 | Beans | 2.9 |
| 10 | Beverages, Fermented | 2.7 |
| 11 | Milk – Excluding Butter | 2.2 |
| 12 | Bovine Meat | 1.8 |
| 13 | Pulses, Other | 1.7 |
| 14 | Plantains | 1.5 |
| 15 | Millet | 1.4 |
| Subtotal share for selected items | | 88.5 |
| Total Calories per capita | | 1959 |

Data source: FAOSTAT

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# Starting point: Peru

- **Food security** staples:
  Rice, maize, wheat and potatoes

- **Potential bioenergy crops**

| Ranking | Commodity | Calorie Share (%) |
|---|---|---|
| 1 | Rice (milled equivalent) | 22 |
| 2 | Maize | 13.2 |
| 3 | Wheat | 11.7 |
| 4 | Potatoes | 9.9 |
| 5 | Sugar (raw equivalent) | 8.5 |
| Subtotal share for selected items | | 65 |
| Total Calories per capita | | 2 595 |

Data source: FAOSTAT

# The BEFS Analytical Framework
# Country level evidence

Natural Resources

- What is the feedstock availability for bioenergy in country? Crops, livestock and forestry…
  - Resource availability and constraints?

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# The BEFS Analytical Framework

*Natural Resources Assessment*

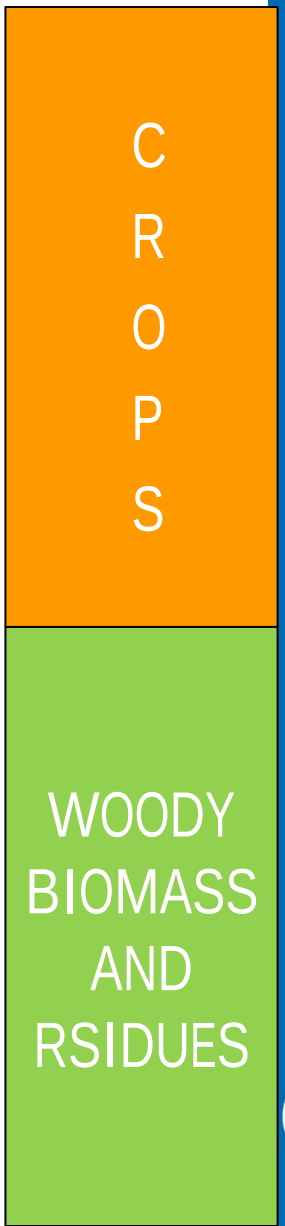
This component covers three major areas:

1. Land suitability
2. Water availability
3. Woody biomass and residues availability

# The objective

- Which **crops** for bioenergy production can be grown under the prevailing agro-ecological conditions?
- What is the current domestic production of these crops?
- How much additional bioenergy feedstock can be produced through intensification of agricultural production?
- How much additional bioenergy feedstock can be produced through expansion of arable land, when accounting for sustainability criteria?

- How much **fuelwood** can be supplied sustainably?
- How much **residue from current agricultural production (crop, livestock production, forestry)** is available to produce bioenergy, taking into account other uses?
- How much **residue from agro-forestry industries** is available for bioenergy production, taking into account other uses?

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# The BEFS Analytical Framework

*Natural Resources Assessment*

This component covers three major areas:

1. Land suitability
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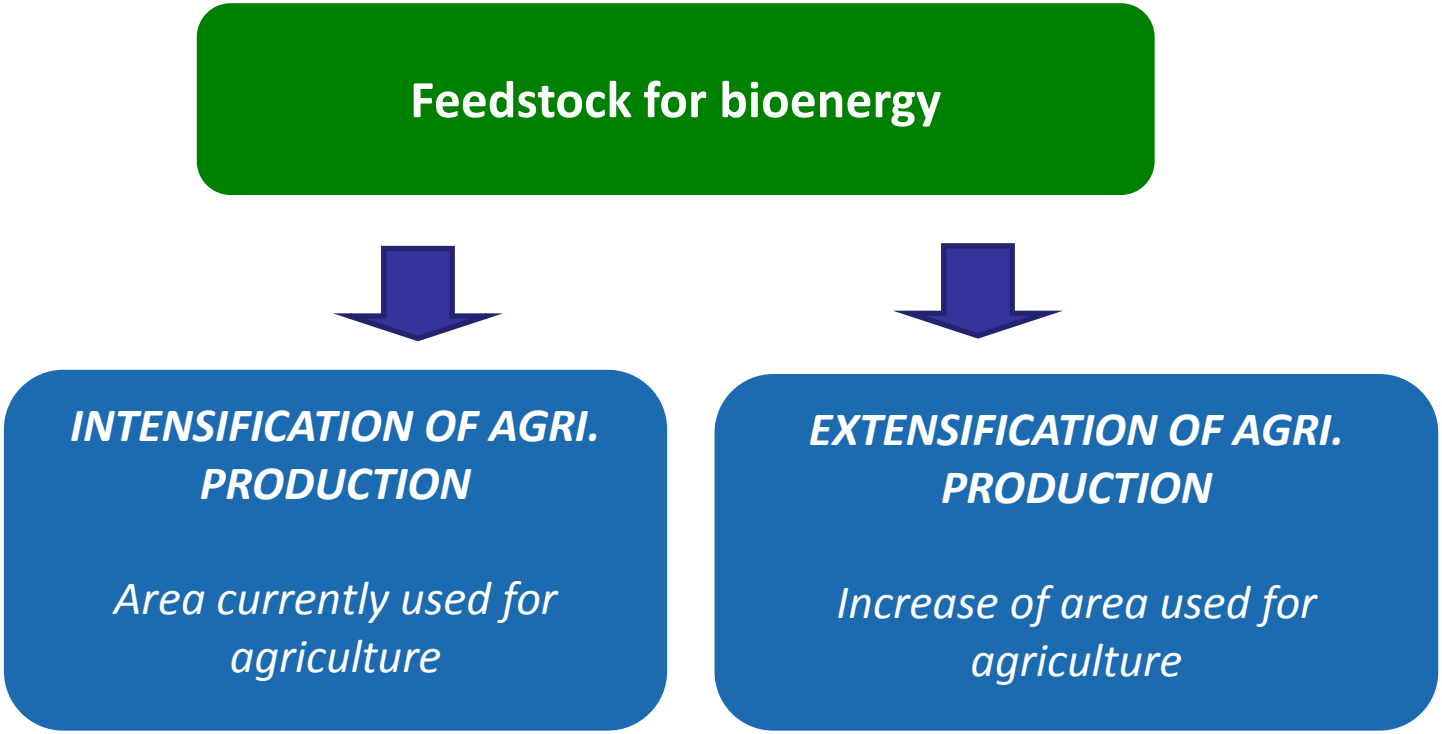
# Assessment of potential for bioenergy crops production




***Methodology applied:***
***Land Suitability Assessment (LSA)***

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# Land Suitability Assessment (LSA)

*The methodology concept*

***Agro-ecological zoning (AEZ)***

| *Geospatial and numerical data* |
| --- |
| - Land characteristics<br>- Crop requirements<br>- Agricultural practice and level of inputs |

***Land availability assessment***

| ***DEFINITION OF AVAILABILITY CRITERIA*** |
| --- |
| - Land cover<br>- Land use (current and future demand)<br>- Policy priorities |

**Land suitability maps**
(potential yields for suitability classes)

**Exclusion mask**

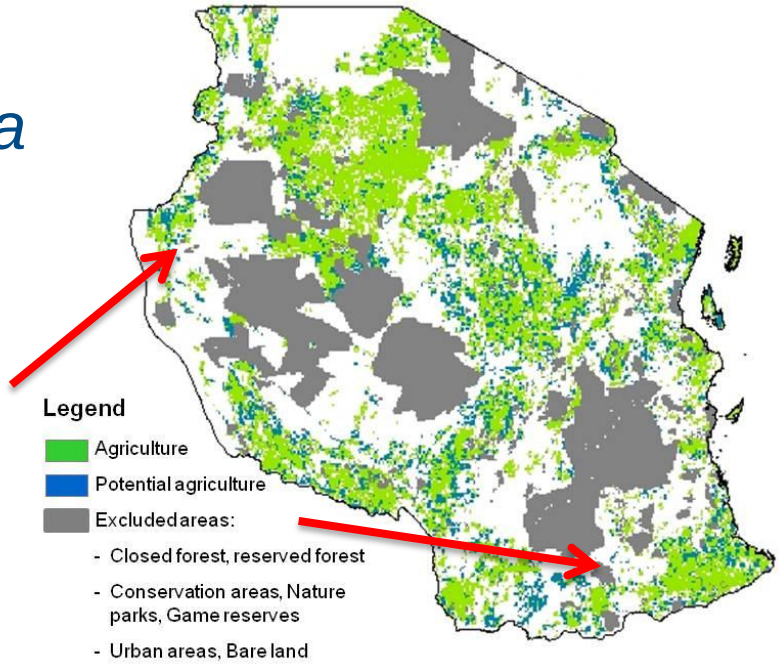
***FINAL OUTPUT***

- ***Land suitability and availability maps***
  - how much bioenergy feedstock can be produced
  - how much land is available and where it is

# Intensification

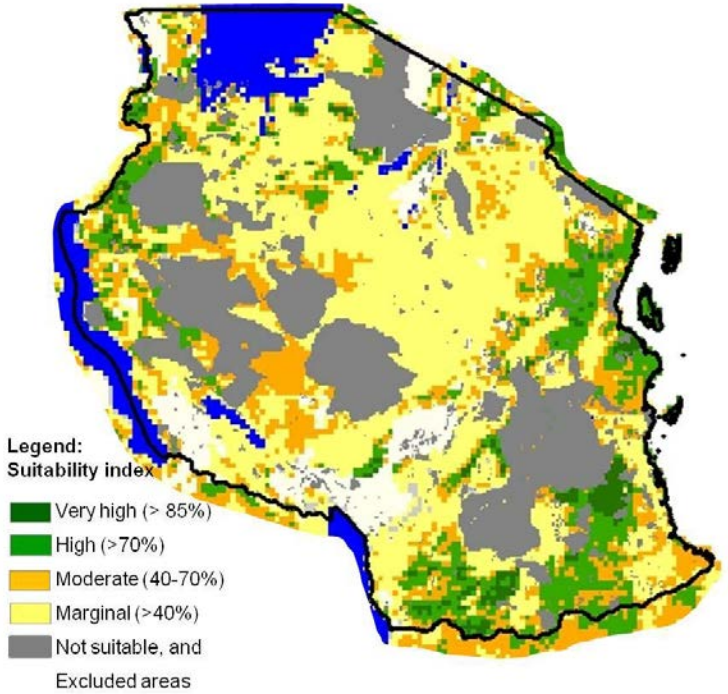
## *Example: Cassava in Tanzania*

- food crop
- accounts for 15%  per capita calorie consumption
- produced with no or very low inputs (subsistence agriculture)
- production areas:
  NW and SE parts of the country
- total harvested area: 841,868 ha
- average yield (10y): 6 t/ha
- average annual production: 5 mill. t




***Agro-ecological suitability and productivity (GAEZ):***

| *Level of inputs* | Potential yield (t/ha) |
|---|---|
| *- Low* | 7 |
| *- Intermediate* | 11 |
| *- High* | 18 |

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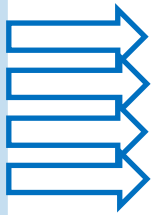
# Expansion of arable land

*Example: Cassava in Tanzania*

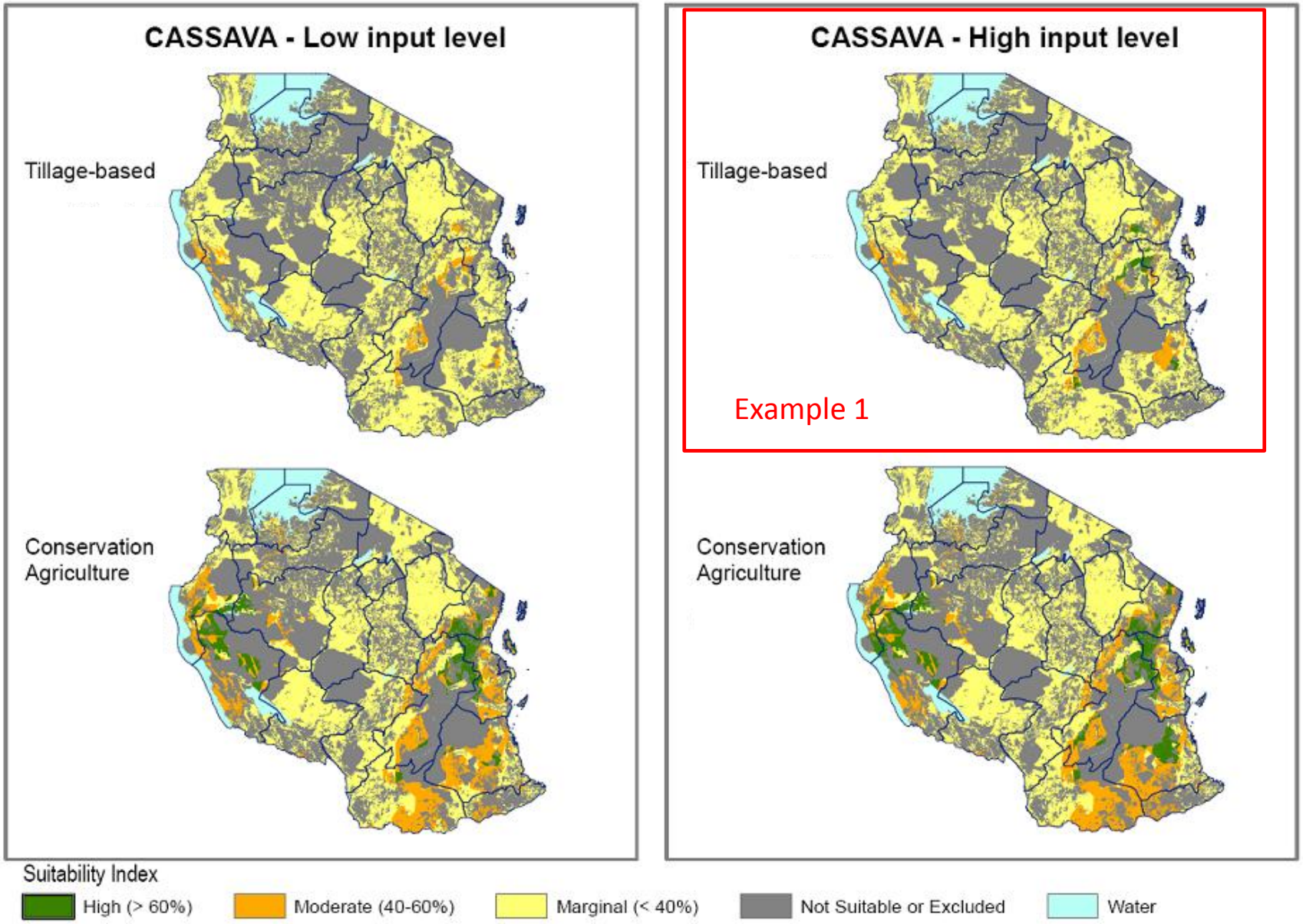
| *LAND AVAIALABILITY ASSESSEMNT* |
|---|
| ***Exclusion areas*** |
| - Agriculture and potential agriculture<br>- Closed forest, reserved forest<br>- Conservation areas, natural parks<br>- Game reserves<br>- Urban areas<br>- Bare land |

| *AGRO-ECOLOGICAL ZONING* | |
|---|---|
| ***Agri. practice*** | ***Input level*** |
| 1. Tillage-based | / Low inputs |
| 2. Tillage-based | / High inputs |
| 3. Conservation agri. | / Low inputs |
| 4. Conservation agri. | / High inputs |
| Rain-fed conditions | |



***Land suitability maps***

# Land suitability and availability maps for cassava



# Expansion of agricultural land - cassava in Tanzania
*Example 1*

| LUT | Highly suitable land | | | Moderately suitable land | | |
|---|---|---|---|---|---|---|
| | Area (Mil ha) | | P. Yield | Area (Mil ha) | | P. Yield |
| ***TA - H*** | 1.7 | 43% | ≈ 25.7t/ha | 2.3 | 57% | ≈ 21.4 t/ha |

- Increase of the total harvested area by ***2% (≈17.000 ha)***
- Improvement in agricultural production to ***high input level production***

| **Expansion of agri. land** | | |
|---|---|---|
| **Baseline** | **Land use** | **Cassava production** |
| | **000 ha** | **million tons** |
| ***Cassava production area*** | 842 | 5 |
| **Scenario 1** | **ha** | **t** |
| **Additional land under cassava** | 17 | 0.4 |
| **Total (current + expansion)** | **859** | **5.4** |
| ***Increase in total production*** | | **8%** |

| **Potential bioethanol production** | |
|---|---|
| 1 t of cassava ∽184 l bioethanol | |
| **% of additionally produced cassava** | **bioethanol million liters** |
| 100% | **72** |
| 70% | **50** |

# The land suitability assessment provides

- **information on:**
  - the existing yield gaps and potential results of intensification of agricultural production,
    - which is needed for assessment of costs required to achieve higher yields
  - the potentially available land for extensification of agricultural production and the level of suitability for bioenergy feedstock production,
    - which is used for land use planning

- **baseline for:**
  - the assessment of water availability and sustainability of water use
  - techno-economic and socio-economic analysis of bioenergy development options

# The BEFS Analytical Framework

*Natural Resources Assessment*

This component covers three major areas:

1. Land suitability
2. Water availability
3. Woody biomass and residues availability

# Assessment of woody biomass potential

- Biomass assessed
  - **Fuelwood**
  - **forestry residues**
  - **wood processing residues**
  - **agricultural residues**

- Methodology applied: **WISDOM**
  **The Woodfuel Integrated Supply/Demand Overview Mapping**

- Objective
  - to combine existing data and to provide new relative/qualitative values in order to assess the current situation
  - to identify priority areas for action
  - to serve as a tool for strategic planning

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# WISDOM:

## 1 . Selection of spatial base

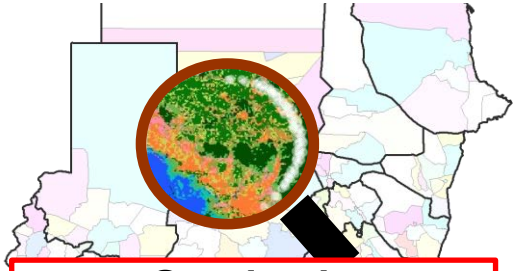
- Pixel level
- Sub-national level

## 2. DEMAND module

*Woody-biomass consumption*

- Type
  - energy, non-energy
- Sector
  - households, commercial, industry
- Area
  - population mapping
  - urban, rural

….



**Geodatabase**

1 - … - … - … -
2 - … - … - … -
3 - … - … - … -
…
n - … - … - … -

## 3. SUPPLY module

*Woody-biomass availability*

- Forestry
  - Land cover (land use)
  - Annual increment / sustainable cut
  - Forestry residues
- Non-forest trees
- Residues from crop production
- Residues from processing industry
- Accessibility (physical, legal)
- ….

## 4. INTEGRATION module

- supply / demand balance
- deficit / surplus areas
- socioeconomic aspects
- …

## 5. Priority areas

- Commercial supply potential
- Supply zones delineation (biosheds)

***=> POLICY SUPPORT***

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# WISDOM
## *Example: Peru*

**1. Spatial base:**

- Province (194 provinces)

**2. Demand Module:**

- Residential, Commercial and Industrial
- *Input data: census, regional energy surveys, official statistics*

**3. Supply Module:**

*(Input data: raster cell size 250m X 250m / 6.25 ha)*

- Natural forest and forest plantations
  - sustainable harvest, physically and legally accessible
- Crop residues: corn, rice, sugarcane, cotton, asparagus, olives
- Residues from industrial processing:
  sawmills, cotton and rice mills, sugarcane and olive oil industries.

# Peru: Demand Module

- ***Residential***

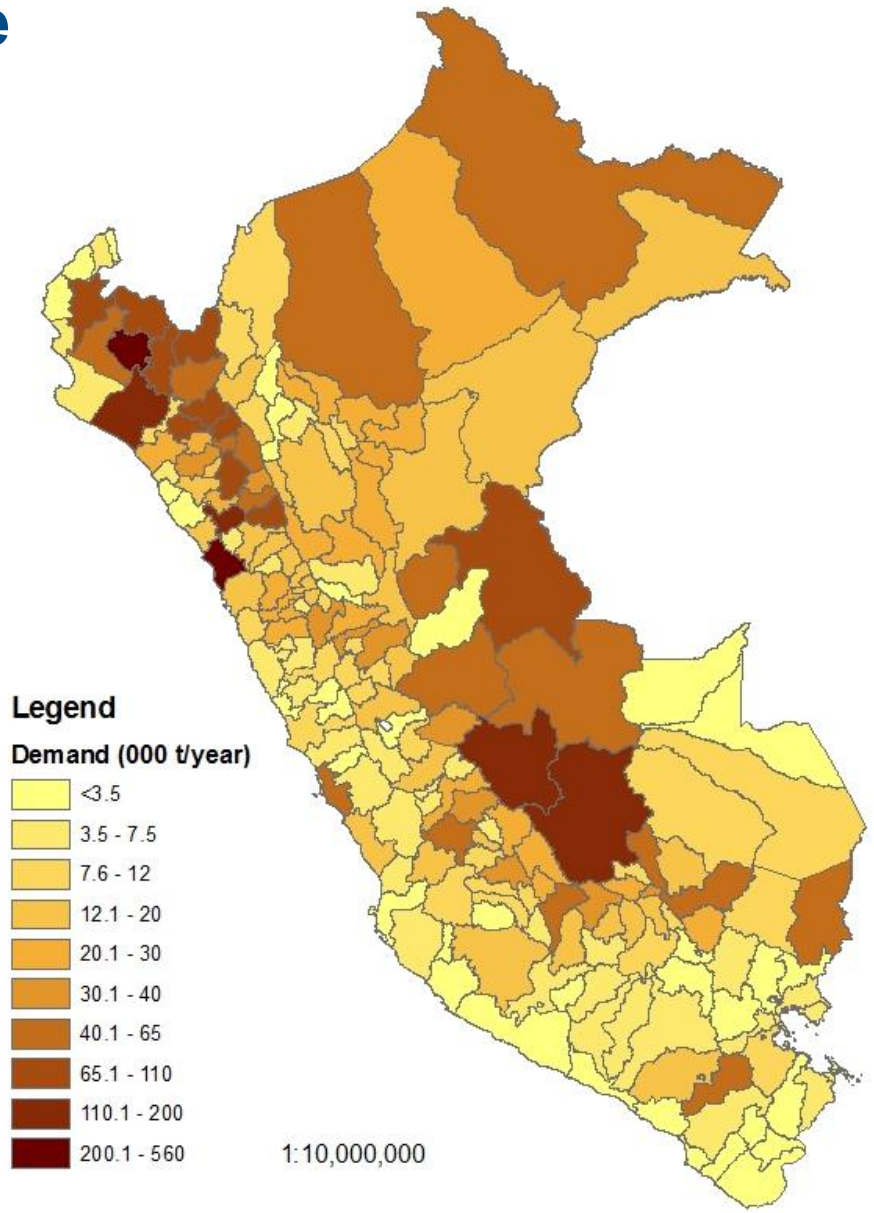
  Household cooking and heating

- ***Commercial***

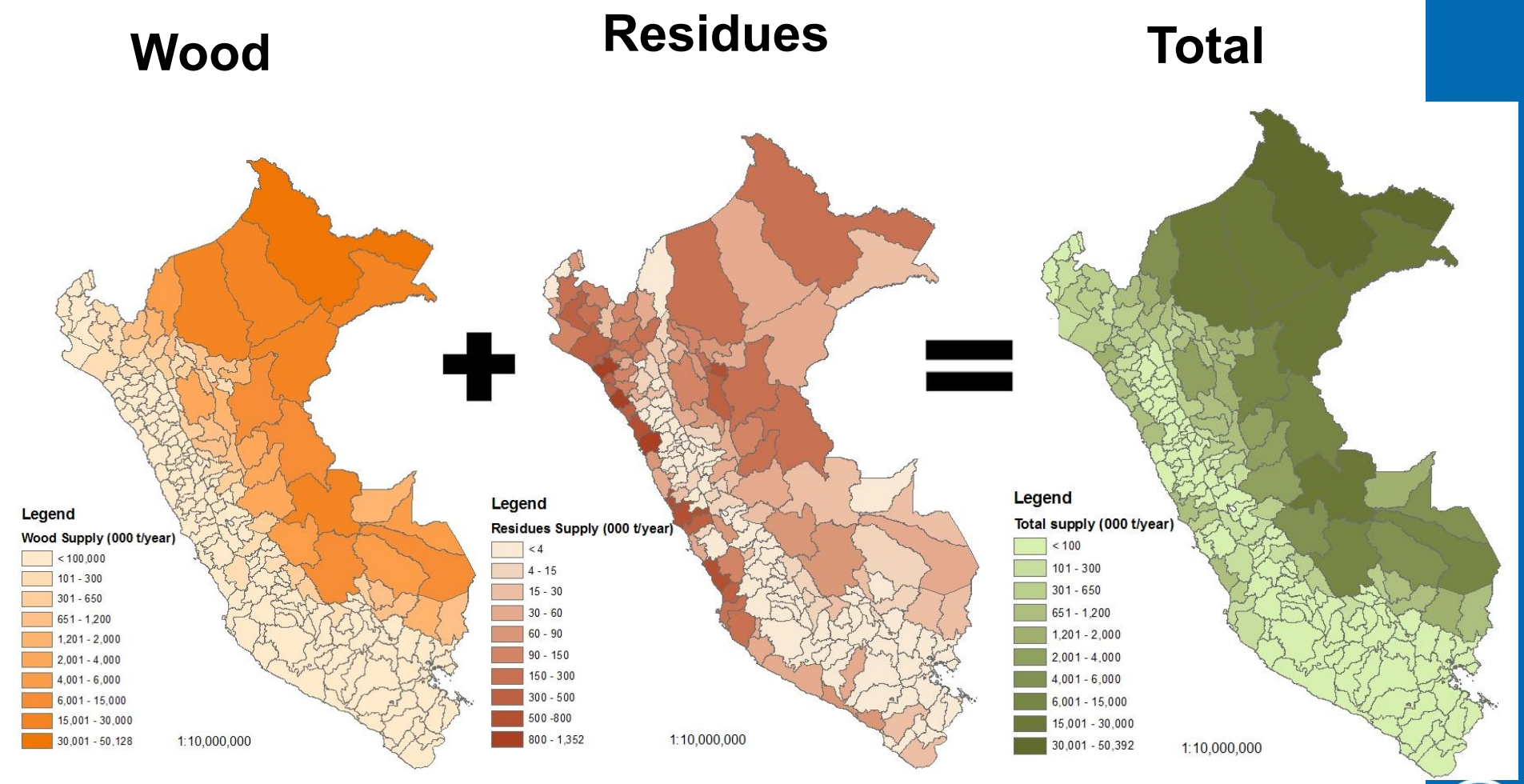
  Hotels and restaurants

- ***Industrial***

  not available

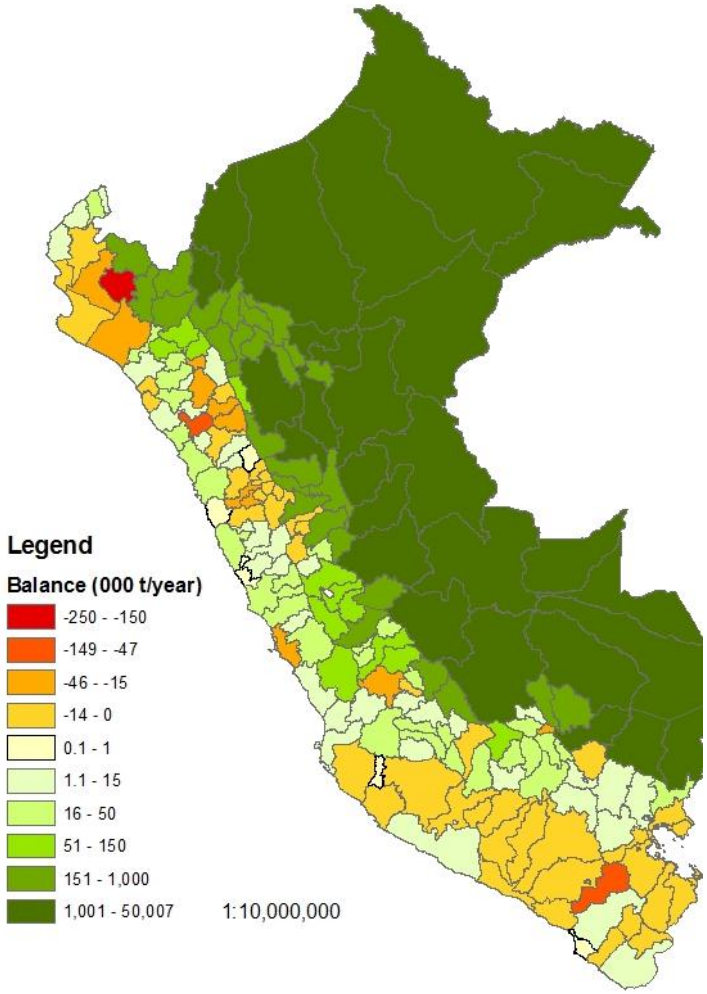


# Peru: Supply Module



# Peru: Integration module

**Woodfuel Balance**
**= Wood Supply — Demand**




- Woodfuel and charcoal are the main energy sources
  (11% of total domestic energy supply)
- 56 provinces (of 194 in total) have deficit in supply
- Highest deficit:
  - Coastal area and Sierra highlands

- Taking into account indirect biomass generated from residues from field crops, agro-industry, and wood processing industries in the analisys, the biomass balance of some areas improves

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# Concluding remarks

## *Natural Resource Assessment*

- The essential **starting point** for analyzing the opportunities and risks associated with bioenergy production and use
- Outputs:
  - potential production of biomass under the prevailing agro-ecological conditions (water, climate, soil type, land cover)
  - potentially available biomass for bioenergy production, taking into consideration existing and future competing uses of natural resources
  - identification of existing and potential constraints for production of biomass for bioenergy
  - identification of potential risks and benefits arising as a result of bioenergy production
- Baseline for:
  - assessment of technical and economic viability of bioenergy production
  - assessment of environmental and social sustainability.

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# The BEFS Analytical Framework
# Country level evidence

**Techno-economic aspects**

- Can biofuels be produced profitably and competitively?
- To what degree can smallholders be involved?
  - What might the tradeoffs be?
- Greenhouse gas emissions

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# The BEFS Analytical Framework
## Technoeconomic Assessment

The technoeconomic assessment covers two major areas:

1. Production cost
2. Greenhouse gases

# Technoeconomic analysis
# Objectives

- Which bioenergy processing technologies are viable?
- Can bioenergy be produced economically?
  - at which scale?
  - to what extent can smallholders be included in bioenergy supply chains?
- How does the cost of bioenergy compare to that of fuel alternatives in the country?
- Can domestically produced bioenergy be cost competitive on international market?

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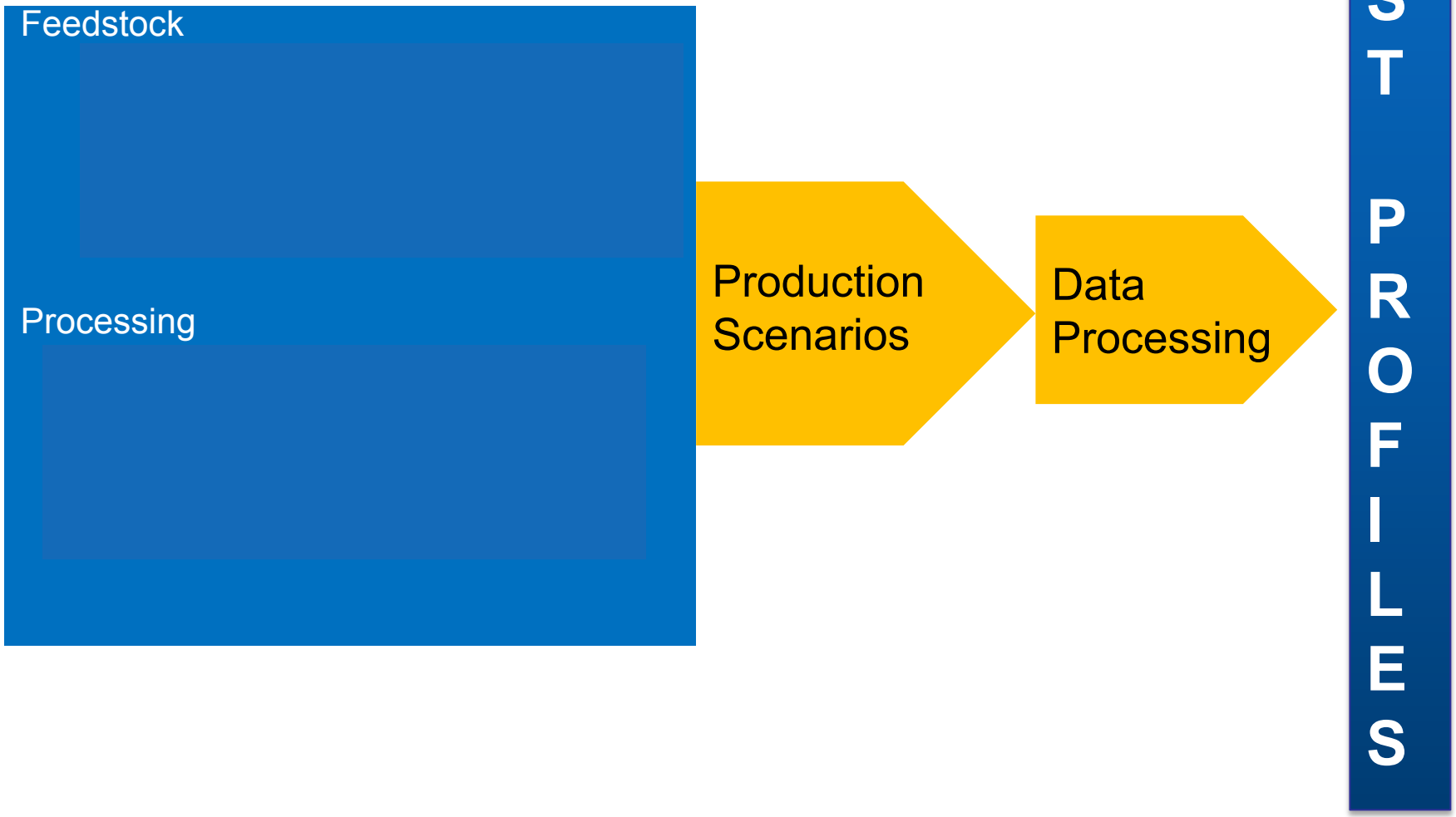
# Methodology

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# Techno-economic assessent:
## Cassava Ethanol in Tanzania

- **Potential bioenergy crops covered are:**
  Sugar cane, molasses, sweet sorghum, **cassava**, palm oil, sunflower, jatropha

- Based on the results from the natural resources assessment, then the questions are: ....

  - *Can the ethanol be produced profitably?*

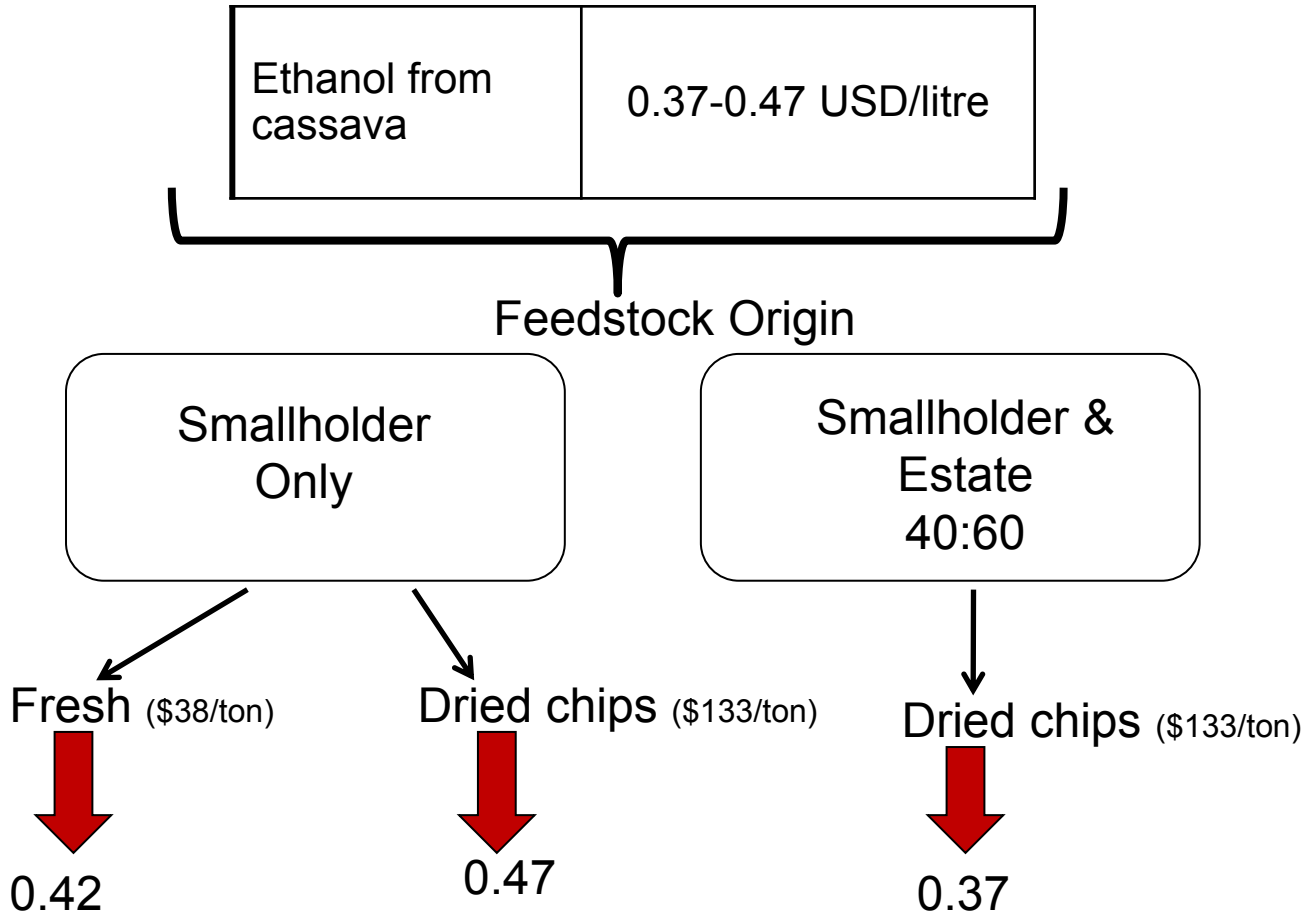
  - *Can the ethanol be profitable with smallholders participation?*

# Tanzania Ethanol from Cassava: Scenarios

| Scenario | Origin Feedstock | Biofuel | Market |
|---|---|---|---|
| 1 | Smallholder 100% | Ethanol 53 million liters/year Feedstock @ plant fresh | Supply 10% domestic blending mandate |
| 2 | Smallholder 100% | Ethanol 53 million liters/year Feedstock @ plant dry chips | Supply 10% domestic blending mandate |
| 3 | 40% smallholder 60% estate | Ethanol 101 Million liters/year Feedstock plant dry chips | Both domestic Supply 10% blending mandate and potential for export market |

# Tanzania Cassava Ethanol Production Cost

## Results




How it compares with ethanol-cassava production in other countries?

In 2010:

Thailand and Vietnam is around 0.34 to 0.40 USD per liter

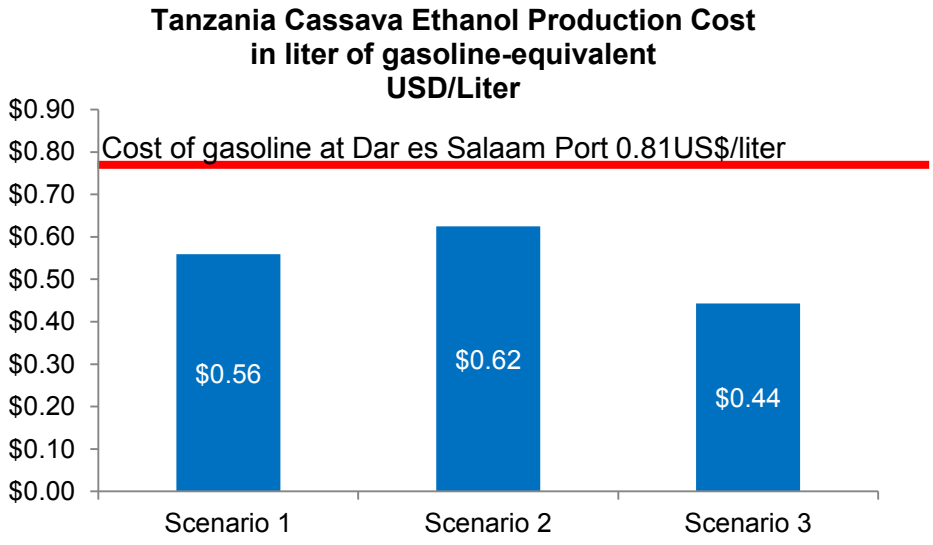
Brazil ranges from 0.45 to 0.47 USD per liter

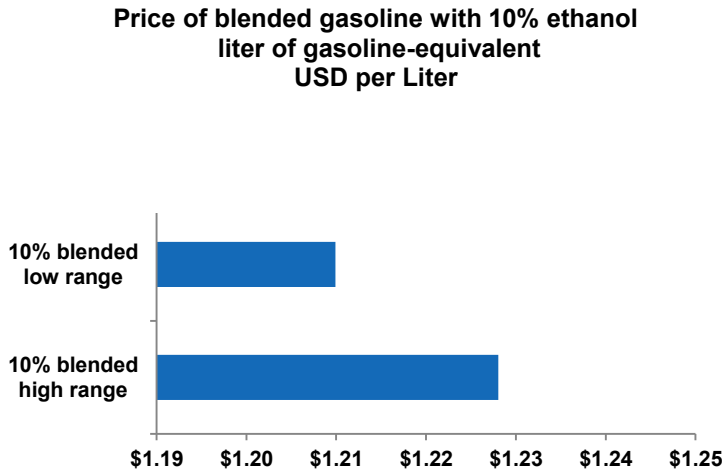
India is around 0.65 USD per liter

# Tanzania Cassava Ethanol: How can the results be used to inform policy?

## Domestic market:

How does the ethanol compete with gasoline in the country?



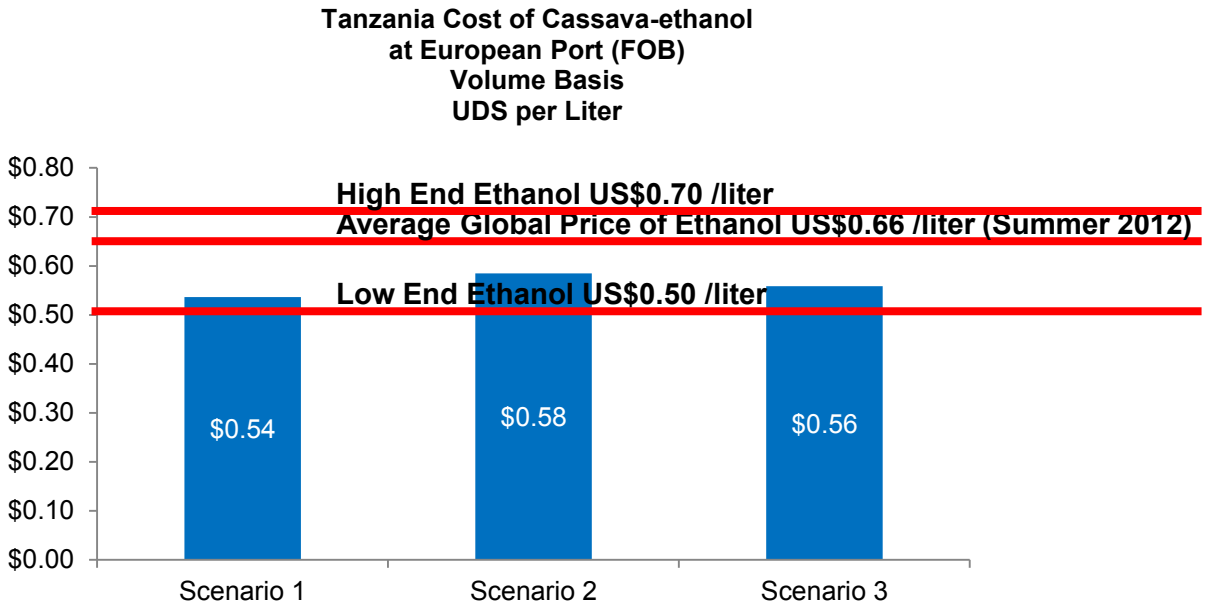




The production costs are in liter of gasoline-equivalent to reflect the less energy content in 1 liter of ethanol when compare to gasoline.
**In estimating the price of a blended liter of gasoline with 10% ethanol, all taxes, charges and fees of about 0.44 USD/Liter applicable to gasoline were applied to ethanol.

# Tanzania Cassava Ethanol: How can the results be used to inform policy?

## Ethanol export market to EU

Cost at EU port: Production cost + local transport + shipping

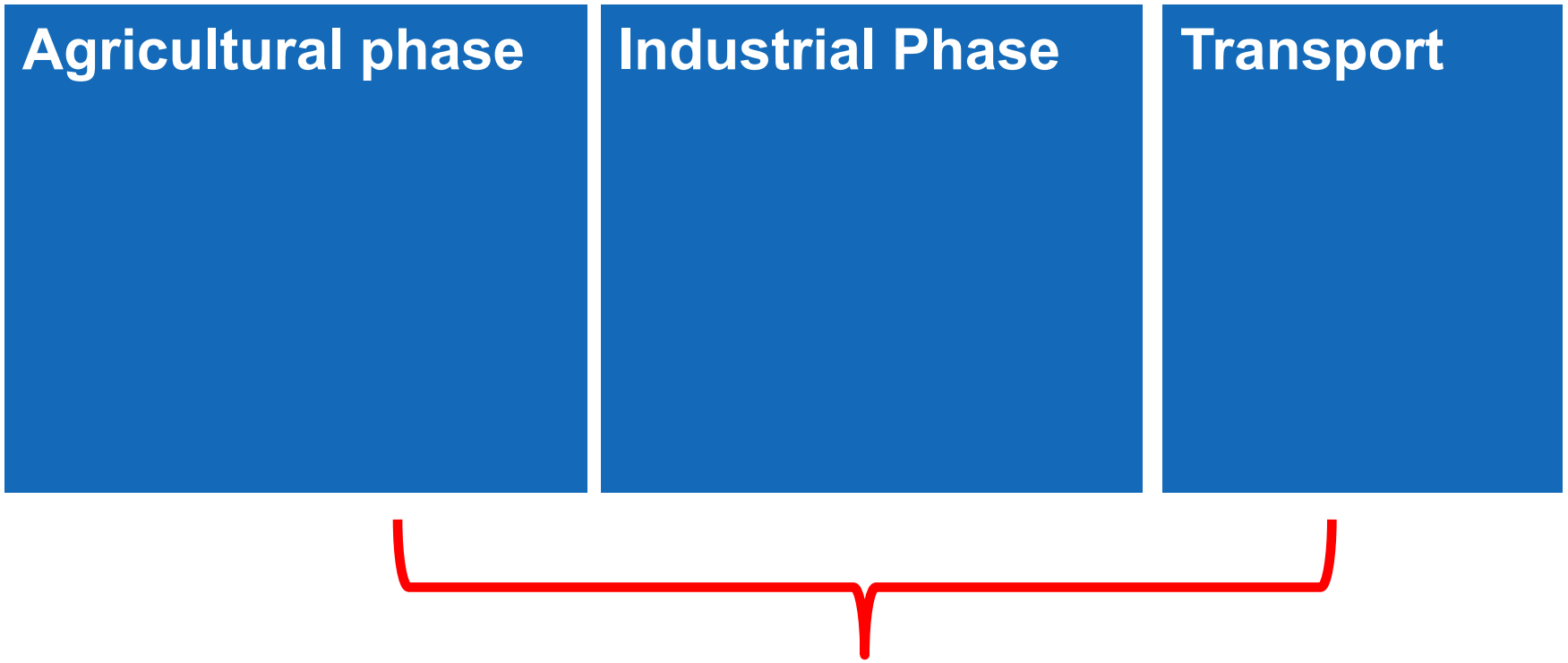


# Greenhouse gas emissions Objective

- Which bioenergy feedstocks, management practices and processing technologies can deliver the largest greenhouse gas emission savings?

- Can the biofuel meet national GHG sustainability criteria or for importing markets?

# Methodology




**Total emissions for biofuels**

Agriculture + Industrial + Transport of feedstock & Biofuel

# Net Agricultural Emissions

***This option is a Source***

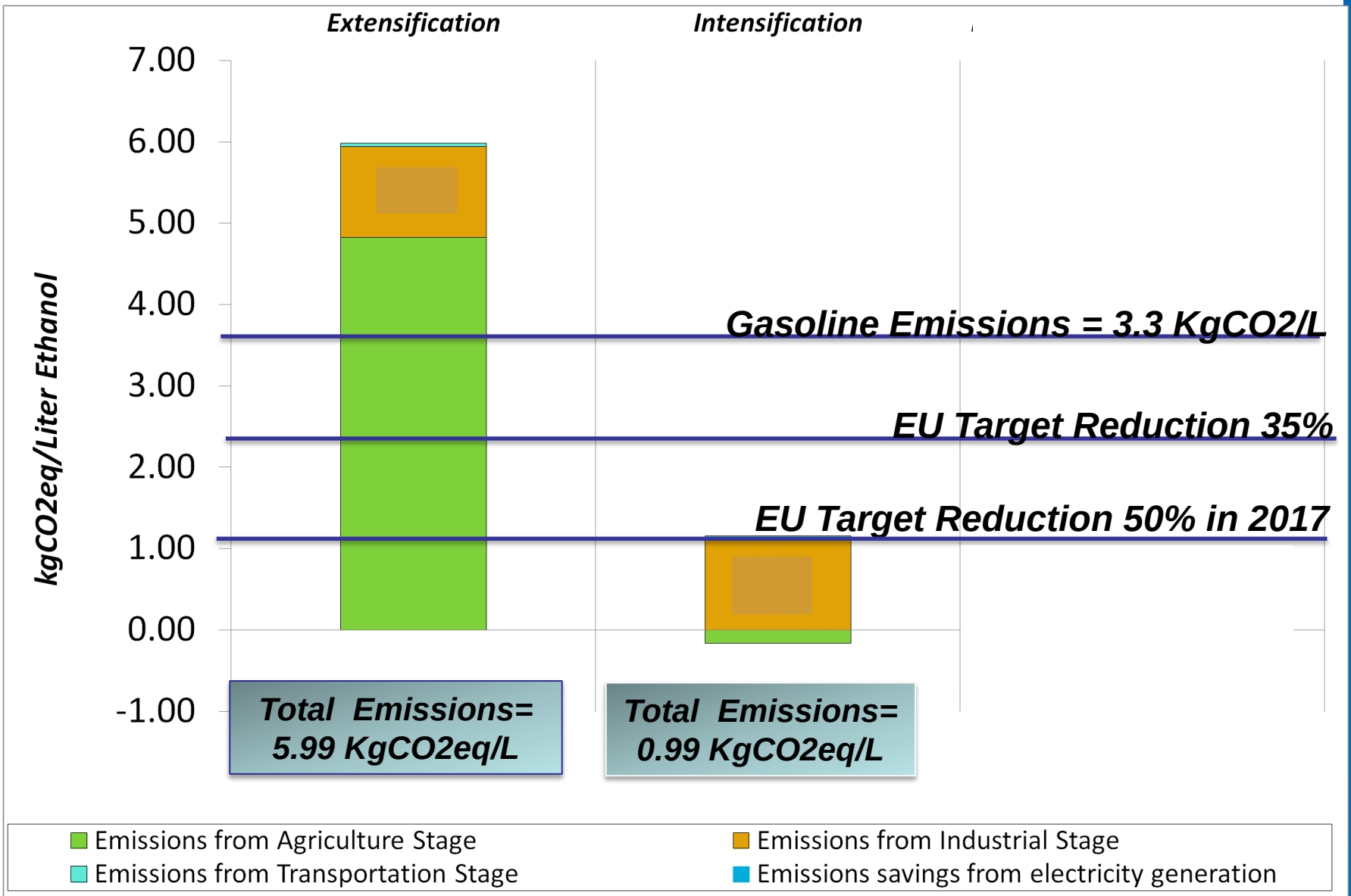
***This option is a Sink***

**kgCO2eq/Liter Ethanol**

6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00

***Extensification*** ***Intensification***

# Total GHG emission and sustainability implications



# Results

Under the scenarios studied, cassava ethanol:

- Could be competitive with smallholder participation but yields will have to improve
- Can compete with gasoline in the domestic market
- Global prices for ethanol may not be sufficiently high to make it competitive for export
- Generation of GHG emissions requires careful planning in both feedstock and industrial processing to find most sustainable alternative

# The BEFS Analytical Framework
# Country level evidence

Socio-economic aspects

- What are the national level impacts? Labour, growth, poverty?
- What are the household level impacts and who are the vulnerable?



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# The BEFS Analytical Framework
## Socioeconomic analysis

- Economywide impacts (*long run*)
- Household level impacts and vulnerability (*short run*)

# Economywide effects

## Objectives

Allows to, in the longrun, account for economywide **linkages** and Identify **trade-offs** between growth, poverty and food security

- Will establishing a biofuels sector stimulate economic growth?
- Which feedstock is the most effective at generating national economic growth and poverty reduction?
- What is the preferred combination of large-scale estate and small-scale outgrower schemes?
- What are the impacts on production factors?

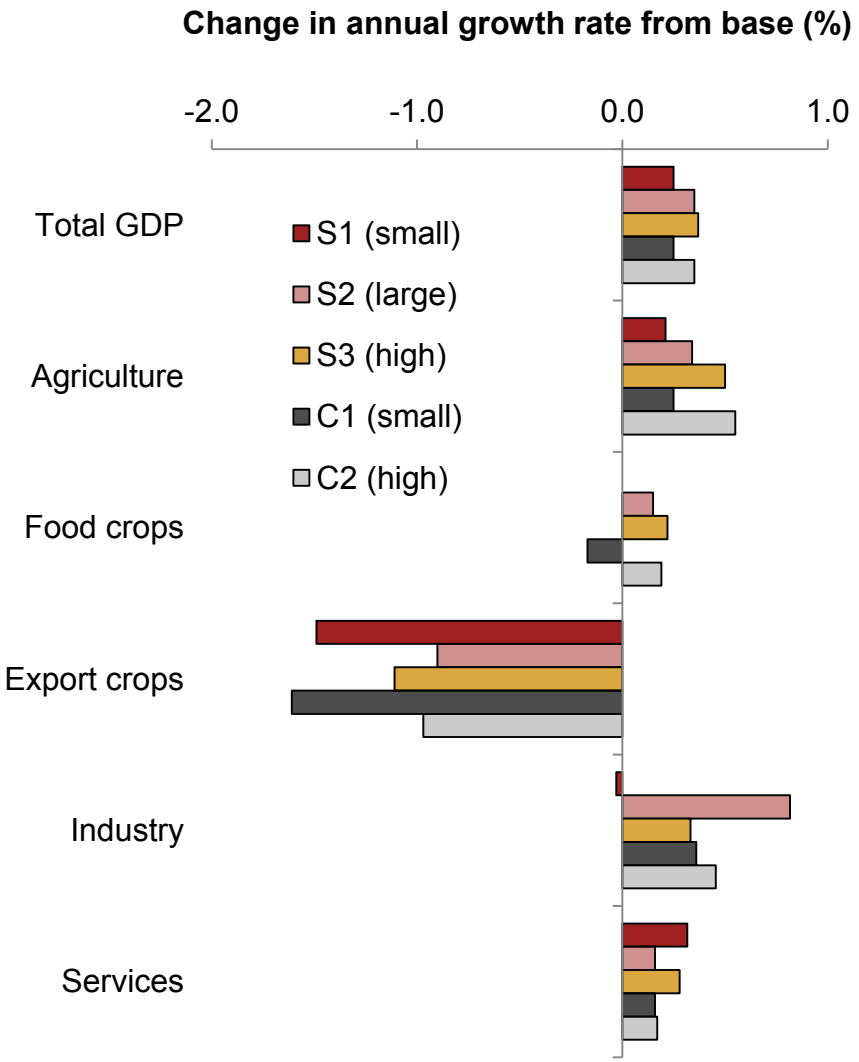
# Biofuels production options
## Modeled scenarios

- Computable general equilibrium (CGE) model (Thurlow 2007)
  - timeline 2007-2015, SAM 2007
- Scenarios build on the technoeconomic analysis
- Scenarios differ according to production technologies/strategies eg. Feedstock, scale of production, land

| Scenarios | Scale of feedstock production | Feedstock yield level | Land expansion |
|---|---|---|---|
| **Sugar 1** | Small | Low | Yes |
| **Sugar 2** | Large | High | Yes |
| **Sugar 3** | Small | High | No |
| **Cassava 1** | Small | Low | Yes |
| **Cassava 2** | Small | High | No |

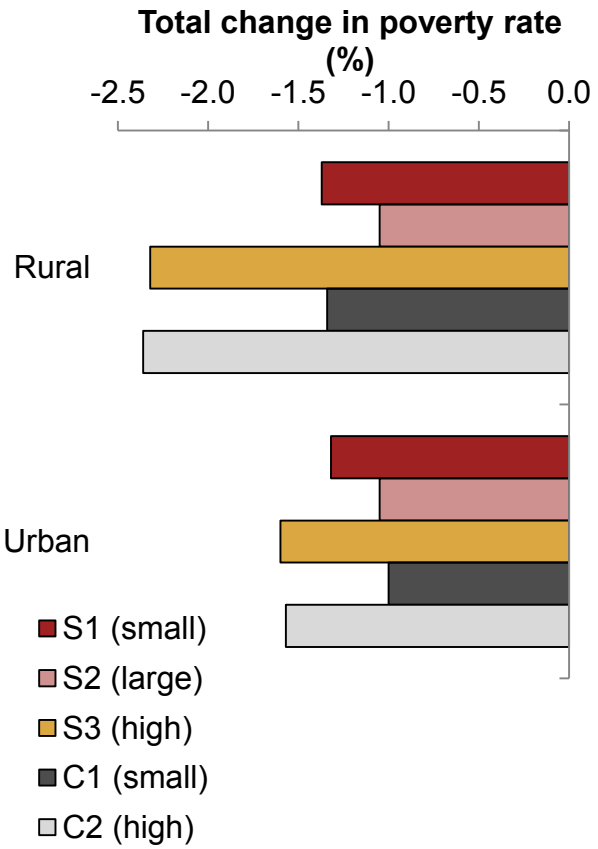
# Modeling results
## Economic growth, 2007-2015

- Overall GDP growth rate increases (0.3%-0.4% p.a.)
- Large increase in exports
- Exchange rate appreciates, reducing non-biofuel export crops' competitiveness
- Food crops expand as non-biofuel exports release land and labor (except for C1)
- Manufacturing expands due to biofuels processing



# Modeling results
## Household incomes and poverty, 2007-2015

- Biofuels reduces poverty rate by 1.1-2.4% (max 0.9m people)
- Outgrower schemes and cassava are more pro-poor
- Both rural and urban poverty declines



# Results

- Both large-scale and small-scale biofuel production approaches stimulate economic growth (GDP)
- All production options reduce poverty, but small-scale outgrower approaches are most pro-poor
- There is little evidence of a food vs. biofuel trade-off
- Rather it is non-biofuel export crops that will be displaced by new biofuels exports

# Household level impacts and vulnerability
## Objectives

- In the short run, as the bioenergy sector develops, food prices change
- Food prices can change because of international and domestic supply and demand shocks
  - This can also include changes in biofuel demand

- We need to understand
  - how does the price change **impact** households?
  - are any household groups **vulnerable**?

# Household level impacts and vulnerable groups

- The resulting change in food prices affects countries and households
  - Net exporters vs net importers
  - Net buyers vs net sellers

- Households may produce and consume a crop at the same time

- Price increases will affect households in different ways:
  - *Net consumers*: Those who buy more food than they sell will be hurt by higher prices.
  - *Net producers:* Those who sell more food than they buy benefit from higher prices.

- Given a price change, we calculate the **net welfare impact** on the household based on the position of the household (Some literature: Minot and Goletti 1998, Deaton 1988, Dawe and Maltsoglou 2009)

# An Example: Tanzania

## Which specific food crops do I need to be concerned of?

- **Food security** staples: **Maize** and **Cassava**

**Not Maize !**

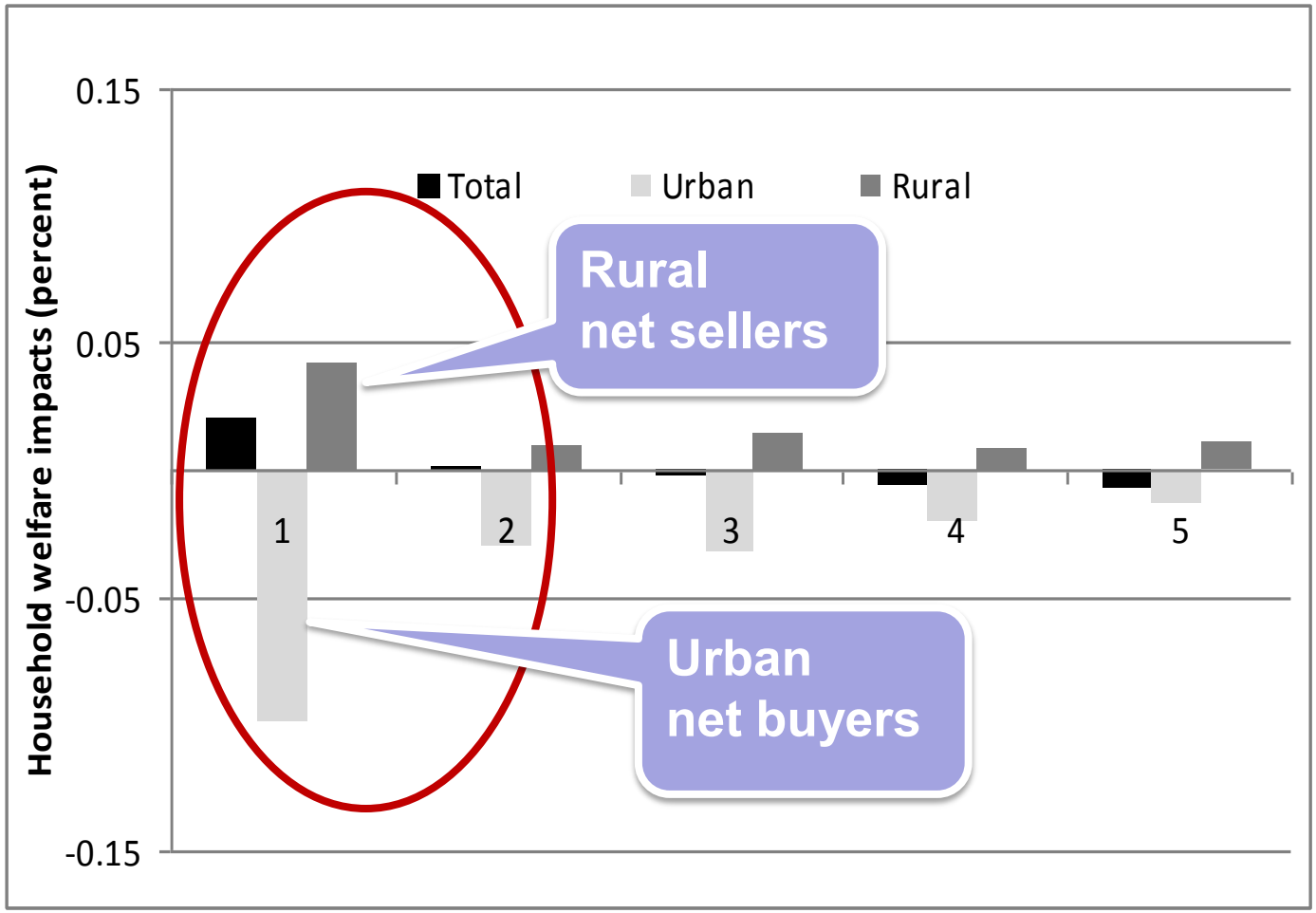
| Crop | Net importer (%) | Net exporter (%) |
|---|---|---|
| Maize | - | 2 |
| Cassava | - | - |
| Sugar | 8 | - |
| Palm oil | 64 | - |

| Ranking | Commodity | Calorie Share (%) |
|---|---|---|
| 1 | Maize | 33.4 |
| 2 | Cassava | 15.2 |
| 3 | Rice (Milled Equivalent) | 7.9 |
| 4 | Wheat | 4.0 |
| 5 | Sorghum | 4.0 |
| 6 | Sweet Potatoes | 3.3 |
| 7 | Sugar (Raw Equivalent) | 3.3 |
| 8 | Palm Oil | 3.0 |
| 9 | Beans | 2.9 |
| 10 | Beverages, Fermented | 2.7 |
| 11 | Milk – Excluding Butter | 2.2 |
| 12 | Bovine Meat | 1.8 |
| 13 | Pulses, Other | 1.7 |
| 14 | Plantains | 1.5 |
| 15 | Millet | 1.4 |
| Subtotal share for selected items | | 88.5 |
| Total Calories per capita | | 1959 |

Data source: FAOSTAT

# Household welfare impact: Maize

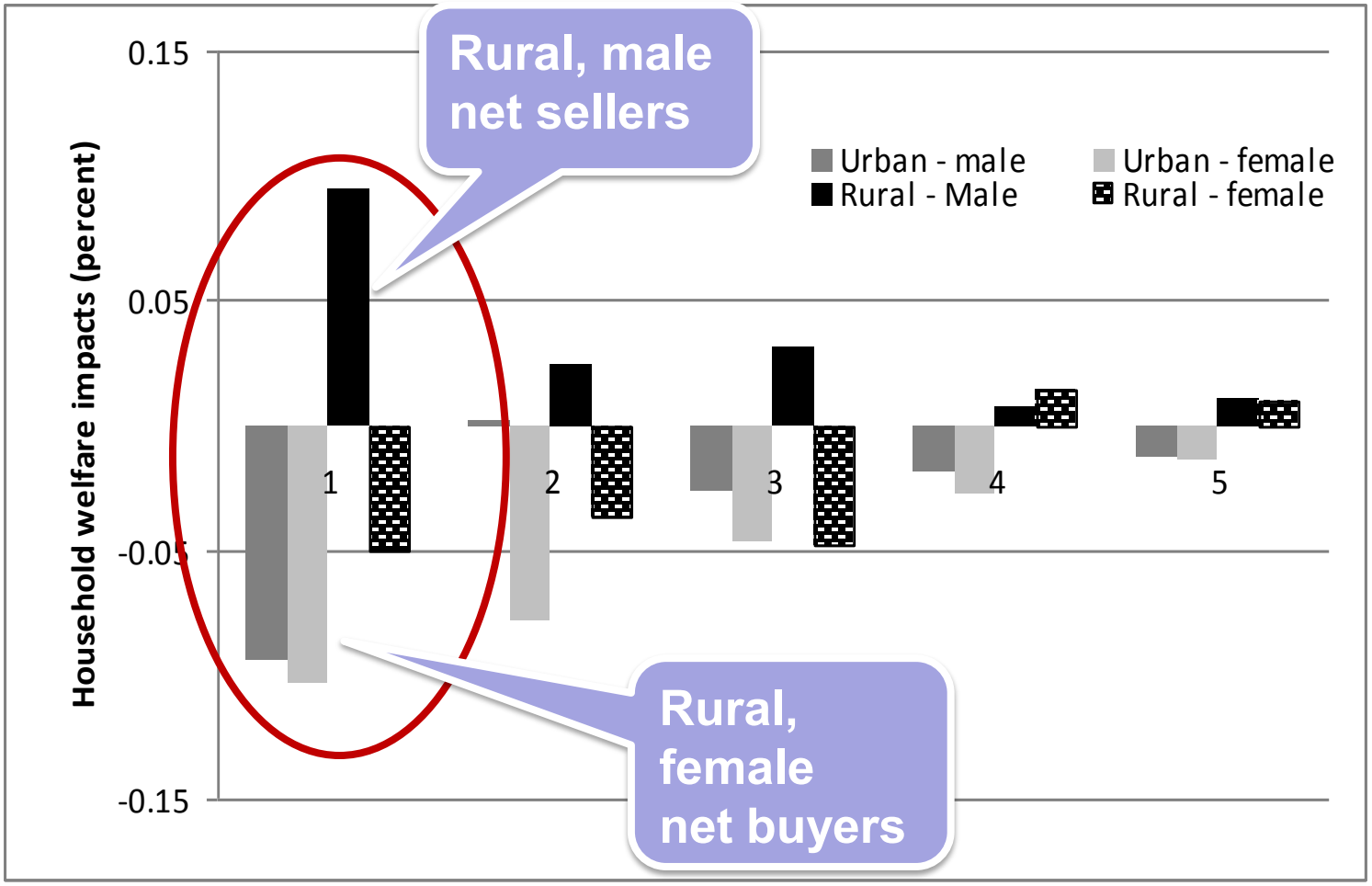
## Assuming a 10 percent price change




Source: Calculations by the authors
Data: National Panel Survey 2008-2009 for Tanzania (3280 households)

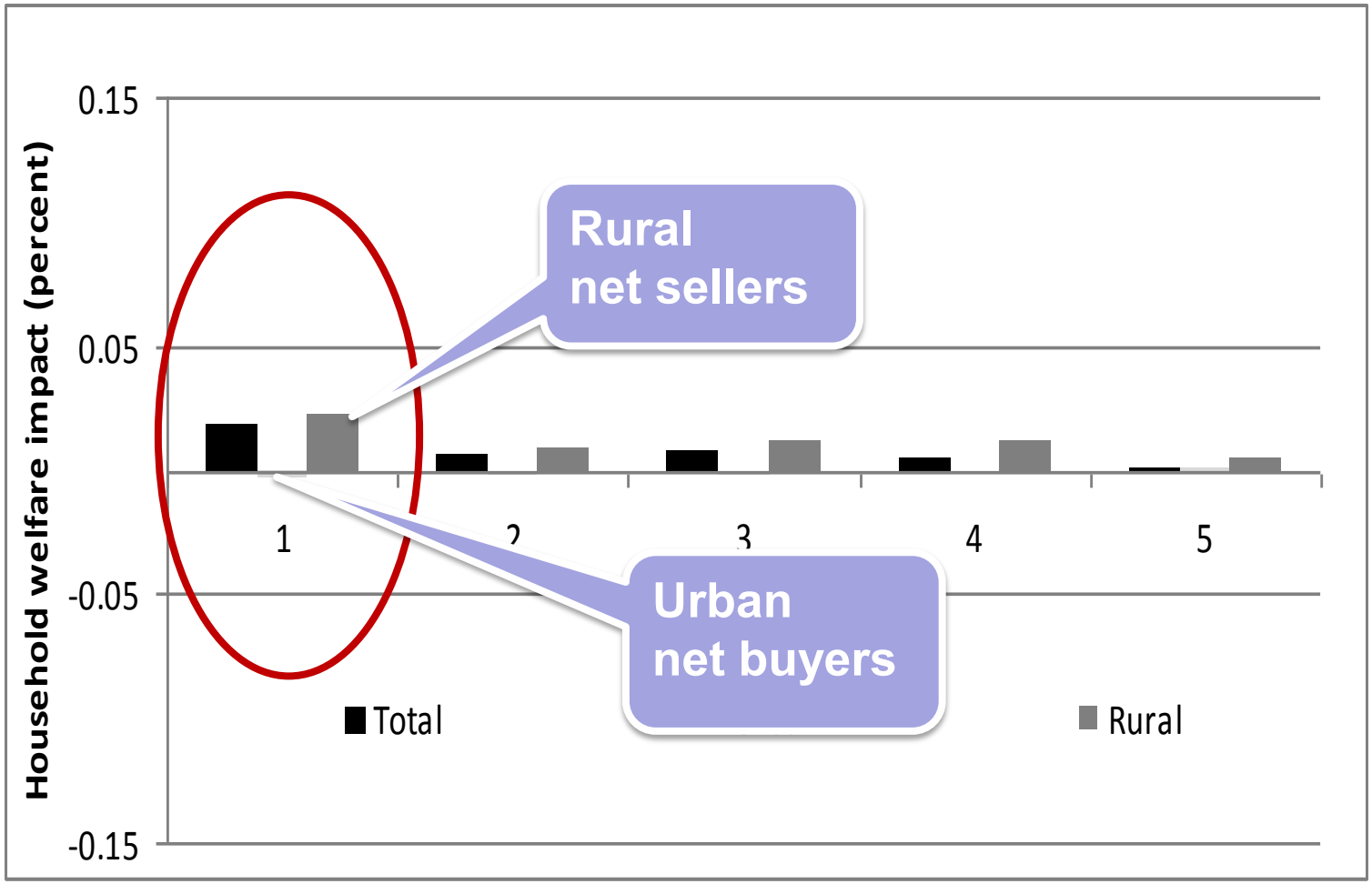
# Household welfare impacts: Maize and gender

## Assuming a 10 percent price change




Source: Calculations by the authors
Data: National Panel Survey 2008-2009 for Tanzania (3280 households)

# Household welfare impact: Cassava
## Assuming a 10 percent price change




Source: Calculations by the authors
Data: National Panel Survey 2008-2009 for Tanzania (3280 households)

# Key food prices
## Maize and Cassava Price Changes in Tanzania

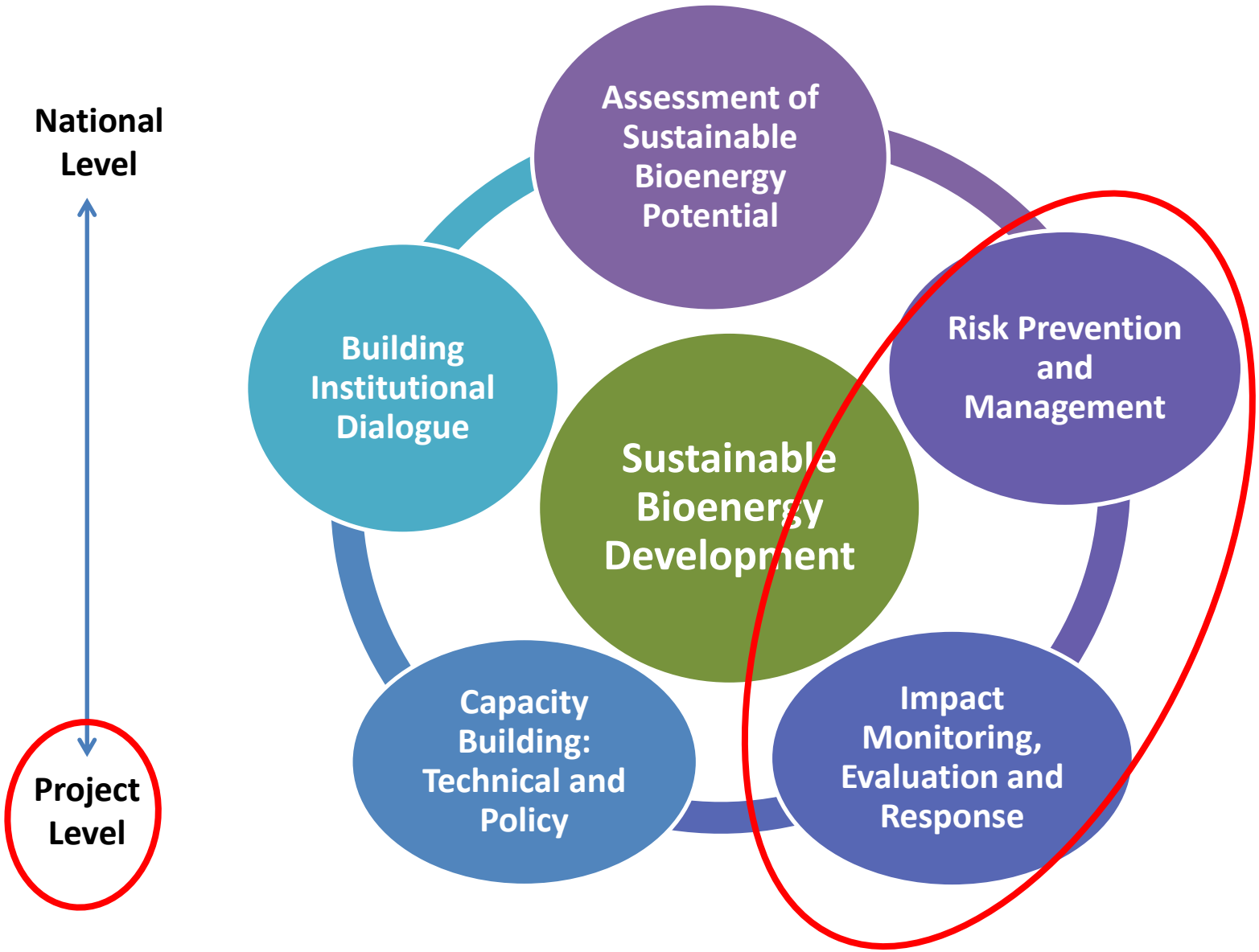
- Maize and cassava market are interlinked, maize prices have been increasing and cassava prices have followed

**Price Changes**:

| **Commodity and Marketing Level** | Domestic Retail Fresh Cassava | Domestic Retail Dried Cassava | Domestic Maize Wholesale |
|---|---|---|---|
| **Real Percent change between 2003 - 2008** | +50% | +42% | +44% |

Source: Ministry of Trade, Calculations by the authors

# The BEFS Approach



# BEFS Operator Level Tool

A web-based tool that can be used to get a preliminary indication of potential **risks** and **benefits** for food security from bioenergy investments

http://www.fao.org/bioenergy/foodsecurity/befsci/operator-tool

# BEFS Operator Level Tool: scope

The tool consists of three parts:

1. **Change in the supply of food** (crops and livestock) **to the domestic market**

2. **Resource availability and efficiency of use** (land, water and fertilizers)

3. **Physical displacement, change in access to resources, compensation and income generation**

# BEFS Operator Level Tool: indicators and scoring system

- Each part includes **indicators** addressing key environmental and socio-economic dimensions relevant for food security

- For each indicator, **benchmarks**, **thresholds** and a **scoring system** are provided:

- **Potential Benefit for Food Security**
- **No Significant Influence on Food Security**
- **Potential Risk to Food Security**

www.fao.org/bioenergy/foodsecurity/befsci/operator-tool

# THANK YOU!

http://www.fao.org/bioenergy/foodsecurity/befs

PLEASE DO NOT HESITATE TO CONTACT US:

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Phone: +39 06 57055376
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# Next steps

- Currently preparing BEFS Rapid Appraisal
- Ongoing work with countries in the application of the various components
- A number of pending assistance requests from countries, funding currently not secured

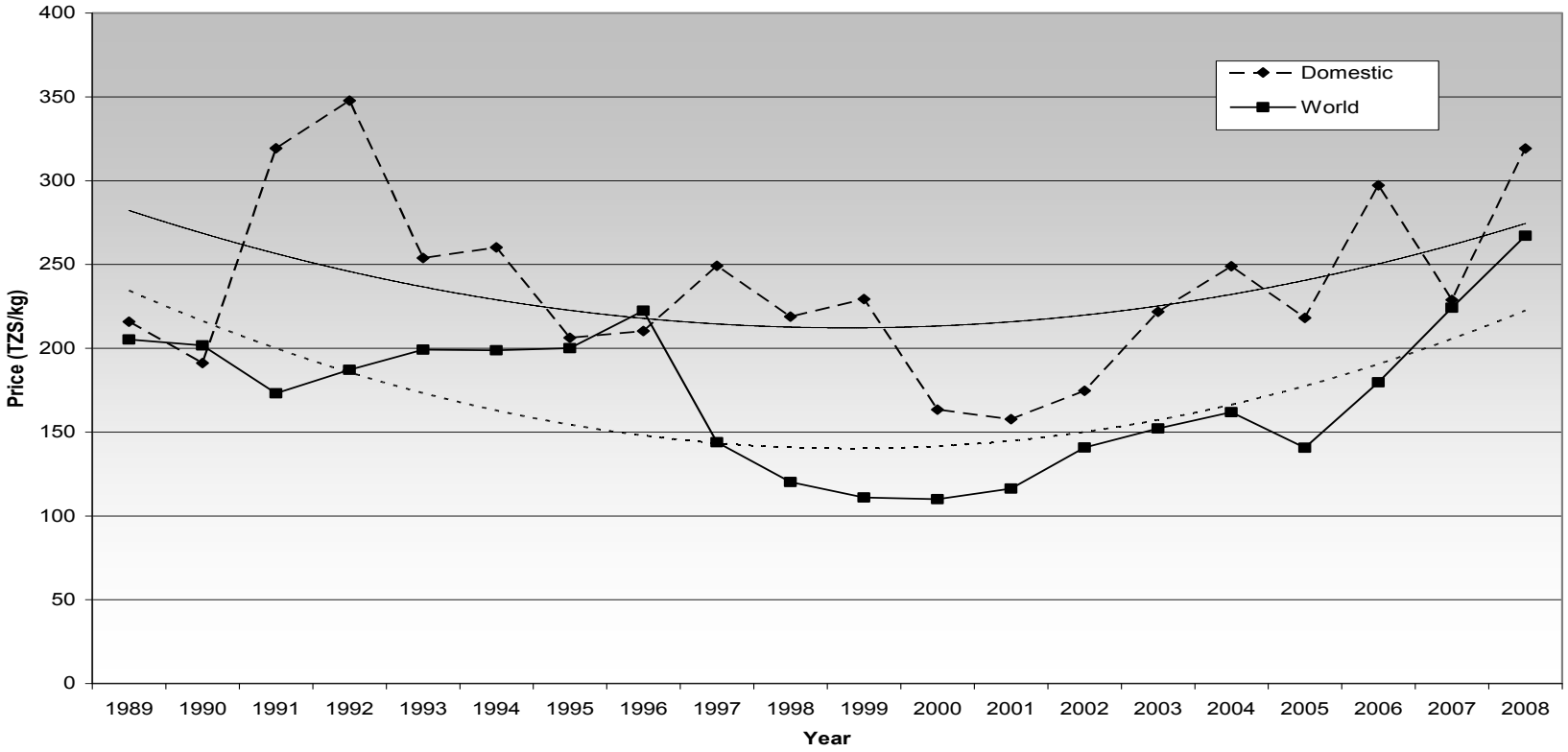
# Concluding remarks

- Bioenergy development is country, context and feedstock/process specific
- Bioenergy policy formulation should be based on country specific data and analysis
- **Tools are now available** to help governments and operators reduce risks and enhance opportunities of bioenergy
- *Per se* **biofuels are neither good nor bad,** what matters is the way they are managed
- **Small-scale bioenergy is important for livelihoods** and can be less risky

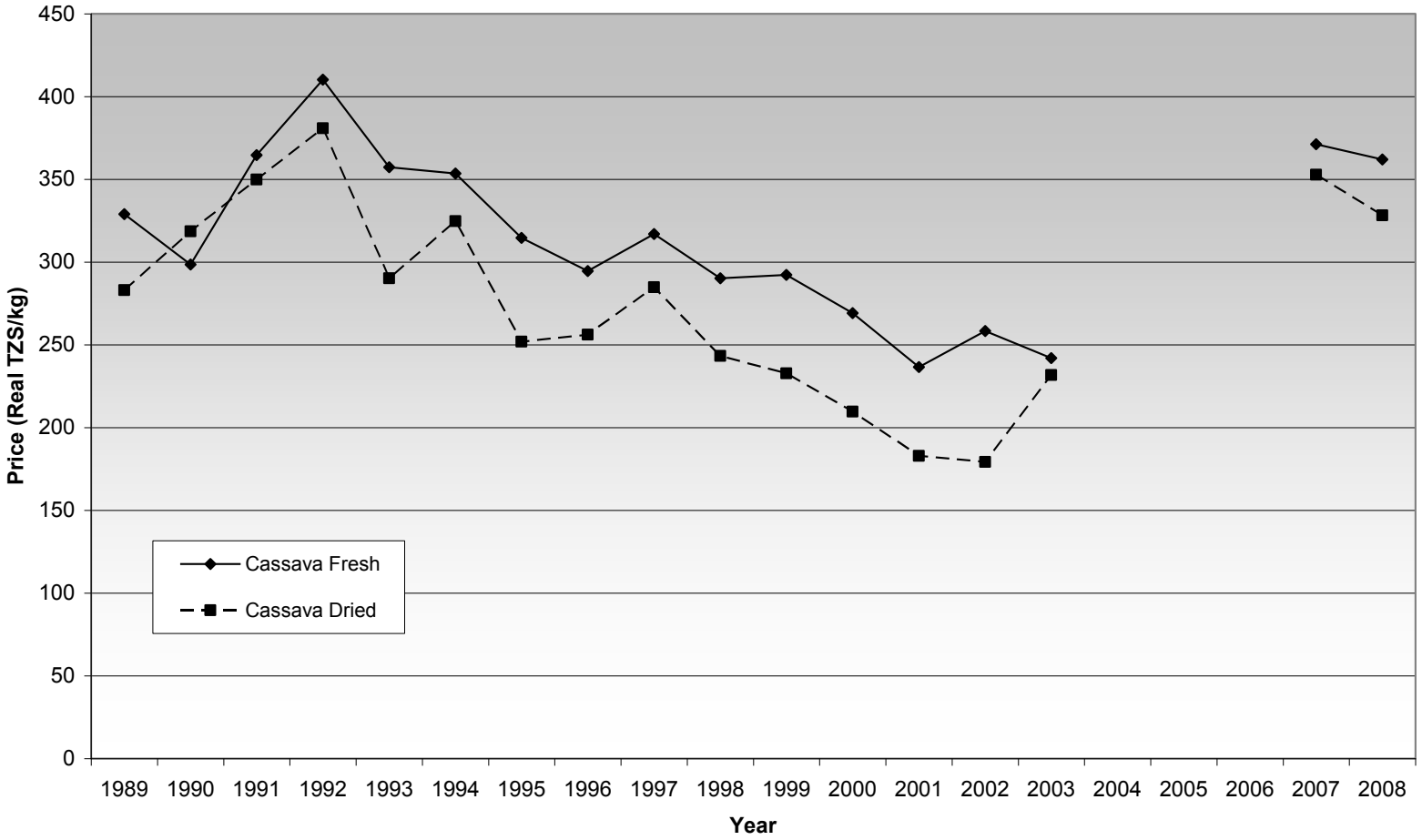
# THANK YOU!

WWW.FAO.ORG/BIOENERGY
WWW.FAO.ORG/BIOENERGY/FOODSECURITY/BEFS/EN/

# Maize Price in Tanzania



# Cassava Price in Tanzania




....maize and cassava market are interlinked

# Tanzania – Who wins or loses from a rise in cassava food prices?

**Welfare impacts in Kilimanjaro for a 10 percent increase in the price of cassava**

**Welfare impacts in Ruvuma for a 10 percent increase in the price of cassava**