Robots and Transformations of Work in Farms -Protocol for a Systematic Review

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Protocol for a Systematic Review

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Abstract

In developed countries, the number of people working in agriculture keeps going down. Agricultural work is changing as wage-earning is increasing as well as part-time work and outsourcing. At the same time, robots are developed in many agricultural sectors (livestock, horticulture, field crops) and are part of the changes in work. This systematic review protocol details the method used to answer two questions related to robots and work in agriculture. First, we question what the transformations of work in agriculture are related to robots. Secondly, we will identify the explanatory factors of robotization in relation to work in farms. We have used a research query in order to find the different approaches and disciplines interested in work in agriculture. Two databases have been querying: Web of Science and Scopus. The data selection will include a screening stage using *Rayyan*®, a web app facilitating systematic reviewing. Eligibility criteria are detailed and a risk of bias analysis is designed. Finally, we detail the axes of analysis that will be used for the qualitative analysis.

Introduction

Since its introduction in our language by science fiction and C.Kapek in 1920 (Capek 2011), the word *robot* has always been the object of hope or fear. On one hand, robotization is expected to enhance our lives, release from hard works and even represent a hope for a job liberation (Asimov 1950). On the other hand, robotization and automation threaten some jobs and even our social organization built around work (Rifkin 1995). But social sciences show that it is more about a displacement and a deep transformation than a replacement (Dujarier 2008, Autor 2015, Flichy 2017, Gaborieau 2017, Askenazy and Bach 2019, Casilli 2019).

Agriculture has long been concerned with robotization. Since the late 1990s in Western and Northern Europe, many dairy farms have introduced automated milking system. Furthermore, nowadays new stakeholders arrive in the agricultural sector such as start-ups and venture capitalists (Rotz, Duncan, *et al.* 2019). They are following – or encouraging - a movement of digital revolution in agriculture (Himesh *et al.* 2018) which represents a promising market. New agricultural sectors are concerned by robotics such as aquaculture, horticulture, vine-growing or field crops (Duckett *et al.* 2018). In developed countries, this robotization takes place in a context of transformation of agricultural work. Between 2007 and 2013, the agricultural employment in European Union dropped by 19% (Hostiou *et*

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al. 2020) related to a significant labour productivity gain. In France, while the historical family farming model is still the majority, there has been unprecedented growth in the number of salaried workers (Centre d'Études et de Prospective, 2019). Job insecurity and part-time, outsourcing, diversification, rising of suicide or differentiation by skill levels are all transformations of agricultural work in developed countries. These two phenomena - robotization and work transformations - raise questions about their possible interactions. But agriculture is rarely the subject of such analyses linking robotization and global transformations of work (Hostiou *et al.* 2017, Carolan 2019).

The diversity of disciplines and scientific communities (Malanski *et al.* 2019) interested in work in agriculture encourages a systematic review to describe the full range of work transformations related to robotics. This present review is also a means of questioning robotization across all relevant agricultural sectors and countries. The purpose of this systematic review is to answer two questions about the links between work and robotization in agriculture. First, we will question what the transformations of work in agriculture are related to robotics. Secondly, we will identify the explanatory factors of robotization in relation to work in farms.

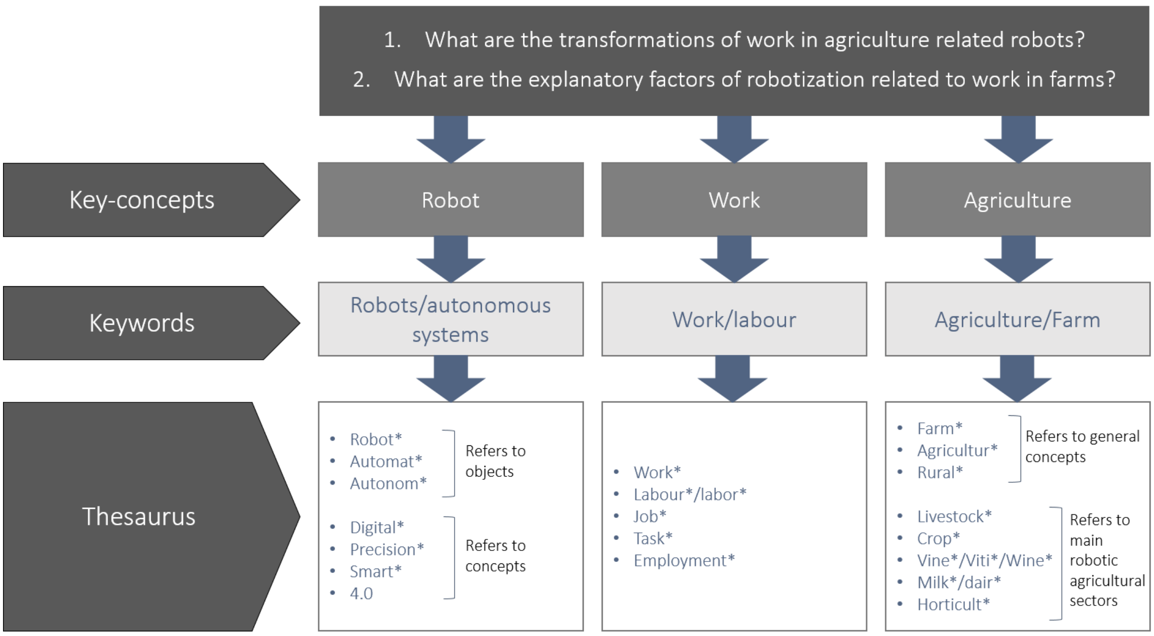
Several methods can provide answers to these questions. We have chosen a systematic review of literature (SRL) considering that literature already provides a diversity of answers that can be synthesized by the systematic approach. According to Petticrew & Robert "*systematic reviews are literature reviews that adhere closely to a set of scientific methods that explicitly aim to limit systematic error (bias), mainly by attempting to identify, appraise and synthesize all relevant studies (of whatever design) in order to answer a particular question (or set of questions)"* (Petticrew and Roberts 2006). A SRL is an original approach in agricultural social sciences and none has ever been done on work in agriculture. This review is also a methodological contribution and proposition to shed light on certain research questions within our scientific community.

Methods

Concepts and framework

✓ From key-concepts to the query

Figure 1: Translate a research question into keywords and thesaurus for query construction



✓ Work in agriculture: framework and thesaurus

The main difficulty of our review question lies in the concept of "*work in agriculture*". In fact, "*work*" is a polysemic word and rich in a variety of ways of seeing. Each discipline, each current of thought has its own definition of work: e.g. sociology of work, ergonomics, economics, zootechnics, agronomy. This disciplinary diversity is accompanied by a diversity of analytical frameworks and approaches, what we call *dimensions of work*. All dimensions of work are concerned by robotization, thus the robot invites to consider work from a multidisciplinary perspective. Several hypotheses about work transformations related to farm robotization are the motive for a systematic review. We have classified these hypotheses into four dimensions: farm structure, technical-economic performances, work organization and meaning of work. These dimensions reflect both the disciplinary diversity of the work in agriculture and the systemic transformations that the robot produces.

i. Different hypotheses are relating to **structural changes** on the farm and in the labour market. Robotization would encourage an increase in farm size (Rotz *et al.* 2003, Fleming *et al.* 2018), changes in social relation of production (e.g. use of off-farm work, wage labour development), changes in added value distribution, work segmentation and wage inequality as a result of high-skill/low-skilled bifurcated labour market (Kristal and Cohen 2017, Rotz, Gravely, *et al.* 2019).
ii. Other hypotheses concern **technical-economic performances**. We assume that robotization is generally accompanied by an improvement in technical work performances: yield increase, physical labour productivity (yield/worker) and economic labour productivity increase (NVA[6]/worker). However, this is accompanied by an increase in production costs, a decrease in the economic productivity of the land (NVA/ha) and changes in agricultural products quality (e.g. milk quality in the case of AMS[7]).
iii. The third sort of hypotheses concerns **work organization**. Our framework of work organization is composed of two dimensions: individual organization on-farm level and collective organization (on-farm and off-farm levels). On the one hand, at on-farm level, we assume that robotization changes task repartition between workers and time organization (farming system approach - N. Hostiou & Dedieu, 2012). We assume that robotization lead to a decrease in on-call work, the appearance of new tasks and the disappearance of some tasks, a new working time management. On the other hand, the collective dimension of work organization is also concerned. Our hypotheses are that robotization changes self-help groups and are created robot focus groups. We also suppose that the work collaboration of farmers changes. In particular, we assume the new role of advisers and new relations between farmers and advisers. Technicians of robotic companies could be new stakeholders into farm work.
iv. Last, the **meaning of work** brings together different aspects of the subjective dimension of work (Fiorelli *et al.* 2010).
    a. We assume that the robot allows a lower physical workload and arduousness. But it can also increase the mental workload by the permanence of the man-machine relationship via digital intrusion;
    b. New individual identities (e.g. job representation) and feeling of community could go along with robotization. This may also encourage a blurring of the boundaries between professional and personal life (links between spaces and identities);

[6] Net Value Added
[7] Automated Milking System

c. The relationship with animals and plants can be transformed by robotization (e.g. work relation with animals, plant representation from a living object to a data system);
d. The construction of the rationality can be affected by the robotization with an increase of metric representations of reality and less resort to sensitive observations of living things.

These hypotheses depend both on the type of production and on the type of robot. The types of farms and forms of labour mobilization should also be determinant.

In elaborating the research query, we need to cover the disciplinary and conceptual diversity of work in agriculture while eliminating into results background noise as much as possible. First we have referenced all its thesaurus using AGROVOC (Caracciolo *et al.* 2013). Then we compared our thesaurus of "*work*" with other major reviews related to work in agriculture (Hostiou *et al.* 2017, 2020, Malanski *et al.* 2019). "*Work*" is the term most commonly used in scientific communities interested in work in agriculture (Hostiou et al., 2020; Hostiou et al., 2017; Malanski et al., 2019). "*Labor*" or "*labour*" are mainly used in sociology and economy to look at work as a social relationship to each other but also as a performance (labour productivity). "*Job*" often refers to the notion of identity and status. The "*Task*" is mainly an ergonomic vision of work. Last, "*Employment*" generally refers to a macroeconomic vision of work. Obviously, the semantic boundaries are more complex. But we have tried to restore this semantic diversity in order to analyse the transformations of work in all its dimensions.

✓ **Robot definition and thesaurus**

Thinking a systematic definition of the robot is difficult since its conception evolves in time and space. *Robot* covers very different realities from the first robots in the beginning of the 20th seeking to copy animal behaviour to validate biological and psychological hypotheses (Meyer 2015) and today's the "social robots" that integrate the social rules and behaviours of humans (Belpaeme et al. 2018). The forms and uses of robots are also diversified as Erico Guizzo from the IEEE[8] points out:" « *There are robots the size of a coin and robots bigger than a car. Some robots can make pancakes. Others can land on Mars*» (Guillot 2018). As a result, the scientific community does not share a clear definition of a robot.

The most commonly used definition of a robot comes from the Robotic Industries Association (RIA) which defines the robot as "*a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed functions for the performance of a variety of tasks*". Its definition is complex and debated because it refers to the different conceptions of work and autonomy. Moreover, this definition does not seem to be adapted to the agricultural context. There are at least four elements that make agriculture a special sector and justify a specific definition for agricultural robot. First, farm activities are deeply settled in ecosystems and farmers work with living beings as animals and plants. Secondly, agriculture involves a wide variety of tasks: e.g. animal care, tillage, equipment maintenance, accounting. Thirdly, agriculture is subject to great variability, both due to natural conditions (climate, pests) and the volatility of food prices. Finally, it is important to consider that 90% of farms around the word are family farms[9] (FAO[10]) with its particular work organizations, social relations and economic reasoning (Tchayanov 1990, Gasselin *et al.* 2014, Bosc *et al.* 2018). These specificities make agriculture a different sector especially from

[8] Institute of Electrical and Electronics Engineers
[9] 90% of farm are run by an individual or a family who rely primarily on family labour
[10] http://www.fao.org/zhc/detail-events/fr/c/272677/

industry - the first sector concerned by robotization – in which the division of labour, its organization and social relations are wholly singular.

Lowenberg-DeBoer et al. (2020) proposes a definition of a *field crop robot: "a mobile, autonomous, decision-making, mechatronic device that accomplishes crop production tasks (e.g. soil preparation, seeding, transplanting, weeding, pest control and harvesting) under human supervision, but without direct human labour*". Here, the *mobile* character is essential and adapted to the dispersion of the field crop plots. But it is not compatible with livestock robots as automated milking system. Because this definition is limited to field crops, we propose here a definition of the agricultural robot adapted to the different farming sectors. For this definition, we refer to the different concepts mobilized in the different existing definitions (cf. Annexe 2):

- robot's autonomy and no human intervention;
- decision-making : adaptation to the environment through data collection and analysis;
- multifunctional: performs different tasks;
- re-programmable via a man-machine interface;

The concepts of *robot's autonomy* and a relative independence of human work are mobilized by Lowenberg-DeBoer et al. (2020) as usual into the different definitions of the robot (cf. Annexe 2). In agriculture, autonomy refers to the autonomy of farmers. This is why we prefer the concepts of *adaptation* to its environment. This adaptation is allowed by data collection (via sensors), data analysis (software) and tasks modulation (via actuators). This adaptation to the environment is what differentiates the robot from the automate (Guillot 2018). The agricultural robot environment differs from an industrial robot environment by a relationship to the living beings (animals and plants). The robot does not require direct human intervention. However, it is not independent of human labour, whether for its manufacture, its maintenance or for the new tasks it imposes (e.g. programming, data interpretation). So we prefer to specify that robot performs without *direct* human intervention.

The concept of *decision-making* is also often used for the robot's definition. Because *decision* is an important concept for farm system and farmers' choice analysis, using it for the *robot* is ambiguous. A farmer's decision cannot be substituted by a robot especially because it enlists cognitive and affective dimensions (Carpentier-Roy 1992, Cerf and Sébillotte 1997, Dejours and Gernet 2016). So we have decided to rule it out. *Multifunctionality* and *re-programmability* are also usually used into robot definitions.

After all, we propose a definition of the agricultural robot (AR) that will be used for the selection of publications and compatible with different agricultural sectors (vine-growing, livestock, field crop, horticulture). This definition of the AR includes three parts: i. what does it do? ii. what it is? iii. what does it produce?

An agricultural robot is an re-programmable mechatronic[11] device that performs different farming tasks without direct human intervention and adapted to its environment through data collection and analysis. The agricultural robot is characterized by interactions with the biological and physical environment (plants, soil, animals, etc.). It is composed of a hardware artefact made up of one or more sensors (data collection) and actuators (tasks making) and a software artefact that allows data analysis (task modulation). The agricultural robot produces tasks (actuators), data (sensors) and services (data analysis).

[11] Combination of electrical, mechanical and computer engineering

This definition is a first proposition for publication selection and will certainly evolve during the final analysis of the papers. It is a starting point for understanding what is and what is not a robot in agriculture.

For the query research, we used two types of robot thesaurus. The first type refers to object and their characteristics: “autonomous” and “automated”. The difference with “robot” is not explicit given the difficulties to define the robot. So, “autonomous systems” or “automated systems” are commonly used as a “robot” synonym. The second type of thesaurus refers to concepts. The robot can be included into broader concepts as precision agriculture, digital agriculture, smart farming or agriculture 4.0. Consequently, we considered these concepts in our query.

- ✓ **Agriculture thesaurus**

Work transformations after robotization can be studied on specific tasks and not on the whole farm organization. Below (Table 1), we have referenced the agricultural tasks that are subject to robotization. This list is not exhaustive given the diversity of robot definitions and the rapid development of the agricultural robotic sector. So using these tasks for the research query represents a risk of non-exhaustiveness. So we preferred to reference the main agricultural orientations concerned by robotization: livestock, dairy farming, field crops, horticulture and vine-growing. These terms are sometimes preferred to generic terms (farm, farming, agriculture).

Table 1. Agricultural tasks robotized at farm level

CROPS FARMING (Aravind *et al.* 2017)	*LIVESTOCK* (Allain 2019)
Harvesting, picking Tilling (soil works) Crop scouting and control Seeding and transplanting	Milking Feeding Cleaning Treatment Transport

We choose not to include aquaculture, although it is sometimes associated with the agricultural sector. Indeed, work and robotics in aquaculture refer to very different technical, economic and social realities from those of agriculture.

✓ PICO framework

We use a PICO framework for the formulation of our systematic review question (Methley *et al.* 2014). We present the different component of the PICO search tool in the table below:

Table 2: Participants, Interventions, Comparators and Outcomes - PICO description

PICO COMPONENTS	
Participants **(population)**	Farm, farm system, farmers and farm workers in all agricultural sectors (e.g. field crops, livestock, horticulture, vine-growing) (in consistency with our work analysis framework)
Interventions **(exposures)**	Adoption of robots for farming (in consistency with our robot definition – page 5)
Comparators **(control)**	• Farm **without** robots • Farm **before** robot adoption
Outcomes	• **Farm structure and labour market:** farm size, social relationship of production (e.g. family work, wage labour), added value distribution, any variable related to production factors organization and interaction (land, labour and capital) and labour market; • **Performances**: i. Technical indicators (e.g. yield, efficiency, quality of milk, energy sobriety, input economy); ii. Economic indicators (e.g. productivity, incomes, surplus, job created); • **Organization** at individual and collective levels**:** For both organization dimensions, we will pay particular attention to the autonomy of work and workers: iii. On-farm level: any analysis related to the question: who do what and when? iv. Off-farm level: any analysis related to off-farm work as advisors, robot technicians and collective organizations (e.g. self-help groups, roles of robot technicians, new roles for farm advisors); • **Meaning:** i. Mental and physical workload (e.g. arduousness, digital intrusion) ii. Individual and collective identities (e.g. job representations, feeling of community) iii. Relation to the living (plants, animals, ecosystems) iv. Pleasure at work v. Rationality construction (e.g. metric, pragmatic, economic)

Research strategy

✓ Information sources

We use two databases: *Web of Science Core Collection* (WoS) and *Scopus*. Some articles identified during the query test phase can be added to the corpus after validation by at least two reviewers. Grey literature publications may be added if they are cited in peer-reviewed articles into the corpus and thus recognized as useful by the scientific community (reports from collectives, research or consulting offices and written by scientists).

✓ The query

For this query, we will consider articles, books, book chapters and reviews. We exclude proceeding papers because they are part of a publication process but do not necessarily represent a finalized scientific work. There are no limits on disciplines, methods and countries. Indeed, the aim is also to show how the question of the transformation of work in robotic farms come up according to disciplines, periods and countries. We collect all this document published between 1955 and 2020. The 1990s correspond to the development of the first milking robots –automated milking system- on dairy farms. It is therefore from these years onwards that the number of publications increases. However, it will be pertinent to analyse how the robotization of work in agriculture issues has evolved over time. The robot question in agriculture has been asked earlier (Sistler 1987, Kawamura and Namikawa 1989). This SRL will enable to see whether older publications have addressed the issue. The search will only include articles in English.

After several tests to assess the relevance of the terms included into our query, we have retained the following equation. Below, we detail our query for the WoS database. We use the same query for Scopus - some differences are due to the syntax and Boolean operator's specificities.

Our three key concepts - robot, agriculture and work - are broad and imprecise concepts. A search associating these three concepts with AND in the field TOPICS gives too much background noise. That's why we have associated these terms two by two in the title and the remaining third in the TOPICS.

✓ WoS research

Set 1:	TI=(robot* OR automat* OR autonom* OR digital* OR precision* OR smart* OR 4.0)
Set 2:	TS=(work* OR labor OR labour OR job* OR task* OR employment*)
Set 3:	TS=(farm* OR agricultur* OR livestock* OR crop* OR horticultur* OR vine* OR wine* OR viti* OR dair* OR milk* OR rural*)
Set 4:	TI=(work* OR labor OR labour OR job* OR task* OR employment*)
Set 5:	TI=(farm* OR agricultur* OR livestock* OR crop* OR horticultur* OR vine* OR wine* OR viti* OR dair* OR milk* OR rural*)
Set 6:	TS=(robot* OR automat* OR autonom* OR digital* OR precision* OR smart* OR 4.0)

SUB-SETS/RESEARCH FIELDS	TITLE (TI)	TOPICS (TS)
#1 AND #4 AND #3	R AND W	F
#1 AND #5 AND #2	R AND F	W
#4 AND #5 AND #6	W AND F	R

R: Robot; W: Work; F: Farm

Query used (sum of the 3 sub-set):

((#1 AND #4 AND #3) OR (#1 AND #5 AND #2) OR (#4 AND #5 AND #6))

Language : English
Document types : Article OR Book OR Book Chapter OR Review
Custom year range : 1955 to 2020
Web of Science Core Collection : SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI

✓ **Scopus research**

((TITLE(robot* OR automat* OR autonom* OR digital* OR precision* OR smart* OR 4.0)) AND (TITLE(work* OR labor OR labour OR job* OR task* OR employment*)) AND (TITLE-ABS-KEY(farm* OR agricultur* OR livestock* OR crop* OR horticultur* OR vine* OR wine* OR viti* OR dair* OR milk* OR rural*))) OR ((TITLE(robot* OR automat* OR autonom* OR digital* OR precision* OR smart* OR 4.0)) AND (TITLE(farm* OR agricultur* OR livestock* OR crop* OR horticultur* OR vine* OR wine* OR viti* OR dair* OR milk* OR rural*)) AND (TITLE-ABS-KEY(work* OR labor OR labour OR job* OR task* OR employment*))) OR ((TITLE(work* OR labor OR labour OR job* OR task* OR employment*)) AND (TITLE(farm* OR agricultur* OR livestock* OR crop* OR horticultur* OR vine* OR wine* OR viti* OR dair* OR milk* OR rural*)) AND (TITLE-ABS-KEY(robot* OR automat* OR autonom* OR digital* OR precision* OR smart* OR 4.0))) AND (LIMIT-TO (PUBSTAGE,"final")) AND (LIMIT-TO (DOCTYPE,"ar") OR LIMIT-TO (DOCTYPE,"re") OR LIMIT-TO (DOCTYPE,"ch") OR LIMIT-TO (DOCTYPE,"bk")) AND (LIMIT-TO (LANGUAGE,"English"))

✓ **Selection process: the screening**

Each stage of article selection involves at least two participants (2 for screening and 3 for eligibility). Any conflict between participants regarding this selection will be arbitrated during a meeting to discuss and decide.

EndNote® will be used to remove duplicates after article extraction from the two databases. For the first studies selection stage – the screening -, we will use Rayyan®, a free web app, "*that helps expedite the initial screening of abstracts and titles using a process of semi-automation*" (Ouzzani *et al.* 2016). Two reviewers - T. Martin and P. Gasselin - will carry out this screening without the possibility to see the choice of the other.

✓ **Selection process: eligibility criteria**

Then, an assessment of eligibility will be conducted. As well, three reviewers will be in charge of this assessment for eligibility: P. Gasselin, N.Hostiou and T. Martin (Annexe 2). This selection follows pre-established criteria:

- Language: English;
- The type of technology considered is well characterized: we will exclude publications that deal with broad concepts as precision farming, smart farming and agriculture 4.0 if the type of technology is not specified – our **intervention** concerns robots;
- Work in agriculture is considered at farm level: we will not consider work transformations in food process firms – our **population** PICO contains farm, farm system, farmers and farm workers;
- At least one of the dimensions of work in agriculture is addressed (PICO framework): farm structure, performances, organization and meaning;

Data analysis

✓ **Outcomes**

Two different types of data will be extracted from articles. Qualitative data concerning work organization changes and meaning of work will be extracted. Some quantitative data will be considered related to work performances (e.g. labour productivity, yields per worker). But we will not carry out a meta-analysis and thus extract its data. We will limit our analysis to collecting the conclusions of quantitative analyses (e.g. increase or decrease in productivity, increase or decrease in working time). If the variability of the conclusions and the number of data allow it, a meta-analysis can be carried out afterwards. Thus, this review does not include quantitative analysis.

✓ Risk of bias

The risk of bias can compromise the proof of evidence related to work transformation. The risk of bias analysis does not constitute a review or an assessment. First of all, we consider that in science every methodological approach can be improved. Secondly, this bias analysis does not constitute an absolute evaluation but an assessment relative to our question and our choice of analytical framework. So there's no judgement on the methodological choices made. The risk of bias depends on four criteria:

- No sample description (characterization of the farm diversity considered)
- No robot description: the robot considered must be identified (brand and model) or described in detail to be able to assess his compatibility with our robot definition.
- No worker characterization: who are we talking about? (e.g. a farmer, a family member, a seasonal worker, an outsource worker); What type of work, tasks? (e.g. milking, herd observation, harvesting)
- Comparison robustness: more generally, the main risk of bias is to attribute work change that does not come from the robots but from structural changes on the farm or from the farm's socio-economic and regulatory context.

We classify the risk of bias at three levels – *high*, *moderate* and *some concerns* - according to the aggregation of pre-established criteria. The aggregation method, i.e. the weight of each criterion will be detailed later according to the types of studies included in qualitative analysis. We use this table for each publication in order to assess the risk of bias.

Table 3: Risk of bias assessment

Study	Sample description	Robot description	Worker characterization – Who ?	Worker characterization – What ?	Comparison robustness	Risk of bias
1	Y/PY/PN/N/NI	Y/PY/PN/N/NI	Y/PY/PN/N/NI	Y/PY/PN/N/NI	Y/PY/PN/N/NI	• High • Moderate • Some concerns

Y: Yes, **PY**: Probably Yes, **PN**: Probably No, **N**: No, **NI**: No Indication

✓ Qualitative analysis

Our work analysis framework consists of three axes. The first corresponds to the performances of the work. No data extraction is foreseen but an analysis of the conclusion with regard to the other axes of analysis. The second axis is work organization. Here we consider the individual organization of work through the temporal arrangement of the different tasks of a worker. The notions of autonomy and constraints are central to our analysis. We will also consider the collective organization of work both on and off the farm (e.g. for France: CUMA, self-help groups). Thirdly, we will analyse work through its meaning, i.e. all the perceptions, values and other things that discourses can provide.

The work transformation analysis method is based on a comparative approach. First of all, this comparison will be made between robotized and non-robotized farms or before and after robot adoption. Then, we will compare:

- The different types of farms (e.g. size, type of work, crop and livestock diversity)
- The different productive sectors (e.g. dairy, field crops, horticulture)
- The different countries studied

Bibliographic context

✓ Preliminary research

In order to verify the relevance of our systematic review project with regard to the state of the art, we carried out a search on Web Of Science (WoS). The goal is to check that no review has been performed on our research question. Initial research confirmed that there is no review concerning work and robot in agriculture. The query used for this preliminary research is the following:

Web of Science Research

TI=((work* OR labor OR labour OR job* OR task* OR employment*) AND (robot* OR automat* OR autonom* OR digital* OR precision* OR smart*) AND (farm* OR agricultur* OR livestock* OR crop* OR horticultur* OR harvest* OR milk* OR pick* OR rural OR feed*) **AND review**)

Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI Timespan=1955-2020

Table 4: Review related to the work in agriculture - WoS research on 04/04/2020

TITLE	YEAR	AUTHORS	JOURNAL
Precision farming for increased land and labour productivity in semi-arid West Africa. A review doi: 10.1007/s13593-017-0424-z	2017	Aune, Jens B.; Coulibaly, Adama; Giller, Ken E.	Agronomy for Sutainable Developement
Task-based agricultural mobile robots in arable farming: A review doi:10.5424/sjar/2017151-9573	2017	Aravind, Krishnaswamy R.; Raja, Purushothaman; Perez-Ruiz, Manuel	Spanish Journal of Agricultural Research
Impact of precision livestock farming on work and human-animal interactions on dairy farms. A review doi: 10.25518/1780-4507.13706	2017	Hostiou, Nathalie; Fagon, Jocelyn; Chauvat, Sophie ; Turlot, Amélie ; Kling-Eveillard, Florence; Boivin, Xavier; Allain, Clément	Biotechnologie Agronomie Société et Environnement

This research gives three results. None of these three reviews are systematic. This first review (Aune *et al.* 2017) looks at the effects of the types of seed used and the fertilization applied on yields. Moreover, it is specific to West Africa. This review illustrates the plasticity of certain concepts such as precision agriculture. Here the precision agriculture practises are seed types, mineral fertilization and manure (Aune *et al.* 2017). In other cases, precision agriculture is defined as "*a whole-farm management approach using information technology, satellite positioning data, remote sensing, and data gathering*" (Koutsos and Menexes 2017). The second review (Aravind *et al.* 2017) is limited to crop farming and does not include livestock. It is an overview of robots in open arable farming and robots are categorized by the type of operation (e.g. tilling, harvesting, crop scouting and control, seeding). There is no work transformation analysis. The third review is the closest to our research question. It focuses on the transformations of work in precision livestock with special attention to robots (milking and feeding). It provides a relevant example of work transformations analysis. However, it is limited to animal production and is not systematic.

This research confirms the absence of systematic review related to robotics systems and work transformations in agriculture. It also indicates the presence of a scientific community interested in the work transformations and technologies in livestock (Hostiou *et al.* 2017, Dedieu 2019, Malanski *et al.* 2019, Servière *et al.* 2019).

✓ Corpus of publications used for query testing

The following table includes essential articles with regards to work in agriculture. All these publications will have to be in the final list of publications. We use this list as a test list for query assessment. This test list has been produced through an alert system for new publications and a non-systematic review related to robots and work in agriculture.

Table 5: Publications corpus for the query test

TITLE	YEAR	AUTHORS	JOURNAL
Automated agrifood futures: robotics, labor and the distributive politics of digital agriculture https://doi.org/10.1080/03066150.2019.1584189	2019	Carolan, Michael	The Journal of Peasant Studies
Automatic herding reduces labour and increases milking frequency in robotic milking http://dx.doi.org/10.1016/j.biosystemseng.2016.12.010	2017	Drach, Uri and Halachmi, Ilan and Pnini, Tal and Izhaki, Ido and Degani, Amir	Biosystems Engineering
Automatic Milking Systems, Farm Size, and Milk Production https://doi.org/10.3168/jds.S0022-0302(03)74032-6	2003	Rotz, C.A. and Coiner, C.U. and Soder, K.J.	Journal of Dairy Science
Comparing technical efficiency of farms with an automatic milking system and a conventional milking system https://doi.org/10.3168/jds.2012-5482	2012	Steeneveld, W. and Tauer, L.W. and Hogeveen, H. and Oude Lansink, A.G.J.M.	Journal of Dairy Science
Designing Automated Milking Dairy Facilities to Maximize Labor Efficiency https://doi.org/10.1016/j.cvfa.2018.10.010	2019	PitkÃ¤ranta, Jouni and Kurkela, Virpi and Huotari, Virpi and Posio, Marjo and Halbach, Courtney E.	Veterinary Clinics of North America - Food Animal Practice
Diversity in agricultural technology adoption: How are automatic milking systems used and to what end? https://doi.org/10.1007/s10460-014-9542-2	2015	Schewe, Rebecca L. and Stuart, Diana	Agriculture and Human Values

Economics of robots and automation in field crop production https://doi.org/10.1007/s11119-019-09667-5	2019	Lowenberg-DeBoer, James and Huang, Iona Yuelu and Grigoriadis, Vasileios and Blackmore, Simon	Precision Agriculture
Impact of automatic milking systems on dairy cattle producers' reports of milking labour management, milk production and milk quality https://doi.org/10.1017/S1751731118000654	2018	Tse, C. and Barkema, H. W. and DeVries, T. J. and Rushen, J. and Pajor, E. A.	Animal
Impact of precision livestock farming on work and human-animal interactions on dairy farms. A review https://doi.org/10.25518/1780-4507.13706	2017	Hostiou, Nathalie and Fagon, Jocelyn and Chauvat, Sophie and Turlot, AmÃ©lie and Kling-Eveillard, Florence and Boivin, Xavier and Allain, ClÃ©ment	Biotechnology, Agronomy and Society and Environment
Innovation, practical benefits and prospects for the future development of automatic milking systems https://doi.org/10.15302/J-FASE-2016117	2017	Jiang, Hongzhe and Wang, Wei and Li, Chunyang and Wang, Wei	Frontiers of Agricultural Science and Engineering
Invited review: The impact of automatic milking systems on dairy cow management, behaviour, health, and welfare https://doi.org/10.3168/jds.2011-4943	2012	Jacobs, J. A. and Siegford, J. M.	Journal of Dairy Science
Robot innovation brings to agriculture efficiency, safety, labor savings and accuracy by plowing, milking, harvesting, crop tending/picking and monitoring https://doi.org/10.1108/IR-08-2014-0382	2014	Bloss, Richard	Industrial Robot
Robotic milking: Technology, farm design, and effects on work flow https://doi.org/10.3168/jds.2016-11715	2017	Rodenburg, Jack	Journal of Dairy Science
Robotics and labour in agriculture. A context consideration https://doi.org/10.1016/j.biosystemseng.2019.06.013	2019	Marinoudi, Vasso and SÃ¸rensen, Claus G. and Pearson, Simon and Bochtis, Dionysis	Biosystems Engineering

Administrative information

Authors

Table 6: SRL participants

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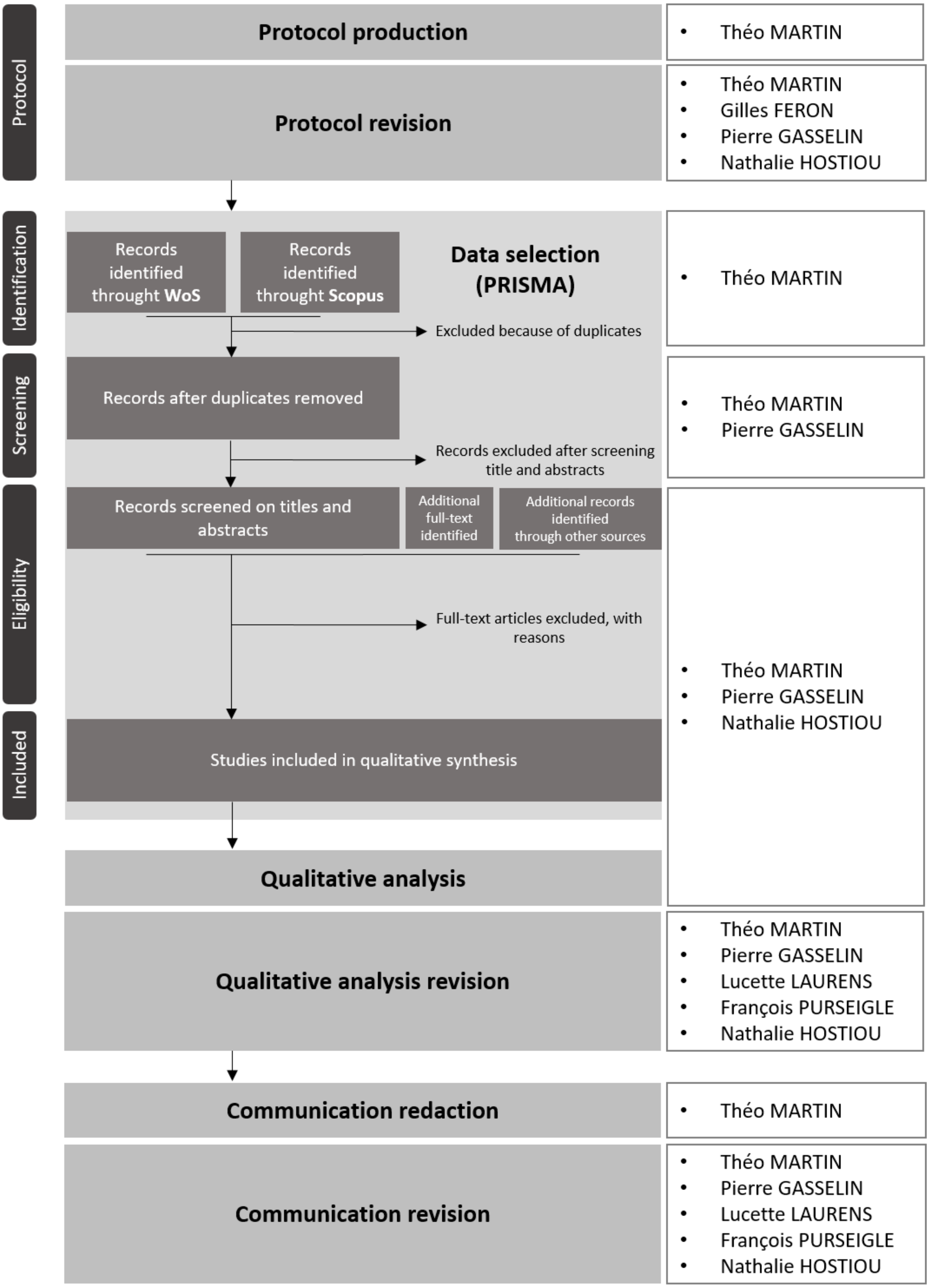
Authors contributions

This SRL is part of a PhD study led by Théo Martin (UMR Innovation – INRAE). He leads this review and therefore participates in all stages. Pierre Gasselin, co-director of the thesis participates in the review of the protocol, the selection of papers (screening and eligibility), the analysis and writing stages. Nathalie Hostiou, participates in the protocol review, paper selection by eligibility criteria, qualitative analysis and writing stages. Lucette Laurens, co-director and François Purseigle, supervisor of the thesis, contribute to the qualitative analysis phase and the paper review. Gilles Feron has contributed to the formulation of this protocol as part of its expertise in systematic review. The Annexe 2 details the contributions of each.

Annexes

Annexe 1: Authors contributions based on PRISMA diagram (Moher *et al.* 2010)



Annexe 2: examples of robot definition

SOURCE	REFERENCE	TYPE OF INSTITUTION	YEAR	ROBOT DEFINITION PROPOSED	KEY-CONCEPTS
Robotic Industries Association (RIA)	(Reddy *et al.* 2016)	Trade association (US)	1979	"A **robot** is a reprogrammable, multifunctional manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks."	• Reprogrammable • Multifunctional
Erico Guizzo, Institute of Electrical and Electronics Engineers (IEEE)	(Guizzo 2019)	Science	2019	« A **robot** is an autonomous machine capable of sensing its environment, carrying out computations to make decisions, and performing actions in the real world »	• Autonomous • Decision-making
International Journal of Mechanical & Mechatronics Engineering	(Yaghoubi *et al.* 2013)	Science	2013	« A **robot** is a machine that can be programmed and reprogrammed to do certain tasks and usually consists of a manipulator such as a claw, hand, or tool attached to a mobile body or a stationary platform. »	• Reprogrammable
British Robot Association	(Ahmad Nayik 2015)	Trade association (UK)	n.d	"An **industrial robot** is a reprogrammable device designed both to manipulate and/or transport parts, tools, or specified manufacturing implements through variable programmed motions for the performance of specific manufacturing tasks."	• Reprogrammable
International Standards Organization (ISO)	(Ahmad Nayik 2015)	International organization	n.d	**Robot** as "An automatically controlled, re-programmable, multi-purpose, manipulative machine with several degrees of freedom, which may be either fixed in place or mobile for use in industrial automation applications."	• Reprogrammable • Multifunctional • Several degrees of freedom (Autonomy)
(Lowenberg-DeBoer *et al.* 2020)	(Lowenberg-DeBoer *et al.* 2020)	Science	2020	**Field crop robot** as "a mobile, autonomous, decision-making, mechatronic device that accomplishes crop production tasks (e.g. soil preparation, seeding, transplanting, weeding, pest control and harvesting) under human supervision, but without direct human labour"	• Mobile • Autonomous • Decision-making • No direct human labour
LEO ROBOTICS : Center for service robotics	http://www.leorobotics.nl/definition-robots-and-robotics	Collaboration of regional corporations and universities	n.d	"A **robot** is an actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks. Autonomy in this context means the ability to perform intended tasks based on current state and sensing, without human intervention."	• Programmable • Autonomy • No human intervention
"Le temps des robots est-il venu ? : Découvrez comment ils transforment déjà notre quotidien"	(Braly and Gasnascia 2017)	Science	2017	"un **robot** est lui capable de collecter des informations sur son environnement, de les analyser et d'adapter ses actions en conséquence, de manière autonome sans intervention humaine."	• Autonomous • No human intervention

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