

Life Cycle Inventories of 5 Rwandan Crops under Status-Quo Production:

Assessment of Locally-Sourced versus Ecoinvent Global Data

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PROTEIN 2FOOD

- Funded by EU's Horizon 2020
- Development of protein-rich food based on traditional EU legumes
- Make use of amaranth, quinoa, buckwheat, production
- Goal: provide alternate to animal based food, EU bakery products
 - To address challenges of population growth and increasing ag. demands

RAPID PLANNING

- Funded by BMBF
- Develop rapid urban planning methodology
- Q: How can the land be used sustainably and efficiently to feed a growing population?
 - requires country specific data on agricultural input (such as fertilizer, water, land)

Larger Context:



- Expected that consumption of meat will grow in Sub-Saharan regions
 - Population growth, urbanization
- Understand potential role of plant proteins with this change
- To see how urban food flows can interact with typical production

To assess environmental impact of these projects:

- must have information on current agricultural production

Research Tasks:

using Rwanda as an example,

- Tasked to create inventories of agricultural production- main crops
 - As a first step to contribute to the research
- However, lack of specific information on agricultural practices
 - Create generic inventories instead
- Assess inventories with other generic datasets
 - LCI, LCA databases

Study Considerations: Why ,generic‘?

- Inventories are based on available literature and not on field research
 - to understand the available information at present in research
- Inventoried crops- produced in greatest volumes in Rwanda 2013-2016
 - Human or animal consumption, stored, commodity
- Analyze inputs and outputs into a closed system
- Cannot analyze the wider production methods (mixed cropping, rotations, etc.)
- Cannot represent each topographical area of production- instead, overall average

Methods and Results

1. Determine Rwanda's Top Crops accrd. NISR
2. Literature review for agricultural parameters
3. Inventory Creation
 1. Literature review results
 2. Ecoinvent Version 3.3- global data for comparison

1. Determine Rwanda's Top Crops accrd. NISR



- Seasonal Agricultural Surveys: 3 seasons/year
 - Subdivided strata of Rwanda
- Majority of cropland on hillsides (82%)
- 3.6% of surveyed operators are “large scale farmers”
 - Average farm size 0.25 ha
- All crops in each food category considered
 - Cereals, tubers and roots, banana, legumes and pulses, veg and fruit, other
- Total kg produced of each crop for each year within all surveyed strata

2. Literature Review for Agricultural Parameters

1. LCA databases

Agrifootprint, Econet, ecoinvent, World Food Database

- Significant lack: Africa, Sub-Saharan Africa, Rwanda crops
- Often only for large-scale production with larger system boundaries for the inventories (ex. Soil to fork, rather than soil to harvest)

2. Exhaustive literature review

'[banana] production' Rwanda

'[banana] production' 'Uganda', '[banana] production' 'Kenya', then '[banana] production' 'East Africa', '[banana] production' 'Sub-Saharan Africa'.

'[banana] manure Rwanda', or '[banana] fertilizer Rwanda'

	Top 5	NISR Food Category	% of NISR food category 2013-2016	% of total surveyed NISR agricultural production 2013-2016
1	Banana*	Banana	100%	29.26%
2	Sweet Potato	Tubers and Roots	36.79%	15.01%
3	Cassava	Tubers and Roots	31.94%	13.03%
4	Maize	Cereals	56.37%	5.03%
5	Sorghum	Cereals	26.98%	2.41%

3. Inventory Creation

For perspective on agricultural parameters:

- Collect inventories on **global average** production of same 5 crops
- ecoinvent
 - 3/5



<https://www.livescience.com/45005-banana-nutrition-facts.html>



<http://news.hamlethub.com/fairfield/places/45574-stamford-museum-s-maize-exhibit-opens-june-24>



<http://www.tellspecopedia.com/Ingredients/sorghum/>



Agricultural Parameter Categories

Agricultural Parameter Categories

Cultivation

- Average yield kg/ha/year
- Average seed requirement kg/ha
- *Biomass energy of dried crop yield*
- *Rooting depth of crop*
- *Soil clay content*

Mineral Fertilizer Use

- 3/5 Rwandan crops applied with inorganic fertilizers
 - 14.1% of maize farms
 - 0.4% cassava farms
 - 2.3% sorghum farms
 - (NISR 2015, 2016)

Manure Application

- Applied to all 5
- urban Kigali farmers apply levels dependent on crop N uptake (interview Kigali cooperative 2017)
- Manure slightly decomposed with crop residues (Yamano et al. 2011)

Agricultural Parameter Categories

Pesticide Use

- 1/5 crops: maize
 - 2.8% maize farms (NISR 2015,2016)
- Yet, no published literature on amount of pesticide applied
- Therefore concluded 0/5 crops

Irrigation

- Not reported for any of 5 crops
- No mechanical irrigation
 - High annual rainfall (1210 mm/a World Bank 2017)

Harvest Machinery

- Not reportedly used for these 5 crops

Agricultural Parameter Categories

Crop Residue Management

- Managed consistently over 5 crops
- No burning
- Left on soil after harvest, sown into soil with next crop
- Unavoidable crop residues taken up at harvest: fed to farm animals, recycled back into soil via manure
 - (interview Kigali cooperative 2017)

Drying and Storage

- Banana, cassava, sweet potato eaten fresh or cooked
- Maize and sorghum sun dried completely (interview Kigali cooperative 2017)

Parameter Category	Parameter	Unit/ a	Banana		Maize		Sorghum		Cassava	Sweet Potato
			Rwanda	Global	Rwanda	Global	Rwanda	Global	Rwanda	Rwanda
			Lit Review	ecoinvent	Lit Review	ecoinvent	Lit Review	ecoinvent	Lit Review	Lit Review
Cultivation	Yield	kg/ha	18,581 <i>(NISR 2013-2016 avg (annual))</i>	36,502	2,818 <i>(NISR 2013-2016 avg (annual))</i>	9,315	2,541 <i>(NISR 2013-2016 avg (annual))</i>	3,860	2,932 <i>(NISR 2013-2016 avg (annual))</i>	14,545 <i>(NISR 2013-2016 avg (annual))</i>
Mineral Fertilizer	Mineral N-Fertilizer	kg N/ha	0 <i>(NISR 2015, 2016)</i>	111.59	13.59 <i>(personal calculations from Fidele 2015, NISR 2015, 2016)</i>	78.53	0 <i>(Kaizi et al. 2012)</i>	6.4	0 <i>(Fermont et al. 2009)</i>	0 <i>(One Acre Fund 2016)</i>
	Mineral P2O5-Fertilizer	kg P2O5/ha	0 <i>(NISR 2015, 2016)</i>	3.76	13.26 <i>(personal calculations from Fidele 2015, NISR 2015, 2016)</i>	54.49	0 <i>(Kaizi et al. 2012)</i>	4.01	0 <i>(Fermont et al. 2009)</i>	0 <i>(One Acre Fund 2016)</i>
	Mineral K2O-Fertilizer	kg K2O/ha	0 <i>(NISR 2015, 2016)</i>	162.36	2.58 <i>(personal calculations from Fidele 2015, NISR 2015, 2016)</i>	66.97	0 <i>(Kaizi et al. 2012)</i>	4.01	0 <i>(Fermont et al. 2009)</i>	0 <i>(One Acre Fund 2016)</i>
	Mineral Ca-Fertilizer	kg CaO/ha	0 <i>(NISR 2015, 2016)</i>	0	0 <i>(NISR 2015, 2016)</i>	283.17	0 <i>(Kaizi et al. 2012)</i>	24.01	0 <i>(Assumption on lack of data)</i>	0 <i>(One Acre Fund 2016)</i>
Manure Use	Manure	kg/ha	95.03 <i>(Personal calculations from NISR 2015 and 2016 data, KTBL 2015, Yamano et al. 2011)</i>	3,504.24	88.06 <i>(personal calculations from Yamano et al. 2011, KTBL 2015, NISR 2014-2016, Hudson Institute of Mineralogy 2017 and Nutrition Value 2017)</i>	0	57.81 <i>(personal calculations from Yamano et al. 2011, KTBL 2015, NISR 2014-2016, Hudson Institute of Mineralogy 2017 and Nutrition Value 2017)</i>	0	11.69 <i>(personal calculations from Yamano et al. 2011, KTBL 2015, NISR 2014-2016, Hudson Institute of Mineralogy 2017 and Nutrition Value 2017)</i>	148.57 <i>(personal calculations from Yamano et al. 2011, KTBL 2015, NISR 2014-2016, Hudson Institute of Mineralogy 2017 and Nutrition Value 2017)</i>
Pesticide	Amount of Active Ingredient Pesticide	kg/ha	0 <i>(NISR 2015, 2016)</i>	4.2	0 <i>(Mukuralinda et al. 2008)</i>	2.33	0 <i>(NISR 2013-2016 avg (annual))</i>	0.15	0 <i>(NISR 2013-2016 avg (annual))</i>	0 <i>(One Acre Fund 2016)</i>

Discussion: Data Limitations

- Severe lack of data
 - Some crops had to be substituted
 - Ex. Irish potato literature for sweet potato
 - Sweet potato 2nd most important Rwandan crop (15% total kg production 2013-2016 NISR)
 - Some crops were omitted completely
 - Dry bean
 - Potato
 - soybean



<http://www.newtimes.co.rw/section/read/190582/>

Discussion: Data Limitations

- Available literature not always representative of Rwanda
 - Survey areas small, selective
- Also for global data:



<https://www.grains.org/news/20150928/disease-weather-limiting-2015-corn-crop-iowa-farmer>



- ‚global‘ datasets= geographies of one country, high-yielding
- USA, China, India
 - For their crops- high yielding, high input

Discussion: Data Quality Analysis

- Without wide variety of data for comparison, data must be taken at face-value
 - Could only compare to other regions and global values, not local data

Status-Quo Production Analysis: How does Rwanda Compare?

Example: Maize

	Yield (kg/ha)	Manure (kg/ha)	N-fertilizer (kg/ha)	P2O5 fertilizer (kg/ha)	K2O fertilize (kg/ha)	Irrigation (m3/ha)	Seed kg/ha
ecoinvent Quebec	8900.0	1060.0	122.5	42.0	28.0	0.0	n/a
ecoinvent Organic Global	7777.0	18353.7	n/a	n/a	n/a	442.5	25.0
ecoinvent Global	9315.0	0.0	78.5	54.5	67.0	2282.2	200.0
Rwanda LCI	2818.0	88.1	13.6	13.3	2.6	0.0	25.0

Discussion: Data Quality Analysis

- Inventories present state-of-the-art on typical production of these 5 crops to the current ability with data constraints

Discussion: Status-Quo Production Analysis



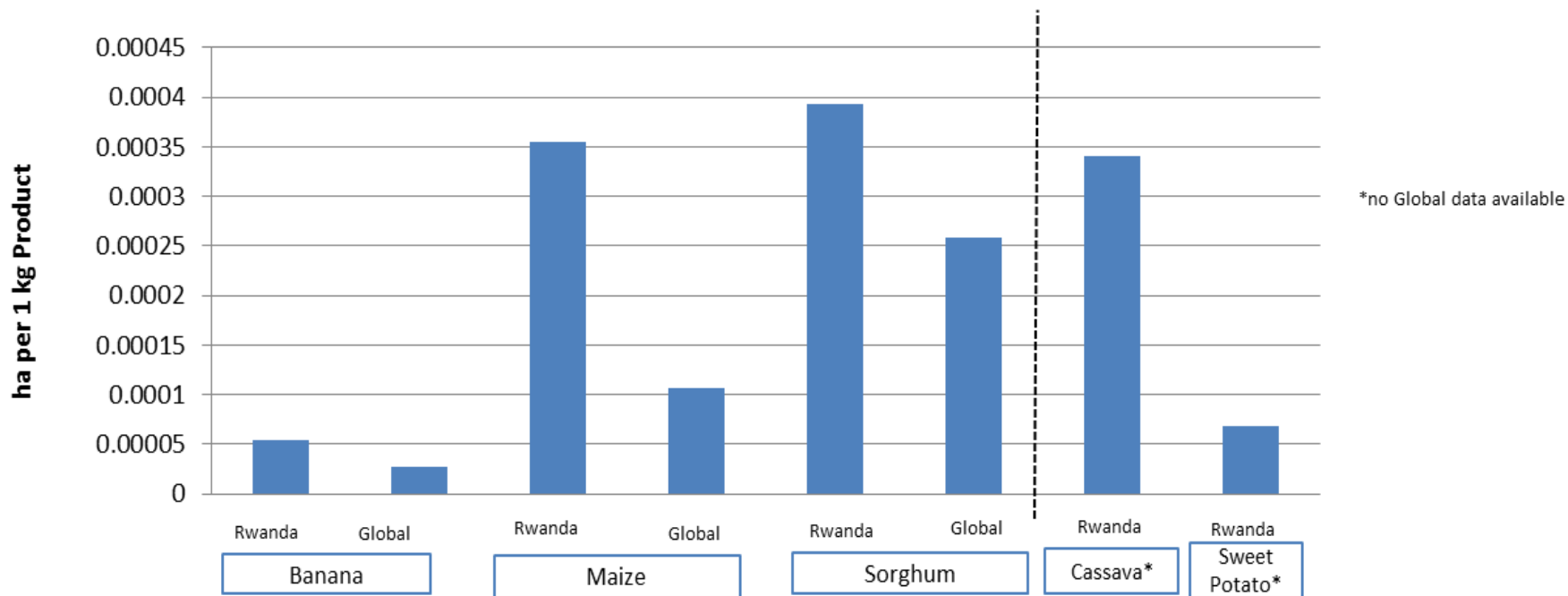
<http://www.newtimes.co.rw/section/read/195664/>

The New Times

- Low technology, low yields
 - Limiting factors: cost, access to farmers, management
- Yield potential is high
 - Banana yield could be twice as high
 - Gap: soil fertility, poor crop management
 - Trials with improved management (wider spacings, compost application) yields improved 24% in 1st growing season (One Acre Fund 2015)

Discussion: Status-Quo Production Analysis

Land Use



- Rwandan production of these 5 crops requires more land than global production:
 - Not efficiently using land

Conclusion: Take-Aways

- 5 Rwandan crop inventories present status-quo agriculture:
 - Low-technology, low-input
 - Conservation tillage
 - Few mineral fertilizers
 - Application of composted manure
 - Lack of harvest machinery
 - No mechanical irrigation



<http://rwandaeye.com/africas-unemployed-youth-should-turn-to-agriculture/>

Conclusion: Take-Aways

- Generic data inventories, YET more applicable to Rwanda than existing LCIs (such as global inecoinvent)
 - Good basis for addressing overarching Q's on country level

Conclusion: Take-Aways

- Further Questions:
 - Should Rwanda intensify its agricultural production to be more efficient, at the risk of the environment?
- To better address guiding questions, need more locally-sourced Rwandan data

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<https://oneacrefund.org/what-we-do/countries-we-serve/rwanda/>

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