Projet d'ingénierie simultanée

Life Cycle Assessment for concurrent engineering

Storage facilities for smallholder's farms in Kenya

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Introduction & background

- The subject "LCA for concurrent engineering" was suggested among the possible semester projects for the students in their sixth semester of Bachelor by the mechanical engineering section of the EPFL.
- It was carried out to review the environmental performances of various storage facilities and methods in the Rift valley in Kenya in comparison with a possible implementation of connected silos, a solution subjected among the other semester projects by Bühler Group, a society specialized in agribusiness.
- Thanks to this new storage facility that reduces the losses, the smallholders would have the possibility to store their grain longer and therefore sell it for a better price.

Life Cycle Assessment (LCA)

- It is a powerful tool used to evaluate the potential environmental impacts and burdens of a product, process, or activity throughout its entire life cycle.
- This encompasses all steps and processes in the product's life, from production and supply of raw materials to the final disposal or recycling at the end of its life.
- At each of these stages, natural resources are consumed and emissions (to air, water and soil) are released to the environment. They are compiled in the life cycle inventory and then related to environmental impacts, such as climate change and resource depletion.
- It provides the environmental impact profile of the product under study and gives valuable information to design a solution with a better footprint.

Current situation in Kenya

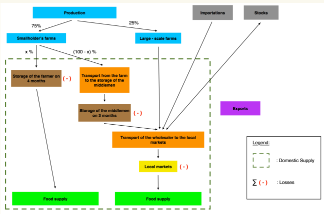
- Maize is the principal food supply in Kenya. It represents around 45 % of the total calories needed by the population.
- The Rift Valley produces more than 50% of the total maize production in Kenya. As the agricultural field work is mainly manual, its productivity is one of the lowest in the world with 1.4 t/ha.
- 75 % of this production comes from smallholder's farms whereas 25% from large-scale farms.
- Losses related to post harvest operations are quite considerable and reach 15 %.
- Smallholders need to store their maize for 1 to 4 months considering the maximal gap of 4 months between the two periods of harvest every year.
- Smallholders are using PP bags for storage because they are affordable and available. However, due to their high losses, the farmers are afraid to loose a huge part of their annual income. They then sell their grain immediately, even if the prices of the market are low.
- Kenya imports maize every year mainly from its neighbouring countries: Zambia, Uganda and Tanzania.
- The maize chain is mainly shaped by two actors, a middleman who works locally by buying the crop to the farmers and selling it in the nearby markets and a wholesaler who buys the maize to the middleman and transports it from surplus to deficit regions over long distances.

Goal of the study

1. Compare the environmental impact of different storage facilities considering two different behaviours of the farmers and the middlemen.
2. Put this result into perspective with the amount of grain saved and the possible empowerment of these farmers on the maize market.

Our functional unit to compare the different scenarios is 1 ton of maize provided in the plate of Kenyan's consumers per year.

Maize's chain - Behaviour 1:



The middleman has PP bags with pesticides and the farmer has:

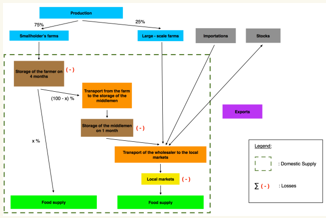
Scenario 1: PP bags

Scenario 2: PP bags with pesticides

Scenario 3: AgroZ bags

Scenario 4: Simple silo without sensors

Maize's chain - Behaviour 2:



The middleman has PP bags with pesticides and the farmer has:

Scenario 5: simple silo without sensor

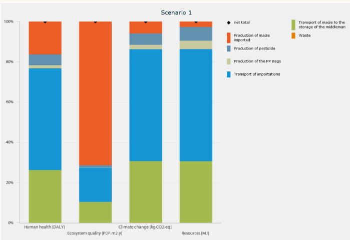
Scenario 6: silo with sensors

Scenario 7: AgroZ bags

For the **scenario 8**, the farmers and the middlemen have AgroZ bags

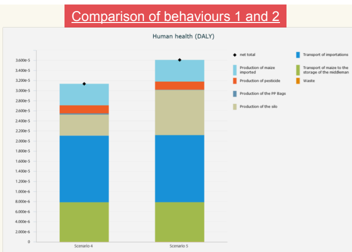
Results

Current situation



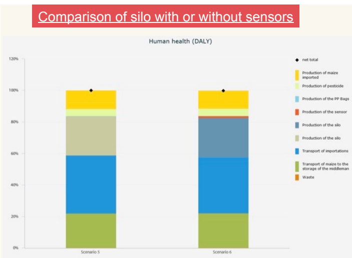
- Whole maize chain: huge impact coming from the transports and the production of maize.
- Exclusion from the system boundaries of the wholesaler's transport and the maize production in Kenya as they are the same for all scenarios.
- Low impact of the production of the PP bags (1-4%).
- Impact of middleman's pesticides near 5%.
- Great impact from transport and production of the imported maize.
- Reducing the losses and thus the importation seems to be the direction to take to improve the footprint of the storage facility.

Comparison of behaviours 1 and 2



- The change of behaviour when the farmer uses AgroZ has no impact on the environmental footprint.
- However, the silo of the scenario 5 must be twice as large as in the scenario 4. Thus, the impact of the behaviour change is 15% greater.

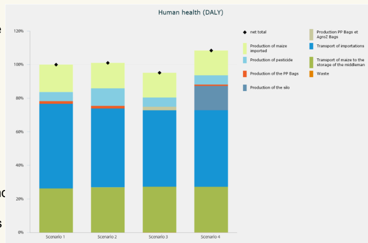
Comparison of silo with or without sensors



- We observe that the sensors only represent 0.6% of the silo's total footprint, thus their implementation comes without any environmental cost.

Comparison of scenario 1 to 4

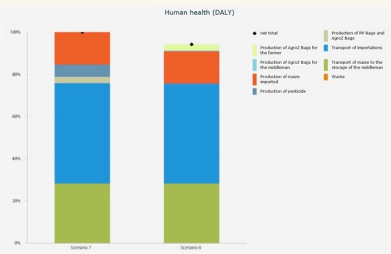
- Sc 2: production of pesticide overcompensates the gain over the importation.
- Sc 4: 9% higher, due to the production of the silo (>13% of its impact).
- Sc 3: AgroZ bags: best performance thanks to the benefice of low losses, no production of pesticides and low impacts of production (still, improvement remains low: -5%).



- Ecosystem quality (not shown): major part caused by the production of maize imported. So, the diminution of losses with new facilities becomes more important, as it decreases the importations. Thus, scenarios 2 to 4 present better behaviours.

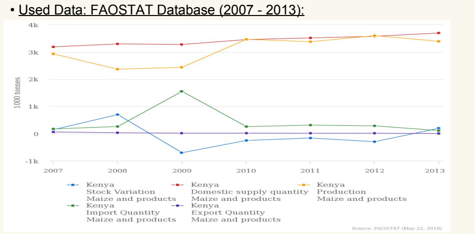
Comparison of scenarios 7 and 8

- Improvement of the storage facility of the middleman by using AgroZ bags.
- Best improvement among all the scenarios compared (Human health: 90% of the current situation).

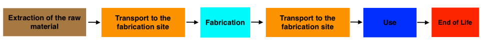


- Sc 7: still have to produce pesticides for the storage of the middleman that represents 6% of the footprint.
- Sc 8:
  - No more pesticides
  - Production of AgroZ bags have much less impact than the one of PP bags with pesticide
  - Reduction of the losses of the middleman and thus the quantity of maize imported

- Used Data: FAOSTAT Database (2007 - 2013):



- Life cycle of used products:



Financial comparison

Storage facility	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 7
Maize sold	621.1 kg	+ 16 kg	+ 22.3 kg	+ 21.7 kg	+ 18.2 kg	+ 19.5 kg
Income	217.4 $	+ 5.6 $	+ 7.8 $	+ 7.6 $	+ 51.1 $	+51.7 $

- Knowing that the total annual income of the smallholders is about 466$, we observe that the maize plays an important role for the farmers financial security.
- As the month to month prices on the market varies considerably, the behaviour change of the farmers can increase their income up to 20%.
- This enhancement when farmers have silos or AgroZ bags are similar. However, an AgroZ bag costs approximately 3$ and lasts 2 years while one silo would cost 50$ by farmers and has a lifetime of 15 years.

Conclusion

- The scenario where farmers use pesticides with the current behaviour makes no significant difference on the environment and has no financial motivations.
- From an environmental point of view, the AgroZ bags offer a slightly better improvement but don't exceed 10% even if the middleman use them as well. The simple and smart silos used with the second behaviour present worse impacts of about +20% compared to the actual situation. This increase is considerable but not eliminatory.
- From a financial point of view, the AgroZ bags and the silo have equal losses and then present the same advantages. Nevertheless, the AgroZ bags are more expensive over time. The silos would then be preferred if their actual price is 50$.
- The silo seems to be a good option to enhance the income of the farmers, but has more impact on the environment. On the other hand, the AgroZ bags slightly reduce the environmental indicators, while being more expensive than the silo.
- It is advised to use the sensors, as they provide important information on the quality of the grains and have negligible impacts on the environment.
- Other important improvements could be done during the post-harvest processes up to the farm, as their losses are still very high.
- Another solution to decrease the global footprint would be to improve the culture in the eastern region of Kenya where the production is low, to reduce the distances made by the wholesaler.