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Environmental impact assessment of field mechanisation for a sustainable agriculture

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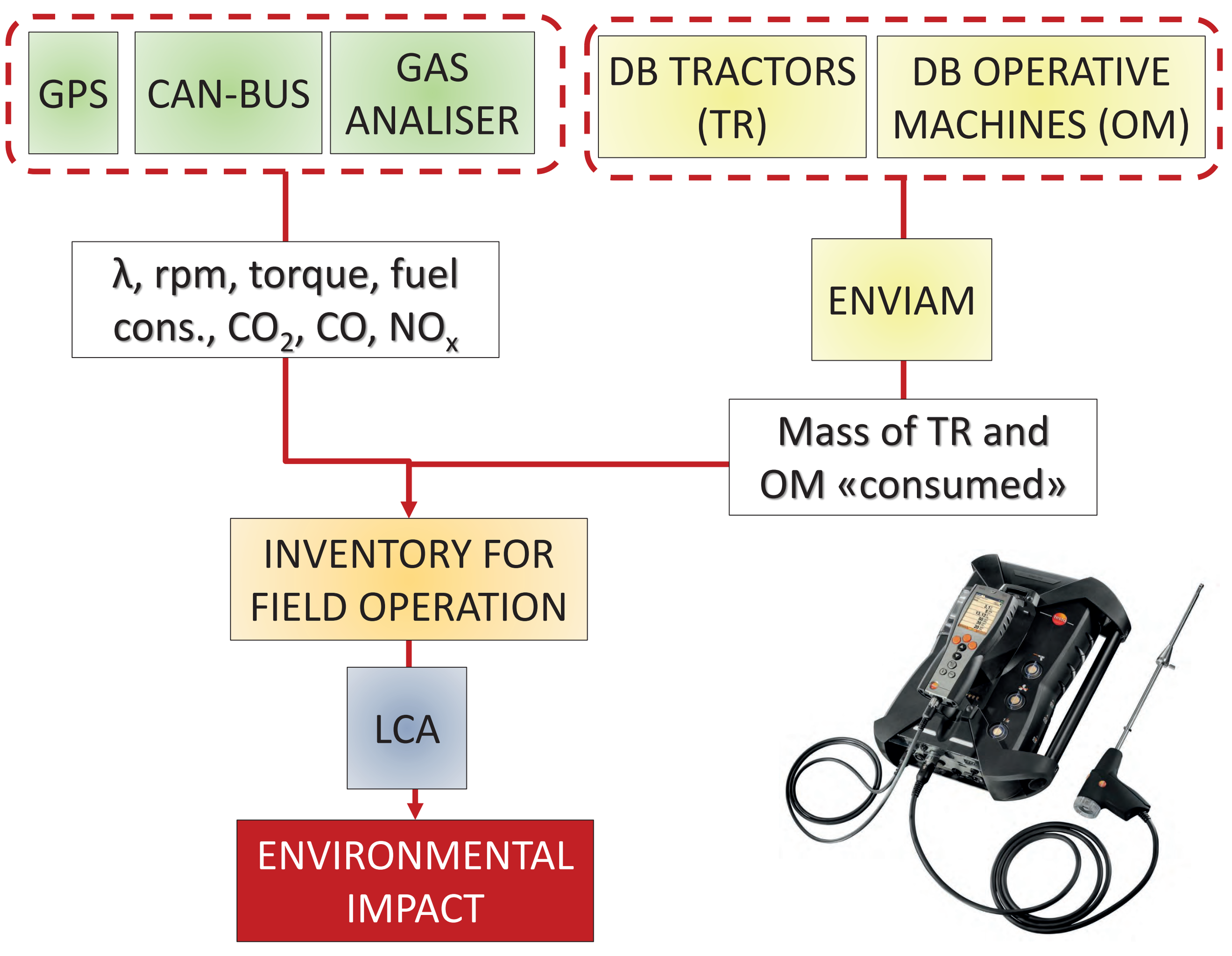
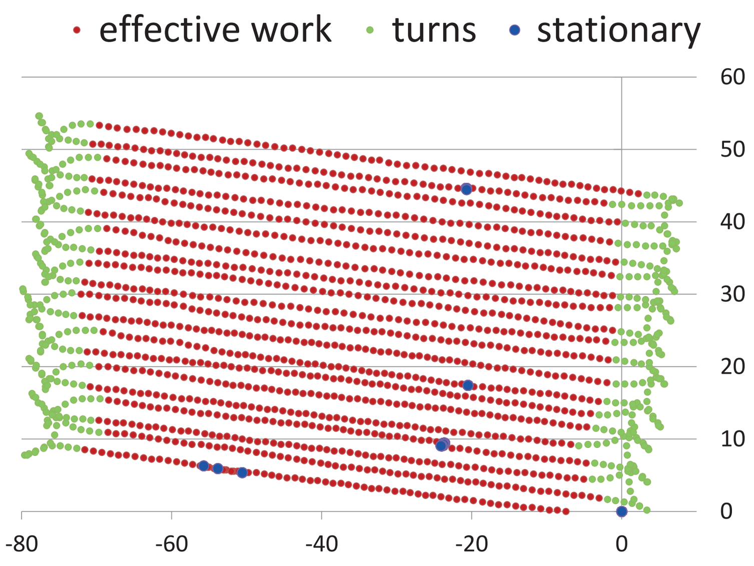
INTRODUCTION: For the environmental impact assessment of agricultural machinery operations, the collection of reliable inventory data (i.e. materials consumption and pollutants emissions) is a prerequisite for the achievement of trustful results. These data cannot be always directly measured and depend on pedo-climatic (e.g., soil texture and water content), site-specific (e.g., field shape, slope) and logistic (e.g., annual working time) variables. Nowadays, thanks to recent technologies installed on tractors, the data collection can be more easily carried out. In fact, by monitoring a tractor working in several different conditions, it is possible to model the engine's behaviour also along other field operations. This determines the possibility of understanding how the inventory reliability affects the environmental impact of agricultural machinery operations got through LCA method.

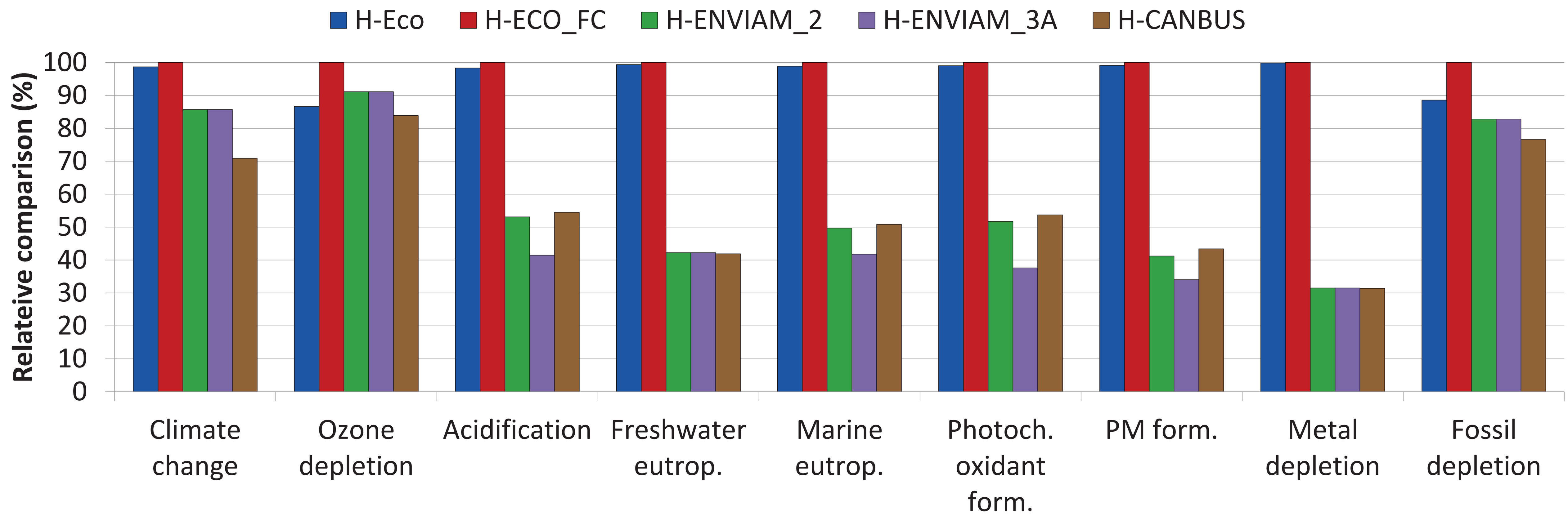




AIM: Describe the main methodological steps to follow – when the technological innovations of recent machinery are available - to have a reliable model for fulfilling inventories. Compare the different environmental loads achievable with inventories of different reliability.

MATERIALS AND METHODS: To perform a reliable environmental impact assessment of agricultural field operations, the methodological framework proposed in this study links: 1) the recent technologies installed on modern tractors i.e **CAN-bus**, **GPS** and engine exhaust **gases analyser** that permit to map the operation with instantaneous data on tractor's variables, on tractor's spatial position and on the exhaust gases emitted to air, 2) **ENVIAM** (ENVironmental Inventory of Agricultural Machinery operations), a tool developed to support the environmental impact evaluation by fulfilling inventories for field machinery operations.
Databases for tractors (TR) and implements (OM) are included, which permits to quantify their effective mass "consumed along the studied operation", 3) the **Life Cycle Assessment** (LCA), a standardised method adopted worldwide for quantifying the environmental impacts of processes or products.

CASE STUDY: Field experiment was performed in a sandy-loam soil in Sweden with a Valtra N101 tractor (82 kW, stage 3A, equipped with a EGR) coupled with a rotary harrow (width 3 m, depth 10 cm) over a total area of 2.08 ha for 2.96 working hours. Three working times were identified: *effective work* (moving forward while working, with a straight direction); *turns* at the headlands (turning position); *stationary* (no change in position, mainly with idling conditions). For each working time, the modelled variables were fuel consumption (FC; dm^3/h) and exhaust gases emissions (EM; g CO_2/h, g CO/h, g NO_x/h). Finally, the environmental impact of harrowing was calculated. To highlight the differences related to data reliability we compared:
H-ECO: the harrowing process of the ECOINVENT® database; **H-ECO_FC**: H-ECO modified considering the FC modelled by ENVIAM (13.7 kg/ha instead of 11.5 kg/ha); **H-ENVIAM_2** & **H-ENVIAM_3A**: H-ECO modified considering FC and EM modelled by ENVIAM for a 2 and 3A Stage (66.2 and 56.3 g CO/ha, respectively; 43,299 g CO_2/ha for both; 229.6 and 134.4 g NO_x/ha, respectively for 2 and 3A Stages); **H-CANBUS** the harrowing process assessed considering the modelled variables using CAN-bus and gas analyser (12.5 kg/ha of diesel and 10.5 g CO/ha, 33,528 g CO_2/ha, 251.1 g NO_x/ha).



When only the FC is modified (H-ECO → H-ECO_FC) only negligible differences are highlighted except for *ozone* and *fossil depletion*. Changing FC and the masses of TR and OM consumed, great impact variations are recorded for *acidification* and *euthophication*. Going from 2 to 3A Emissive Stage *acidification, eutrophication, photochemical* and *particulate matter formation* are reduced, except for the case with CAN-bus because on-field measurements are subject to higher variability than in steady-state conditions and higher emissions can take place.

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