Environmental impacts of agricultural robots and possible improvements: example of weeding robots used in vineyards

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PRADEL Marilys – Research Engineer, INRAE, UR TSCF **SEGUINEAU Cédric** - HSQE Officer, NAÏO Technologies

SIMA AGRITECH DAY By AXEMA

Who are we?





Marilys PRADEL

Engineer's degree in agriculture / PhD Research Engineer – INRAE UR TSCF

Cédric SEGUINEAU

Training / PhD HSQE Officer, NAÏO Technologies

Summary

- 1. Context
- 2. Why it is important to assess environmental impacts of agricultural robots? The case of weeding robots in vineyards
- 3. Possible improvements for LCA methodology and robot ecodesign
- 4. Outlooks



MOVING TOWARD THE AGROECOLOGICAL TRANSITION...

A need to change traditional agricultural models for agroecological models
The agroecological transition = new challenges for agricultural robotics !





... BY REDUCING GHG EMISSIONS RESPONSIBLE OF CLIMATE CHANGE

- ► Agriculture → 19% of GHG emissions in the world
- 45% CH₄ (cattle farming), 42% N₂O (fertilizers), 13% CO₂ (diesel)





Global average temperature



- Robotics and digital equipment can reduce GHG emissions by improving agroecological practices such as optimizing the use of mineral fertilizers (N₂O) or reducing fuel consumption (CO₂)
- However, few studies on the environmental impacts of robotic and digital equipment in agriculture

https://climate.copernicus.eu/climate-indicators/temperature

... AND PRESERVING BIODIVERSITY

Biodiversity loss is a reality

BIODIVERSITY LOSS

Decline of the North American avifauna

Science

2019

Kenneth V. Rosenberg^{1,2}*, Adriaan M. Dokter¹, Peter J. Blancher³, John R. Sauer⁴, Adam C. Smith⁵, Paul A. Smith³, Jessica C. Stanton⁶, Arvind Panjabi⁷, Laura Helft¹, Michael Parr², Peter P. Marra⁸†



Fig. 1 Net population change in North American birds.

Explained by several drivers





of the impact

Source: Millennium Ecosystem Assessment

PRESERVING THE ENVIRONMENT IS ALSO A RESPONSABILITY FOR COMPANIES

- For facing Climate Change and other urges, companies have to comply with growing legal requirements about sustainability (new European Corporate Sustainability Reporting Directive for instance)
- There is a huge trend among companies to put in place voluntary actions to go further, faster, and play an active part in Environmental, Societal or Governance actions. (Employer Brand, Societal demand, ...)
- Several companies build business around Impact: they make profits on actions beneficial for the planet.
- Impact is more and more valued as an extra-financial asset







Source : Fiduciary Trust International (https://urlz.fr/jATd)

WHY IT IS IMPORTANT TO ASSESS ENVIRONMENTAL IMPACTS OF AGRICULTURAL ROBOTS? THE CASE OF WEEDING ROBOTS IN VINEYARDS



IMPORTANCE OF ASSESSING ENVIRONMENTAL IMPACTS OF AGRICULTURAL ROBOTS

No study of environmental impacts of agricultural robots up to now

- A need to :
 - Assess the environmental impacts in a context of conventional equipment substitution by robots
 - Assess which life cycle step is the most impacting in order to ecodesign agricultural robots
 - Provide data on the environmental and energetic efficiency of agricultural robots to final users
- Objective of our study :
 - Assess the environmental impact of weeding agricultural robots used in vineyards for inter-row and intra-row weeding
 - On its whole life cycle
 - Using LCA method

LCA METHOD



Environmental impact assessment



Assessment of a product or a system for its whole life cycle

By means of a quantified balance of inputs (raw material, energy) and outputs (emissions, waste) flows used by the product or the system

Which will be converted in environmental impacts with characterization factors

LCA framework



GOAL AND SCOPE

System boundaries



Functional Unit : Optimal weeding control of the intra-row and interrow of 1 hectare of vines for 1 year

27 comparative scenarios studied



LCA OF COMPARATIVE RESULTS FOR VAL DE LOIRE SCENARIOS



LCA OF COMPARATIVE INTRA ROW WEEDING PRACTICES



LCA OF COMPARATIVE INTRA ROW WEEDING PRACTICES







IMPROVING LCI OF CONVENTIONAL AGRICULTURAL EQUIPMENT

- LCI data for tractors manufacturing need to be updated to fit the current technology (HMI, electronic components, digital equipment, new motorization...)
- Updating data shows :
 - 7 187% à 198% for abiotic mineral resources
 - 7 26% for climate change
 - **7** 54% for human toxicity



□ Tractor production - ecoinvent DB (energy for production and recycling excluded)

Updated tractor production - econvent DB (energy for production and recycling excluded)

Robot production (energy for production and recycling excluded)

IMPROVING AGRICULTURE ROBOTS THROUGH ECODESIGN

Ecodesign can reduce environmental impacts if the lifetime is increased and the robot is used for several agricultural tasks



IMPROVING AGRICULTURE ROBOTS THROUGH ECODESIGN



- Lifetime increase: from prototypes to first serial batches and to a mature technology
 - Robots = still impactful on HT and MRD
 - Equivalent results or slightly lower than conventional operations for CC and FRD
- Versatility and modularity increase
 - Lifetime → related to technology renewable rate
 - In use rate = Impact of weeding operations (relatively less material input is consumed during an operation)
 - Multiplying the operations (implements wider range, additional operations like scouting,...) is a relevant way to increase the use rate
- Availability on the field optimization
 - Logistic and transportations of the robot leads to additional emissions. Increasing the availability of autonomous mode leads to an improved impact on Climate Change

FUTURE CHALLENGES TO BE FACED

- Local effect on soil were not taken into account as no characterization can assess these impact such as soil compaction or specific biodiversity => a need to assess the impact for agricultural robot in a system perspective
- Results focused on the "technology" service provided by the robots. The other services such as reduction of the hardship at work or ability for robots to overcome the skilled labor shortage were not assessed
- Future studies need to consider social and economic indicators in addition to the LCA indicators to assess agricultural robot sustainability
- A need to quantify the overall impact of the use of robotic solutions in agroecological systems



A NEED TO STRUCTURE THE SECTOR OF AG EQUIPMENT

- There is a need for references to compare the impact of alternative technology to conventional ones in order to position the alternatives and look at potential impact transfers
- LCA allows to draw a global scheme of environmental impacts of robotic technology BUT the sensitivity analysis coupled with the residual gap between tractor and robots blurs the conclusions
 - Electric autonomous units seem to have a better impact on CC and FRD
 - Long life robots reach the same level of impact than conventional machinery on MRD or HT





- For every manufacturer who intends to build eco-design solution, it is necessary to have accurate references to be able to assess the environmental impact of the eco-design solution
- Current LCI database on agroequipment are obsolete, and a sector initiative would benefit to every stakeholders
- An appropriate approach would be to provide data to a third-party lab in charge of building average LCI per kind of machine / tractor power

Grand Défi de la Robotique Agricole An Example of an Open Initiative animated by ROBAGRI

- The Grand Défi aims to organize initiative in order to accelerate the agroecological transition by the use of robotics solution
- It is funded by French Government: 21M€ over 5 years (ANR)
- The initiative is opened to every French stakeholder of the sector
- ► The detailed workpackages are currently drafted → works will start in 2023



RobAgri Project Leader : adrian.couvent@robagri.fr



QUESTIONS & ANSWERS