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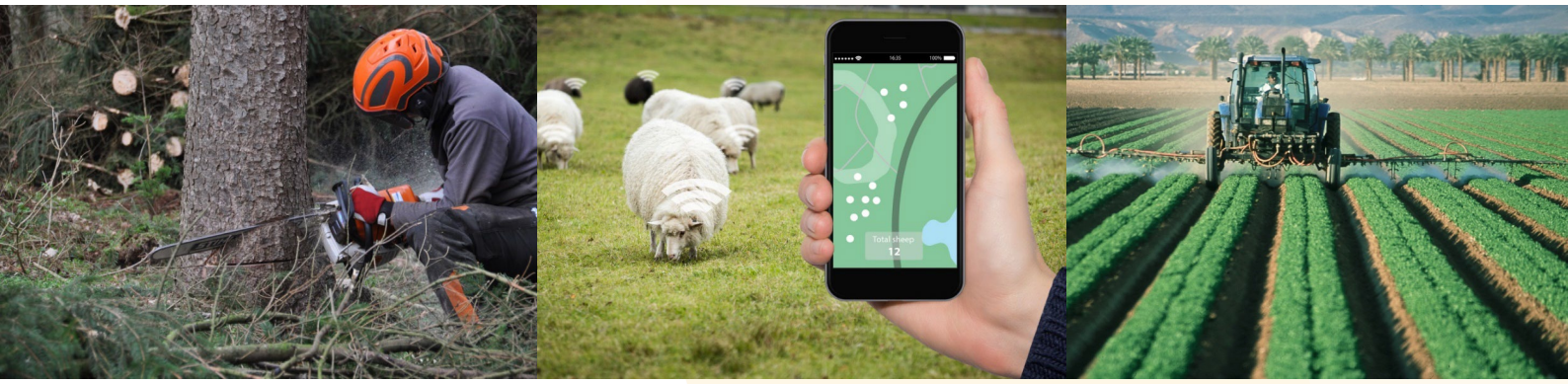

Review of the future of agriculture and occupational safety and health (OSH)

Foresight on new and emerging risks in OSH

European Risk Observatory

Report

European Agency for Safety and Health at Work

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Executive summary

This report has been commissioned by the European Agency for Safety and Health at Work (EU-OSHA) with the objectives of, first, examining future developments in the agriculture sector and, second, considering the implications of these trends for occupational safety and health (OSH).

A sector with serious occupational safety and health challenges

Agriculture and forestry are among the most dangerous professions in Europe, with a high level of accidents affecting the sustainability and viability of the sector. Over the last 10 years, there has been an average of over 500 registered deaths per year in the agriculture and forestry sector and over 150,000 non-fatal accidents (Eurostat, 2017). Recent research indicates that there is significant under-reporting of both fatal and non-fatal accidents in the agriculture and forestry sector throughout Europe (Merisalu et al., 2019). In many instances, national reporting also places agriculture and forestry top or almost top among sectors in terms of the level of risk.

Farmer health is a key issue in the sector. Coronavirus disease 2019 (COVID-19) and the related OSH risks highlight the importance of health and working conditions in the sector with the European Commission establishing guidelines to protect seasonal workers, including their safety and health (EC, C2020 4813 final) and some Member States establishing guidelines for the agricultural sector (OSH wiki 2020 on COVID-19). Over 60 % of agricultural workers report having a limiting chronic disease and high levels of cardiovascular disease (CVD). According to an EU survey from 2012, workers from the agriculture sector were more likely than those in any other sector to report that their work affected their health (Eurofound, 2012). Eurostat (2010) also reported that work-related health problems occur more often in the 'agriculture, hunting and forestry' sector along with in the mining and quarrying sector than in any other sector. This is related to the fact that some of the least favourable job characteristics, such as manual work and atypical working hours, are more prevalent in these sectors. This report summarises a number of OSH risks that affect farmers and foresters. Pesticide-related risks, musculoskeletal disorders (MSDs), zoonoses, skin cancer, and stress and psychosocial issues are all major emerging and continuing risks in the sector that either have not been adequately managed or have been underestimated owing to lack of accurate data over the years.

A sector in transition

This report reviews the future trends in agriculture and forestry, such as new technologies and climate change, identifies the resulting technological and organisational changes in the sector and defines the implications for OSH among farmers, foresters and other workers in this sector. The report looks at a number of potential emerging risks, particularly those that are the most imminent, namely those linked to digital evolution in the sector and resulting from climate change. The review aims to support policy-makers at European and national levels in their development of strategies, regulations, and enforcement, guidance and support measures.

The report examines a number of issues affecting the future of farming and forestry: smart farming (precision farming, digitalisation, etc.) and other technology developments; climate change and environmental issues; society and consumer trends; the labour market and organisational issues; and international trade and economic considerations.

Smart farming (digitalisation and the use of new technologies) has been the subject of much attention in the sector, being identified as one of the few innovations that could potentially bring about a paradigm shift in productivity and increase food production.

According to a survey conducted by the Organisation for Economic Co-operation and Development (OECD), digital intensity ([1]) in the agriculture, forestry and fisheries sector is 'low', with agriculture being among nine other sectors in the least advanced quarter of all sectors. Another report even places the European agriculture sector as second from bottom of all industrial sectors in terms of digitalisation (Calvino et al., 2018; McKinsey Global Institute, 2016).

Resulting changes and occupational safety and health outcomes

Impact of new technologies

The uptake of smart farming and forestry practices varies significantly throughout the sector. One of the most important factors influencing uptake is farm size coupled with income. Smart technology uptake also depends on sufficient access to broadband, but only 50 % of EU rural areas have adequate access to broadband. Each country's cultural context, average level of education, generational challenges and sector-specific aspects all have a major influence on technology uptake within the EU. It is expected that the digital divide will increase the economic gap between small and large farms and between countries. The digitalisation of agriculture has the potential to impact positively on the sector, offering numerous benefits: increased agricultural production, productivity and yields; reduced production costs; improved food safety and quality through the monitoring and traceability of the food chain; increased health and welfare of livestock; and improved environmental protection resulting from allowing farmers to monitor plant health more effectively through sensors and tackle plant diseases early on.

The digitalisation of agriculture will also result in some negative impacts: a reduction in jobs in the sector; a decline in the competitiveness of small family farms; an increase in farmers' dependency on large multinationals and data and tech companies; the challenge of data security becoming a stress factor for farmers; the real safety and security threat of 'hacking' and interference; and the ethical concerns and increased worker stress related to the monitoring of workforce performance and pace through new wearable technologies.

Concerning the impact of smart farming on OSH, smart farming and digitalisation will offer a number of potential improvements in workplace safety for example by substituting capital for labour and minimising risk exposure; improving process control and safety systems management; improving machine and vehicle safety and livestock handling; offering better prevention of MSDs; reducing exposure to pesticides and hazardous substances; improving the work-life balance of farmers; improving health and safety through new smart monitoring technologies and devices; and improving safety in the forestry sector through an increase in the use of wood harvesting technology and remote-controlled felling wedges.

However, because of the slow uptake of new technologies in general, this will not offer an immediate solution to the high level of accident and OSH challenges in the sector. A key challenge that remains is how to ensure the effective adoption of such technology. This is associated with variables such as farm income and scale, farmer age and education, the usability of specific technology, and industry and extension support (support services to farmers' business) for farmers.

New technologies also need to be evaluated to see if they bring any new or additional risks to the workplace, such as new ergonomic risks. There is a need to establish safety protocols and OSH evaluation/certification systems for smart farm technologies. In addition, the use of several artificial intelligence (AI) systems together could potentially 'clutter' the farm workplace with a number of interacting technologies and multiply risk. New smart technologies could also increase the number of lone workers in forestry and agriculture, and high levels of monotony and stress have previously been associated with the introduction of new automated technologies in farming and forestry, such as automated milking systems (AMS).

([1]) Digital intensity — how the extent of digital transformation in sectors is shaped by firms' investments in 'digital' assets, as well as by changes in the way companies approach markets and interact with clients and suppliers, by the (type of) human capital and skills needed, and the way production is organised.

Likewise, the stubborn long-standing risks in the sector (such as accidents related to tractors and other machinery and animal handling, slips, trips and falls, and chainsaw use) remain largely untackled. New digital technologies will only partly offer solutions to these very serious risks with often more holistic approaches to safety and health being necessary to achieve improvements.

Genetic improvement is another technological development that has the potential to transform European agriculture. Improvements could include an increase in yields and crop quality, reducing the need for fertilisers; producing crops that are more resistant to pests or diseases (thus reducing pesticide use); and reducing the need for water or energy, resulting in less greenhouse gas (GHG) emissions.

The reduction in pesticide use through such genetic improvements would in particular result in a significant improvement in the safety and health of farmers and foresters. However, although offering several potential benefits to European agriculture, the contribution of genetic breeding techniques, including new breeding technologies, to improving OSH is likely to be limited in the foreseeable future owing to legislative and regulatory uncertainty and a high level of societal reluctance to accept such technologies.

Impact of climate change

Climate change will impact significantly on agricultural production. On the one hand, crop yields in northern Europe may increase owing to higher temperatures and certain crops may expand further north. On the other hand, drought and heat stress on plants and animals, changes in crop phenology and the extension of pests and plant diseases will impact negatively on production in other specific regions (WMO, 2020). Changes in precipitation patterns will also affect the sector, with the need for irrigation increasing. Farmers will need to modify the types of crops they grow, adapting cultivation and even animal breeds to suit the changing climatic conditions. In the forestry sector, technical measures such as more effective firebreaks and the consistent clearing of brushwood will be necessary to mitigate the risks of forest fires as extreme heat increases their likelihood. Intense heat, risk of fire and changing rainfall patterns could also influence the type of trees planted in new forests, with a shift towards species resistant to drought and high temperatures or even less-flammable tree species. Overall, climate change will contribute to unpredictability and increased risks for crops, animals and farmers.

Other environmental pressures affecting the agriculture sector include the EU's commitment to reducing pesticide use through its Pesticides Sustainable Use Directive ([2]) and the European Commission's general move towards integrated pest management (IPM) ([3]) practices. This has been reinforced by the ambitious pesticide reduction goals of the EU's farm to fork strategy ([4]), which aims to reduce the use of pesticides by 50 % before 2030.

GHG and environmental (e.g. pesticide-related) regulation will also add to pressure on farmers and foresters, obliging them to modify farming practices to make them more environmentally friendly and to improve their environmental performance in general.

OSH in the sector will also be significantly affected by climate change. Extreme weather events, heat and sun exposure, insect-borne diseases, dust and pesticide exposure, increased use of pesticides to combat insect growth and specific forestry risks (extreme danger in clearing up damaged trees due to weather and insect damage) are just a few. Farm and forestry working practices will need to be adapted to minimise the impact of these occupational risks. Such measures could include providing sufficient shade for workers; using non-reflective surfaces to protect against light; providing sufficient ventilation and cooling systems; adapting working hours and planning work to avoid heat and extreme weather; and adopting a more hands-on approach to the monitoring of working conditions, such as workers' water

([2]) Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides.
([3]) https://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides/ipm_en
([4]) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — A farm to fork strategy for a fair, healthy and environmentally-friendly food system (COM(2020) 381 final).

consumption, body heat, etc. Other measures could also help, such as more predictive weather systems and health promotion programmes on exposure to sun and insect-borne diseases.

Concerning IPM practices (see above), we will need to assess whether or not the decreased use of pesticides could impact on the health of farmers and foresters, such as by increasing the risk of musculoskeletal disorders (MSD's) (through an increase in manual weeding) and insect-borne diseases (owing to an increase in the volume of insects).

Impact of labour market trends

Self-employed farmers, who form the majority of the agricultural workforce in most countries (Merisalu et al. 2019) will continue to dominate the OSH agenda in farming and forestry.. Most self-employed farmers and foresters are not covered by OSH legislation and are very rarely inspected, and occupational accidents and ill health are very rarely reported among this group; they also have limited access to OSH resources and training and lack resources to invest in new, safer machinery and farm infrastructure. However, this problem will not be solved until the true extent of occupational accidents and illness in the sector is accurately reported, as accidents concerning many categories of worker are excluded from official data. For example, the reporting of data to Eurostat in the farming and forestry sector is not mandatory for the self-employed and family members, as they are not 'employees'.

Moreover, the frequent use of seasonal and temporary workers in certain agricultural activities, such as horticulture, brings additional risks owing to insufficient training, lack of health surveillance and cultural/language barriers, and has involved undeclared work in some instances. COVID-19 has highlighted the acuteness of some of these OSH challenges, as well as the general situation concerning living and working conditions for seasonal workers.

The major organisational challenges in the sector point to long-standing structural issues, related in particular to the labour market, farm organisation and profitability, which are all closely intertwined socio-economic considerations. Many of the labour market deficiencies (high number of self-employed, temporary, seasonal, migrant, family and older workers) that impact on the OSH conditions in the sector are difficult to remedy, while overall profitability for small farmers (low income and food price margins) also remain unsolved. The lack of decent revenue and income for small farmers undermines inclusive and preventive management approaches, such as effective OSH management practices, and limits investment in new, safer technologies, (OSH) training and skills development and decent salaries and working conditions for seasonal workers.

Trade and economy

Trade can also have impact on occupational health and safety aspects, particularly involving **biological agents and invasive species**. As far as the agriculture sector is concerned, global trade may propagate the movement of alien species, vectors and pests which can have novel or emerging impacts on farmer and forester health and safety, if species are allowed to take hold amongst the local fauna and flora. For example, the spread of ash dieback disease and elm bark beetle which increase risks in forestry have both resulted from international timber and tree movements. In addition, agricultural organisations have raised concern about weaker environmental and food safety standards for food imports and OSH and labour standards in third countries can also be significantly lower**.**

Conclusions

The EU farm to fork strategy recognises the importance of the EU Pillar of Social Rights and its application to the sector; however, there is still a major social-economic deficit in farming today, owing to the marginal profitability and low income for many small farmers (who make up the majority of farmers), undermining the social sustainability of farming and forestry. This socio-economic deficit affects the ability of the sector to fully embrace and manage growing trends, such as digitalisation,

climate change, societal pressures and labour market developments, and is very much linked to the poor level of OSH protection in the sector.

To successfully tackle future OSH challenges in the sector, it will be important to address existing, structural and future OSH issues in a comprehensive and cohesive manner, namely:

- the lack of investment in and uptake of new smart and safer technologies and machinery;
- the growing number of climate change-related risks and occupational health challenges;
- the lack of transparent and the wholly inaccurate occupational accident and ill health reporting in the sector, particularly for the self-employed;
- the fact that there is no clear OSH regulatory framework to protect farmers and foresters and manage OSH, particularly for the self-employed;
- the lack of a prevention culture (farmers and foresters tend to give low priority to OSH over other competing issues), as well as the considerable skills and training deficit, particularly in OSH;
- the existence of widespread atypical, and sometimes irregular, employment practices;
- the lack of appropriate labour inspection resources to combat undeclared work and ensure adequate protection of seasonal and migrant workers in the sector;
- the issue of insufficient farm income and quality management time with which to prioritise OSH issues, particularly for small and family farmers.

Recommendations on OSH measures

- integrate OSH considerations into the development and design of new digital, precision and smart farming technologies (and adapt farm layouts);
- adapt risk assessment techniques and health and safety training to account for new technologies, such as robots and cobots, AI;
- actively encourage the use of technology to enhance safety through the use of smart sensors, IoT, AI and smart PPE;adapt risk assessment, workplace design and awareness-raising initiatives to account for climate change circumstances, ensuring that risk assessments are in particular responsive to sometimes extreme environmental conditions that can change from one moment of the year to the next;
- improve the prevention culture in the sector, in line with international initiatives such as the Safety Culture and Risk Management in Agriculture (SACURIMA) ([5]) and International Social Security Association's (ISSA's) Vision Zero initiative, by establishing a specific sectoral prevention campaign or European network for agriculture safety and health;
- carry out specific OSH research on issues related to safety and health in agriculture (e.g. on quad-bike safety, tractor over-turns, safety-related technologies to prevent farm machinery accidents and smart personal protective equipment (PPE).

OSH related policy recommendations:

- include the self-employed in Eurostat OSH reporting for forestry and agriculture and tackle other OSH under-reporting challenges in the sector;
- promote ratification into national law of the ILO Convention on Agriculture (and its Annex on the self-employed) in order to provide a minimum legal framework for governing safety and health in the sector, particularly concerning the self-employed;
- include agriculture and forestry sector-related activities in the 2021-2027 EU OSH strategy and EU-OSHA work programmes;

([5]) https://www.sacurima.eu/

- include activities on OSH and well-being in agriculture and forestry in the Horizon Europe programme;
- establish a link between EU OSH legislation and common agricultural policy (CAP) conditionality (as the position of agricultural employers and workers organisations may differ on this point, this should be negotiated);
- encourage Member States to include safety measures and training under Pillar II of their CAP plans (CAP Pillar II Article 15 of Regulation (EU) No 1305/2013 ([6]) includes training and advice on occupational safety standards or safety standards linked to the farm as eligible for funding when included in national CAP plans);
- consider establishing a rebate scheme for retro-fitting roll-over protection (ROPS) systems (and seatbelts), which have been used in the United States ([7]) and Australia (Day et al., 2005) in view of the significant number of deaths and injuries resulting from the overturn of farm vehicles (in particular tractors and, in some countries, quad-bikes and similar vehicles).

([6]) Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) and repealing Council Regulation (EC) No 1698/2005, OJ L 347, 20.12.2013, p. 487-548.
([7]) https://www.ropsr4u.org/

1 Introduction

The aim of this report is to review the future trends in agriculture and forestry, to identify the resulting technological and organisational changes in the sector and to define the implications for the occupational safety and health (OSH) of those working in the sector. The review aims to support policy-makers at the European and national levels in their development of strategies, regulations, and other enforcement, guidance and support measures.

The report looks forwards at how the trends and changes in the sector will influence OSH risks over time. It looks at a number of issues affecting the future of farming and forestry and their possible impact on future OSH risks in agriculture. These include smart farming (precision farming, digitalisation, etc.) and other technology developments; climate change and environmental issues; societal and consumer trends; the labour market and organisational issues; international trade and economic considerations; and the impacts on occupational health of working in farming and forestry.

The report also looks at how existing risks may be influenced by new developments, such as smart farming and new technologies, climate change and labour market conditions. There is a large number of unresolved existing risks in farming and forestry that inevitably influence any future predictions in this sector. Many stakeholders consulted for this report, and much of the literature in fact, point to many urgent existing risk factors that have not yet been dealt with effectively.

The report includes a number of references to COVID-19 and its current influence on trends in the sector, as well as on working practices, labour conditions and OSH. Likewise, the report makes reference to the recently published EU Farm to Fork Strategy, which underlines the importance of safety and health and working conditions in the farming and forestry sector.

The main OSH implications for farming and forestry are divided into four sections: impact of new technologies on OSH (chapter 7); climate change and environmental factors (chapter 8); trade and economy (chapter 9); and labour market influences (chapter 10). The report provides a comprehensive list of recommendations for policy-makers and OSH practitioners to improve safety and health in the sector.

2 Methodology

This foresight report is based on three key questions that we sought to answer:

1. What are the key trends affecting the agriculture and forestry sector in general?
2. What are the resulting technological and organisational changes affecting the sector?
3. What are the likely OSH outcomes in the future?

The sectors covered in this review were agriculture, horticulture/greenhouse cultivation, livestock farming and forestry, although, owing to the wide scope of this sector and the need to produce a concise report for policy-makers, the majority of the sources consulted refer to agriculture and forestry.

To identify the **key trends** affecting the sector, we reviewed a comprehensive list of key foresight studies on agriculture and food trends from both European and international organisations (European Commission, European Parliament, Food and Agriculture Organization of the United Nations (FAO), Organisation for Economic Co-operation and Development (OECD), etc.) and similar studies and articles from both grey and scientific literature. The key trends identified were technological innovation through science and technology; climate change and the environment; food and energy demand (food security); trade and economy; and policy and people. Many of these sources are included as references in the appropriate sections and in the reference list. The ‘trends and drivers’ included in this report were selected based on the judgement of the authors, taking into account the frequency of occurrence in the literature, the relevance of the reference and its likely impact on technological and organisational changes, the likely OSH risks and the consequences of those impacts.

Based on the key trends, we prepared a literature search based on 17 keywords ([8]) and phrases to identify resulting **technological and organisational changes** which included the following: changes in people's roles, the workplace and society; working practices; farming practices; use of materials; work organisation and structures; economic structures; the natural and physical environment; technology use and applications; pesticide and chemicals use; the evolution of animal diseases and breeding; and production practices. The database Web of Science was searched in March 2020.

Further sources were also located through backtracking of citations provided within reviewed articles, through experts and practitioners in the agricultural field who sent us actual articles or links to blogs, and through expert meetings and policy workshops about agriculture and forestry. The search was limited to articles published in English but was supplemented by other language sources where available.

Both the **trends and changes** were then reviewed on the basis of 14 expert semi-structured interviews with key stakeholders from agriculture, food and smart farming backgrounds that were held face to face, by telephone or by videoconference.

Based on the trends and changes identified, we carried out a second review of the scientific and grey literature to identify the **OSH implications**, reviewing title and abstract for relevance by combining keywords.

In addition to the traditional literature search, members of the project team carried out further searches of websites of relevant organisations, including but not limited to sources of the types listed below:

- learned and professional journals and societies;
- OSH and agricultural OSH regulators in a range of countries;
- government departments and international organisations;
- university departments;
- SACURIMA ([9]) and ISSA Agriculture Section ([10]) member organisations.

The validity and inclusiveness of the report were reviewed by 21 agricultural OSH experts and 4 observers in a virtual meeting on 8 June 2020 based on a near-final version of the report and a workbook including guidelines and questions. The meeting was facilitated by an external moderator.

3 Scope of the report

This expert review of the future of agriculture and its impact in terms of OSH contains a general overview of (organisational as well as technical) changes that may have an impact on OSH in the agriculture and forestry sector. The review focuses on (1) the main trends affecting the agriculture and forestry sector in general, (2) the resulting technological and organisational changes in the sector, and (3) the consequent implications for OSH (see the three key questions in chapter 2). The review aims to support policy-makers at European and national levels in their development of strategies, regulations, and other enforcement, guidance and support measures. This report does not aim to be a comprehensive overview of OSH in agriculture and forestry owing to the broad area covered, the limited time and resources available and the need to produce a concise report for policy-makers. Therefore the report does not cover aquaculture, urban farming or vertical farming.

Definition of farmers and foresters

The aim of this report is to create a knowledge base that will contribute to the prevention of accidents in agriculture and forestry and promote the safety and health of people working in this sector in general. Therefore, the principal terms used in the report will be 'farmer', 'forester', 'farm worker' and 'forestry worker'. Farm worker and forestry worker are considered to be covered under the definition of "worker"

([8]) For the list of keywords, see Annex 1.
([9]) SACURIMA is an EU COST programme focusing on risk prevention and a safety culture in agriculture: https://www.sacurima.eu/
([10]) International Social Security Association Agriculture Section: https://ww1.issa.int/prevention-agriculture

in the EU OSH Framework Directive (89/391/EEC) as any person employed by an employer, including trainees and apprentices.

In this report, the terms 'farmer' and/or 'forester' will include (farm, forestry or other agricultural) employers, self-employed farmers/foresters and any combination of these terms, as well as anyone operating in a professional or productive capacity directly related to the agriculture and forestry sector who is not a employee. This may also include retired people or family members carrying out productive activities on the farm. The study does not include children, residents, bystanders, etc., who are neither working on nor carrying out a productive activity on a farm or in forestry.

Agriculture and/or forestry

Agriculture and forestry are closely related, yet different in principle. Both are forms of land use, with the majority of people involved thinking and acting in annual cycles, and for forestry in cycles lasting decades. In addition to large independent agricultural and forestry enterprises, there are many small and medium-sized enterprises (SMEs) in the agriculture sector that carry out both agriculture and forestry. In contrast to the professionally managed forestry enterprises with well-trained staff, it is precisely these mixed farms where most accidents occur during forest work. The causes are manifold, but most are simply due to a lack of knowledge and competence.

4 The occupational safety and health situation in farming and forestry

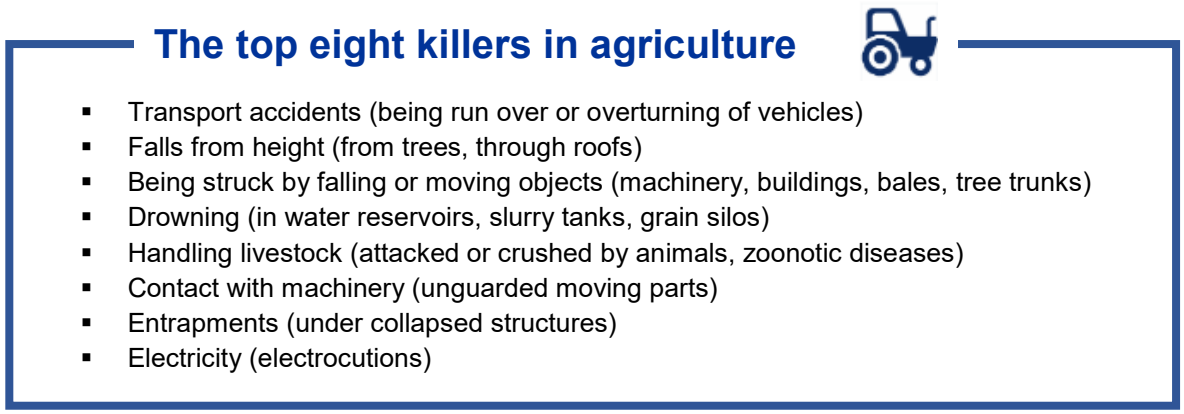
Agriculture and forestry are among the most dangerous professions in Europe with a high level of accidents affecting the sustainability and viability of the sector. Over the last 10 years, there has been an average of over 500 deaths per year in the agriculture and forestry sector (although the figures dropped to 450 in 2017) and over 150,000 non-fatal accidents per year. Even so, experts in the sector are convinced that there is a huge under-reporting of both fatal and non-fatal accidents: one expert estimated that the number of deaths may be as high as four times that figure (Walsh, 2020). The main challenge in calculating accurate accident figures is the lack of reliable data concerning the recording of accidents for the self-employed, irregular or temporary workers, retirees and family members. And this situation is even more alarming if we consider that the major part of the agricultural and forestry working population belongs to these categories.

According to official Eurostat statistics covering people employed in the sector, the incidence of fatal accidents in agriculture and forestry is already the second highest of all sectors at 6.1 per 100,000 workers, after mining, which is only slightly higher at 6.8 per 100,000 (Eurostat, 2019a). The incidence of fatal accidents in forestry alone is 24.5 per 100,000, making forestry work one of the most dangerous professions in Europe. Agriculture on its own (categorised as crop and animal production, hunting and related services) has a lower incidence of 4.1 per 100,000, placing it fourth in terms of sectors. A similar pattern occurs for non-fatal accidents, which number 2,813 per 100,000 for forestry and logging (second most dangerous sector) and 2,019 for crop and animal production, hunting and related services (also fourth most dangerous).

However, in a number of national reports where the self-employed are generally included in reporting) agriculture and forestry appear top in terms of risk sectors. For example, in the United Kingdom, where agriculture represents less than 1.5 % of the working population, it is responsible for between 15 % and 20 % of all deaths of workers, and agriculture, forestry and fishing is classified by the UK Health and Safety Executive (HSE) as the country´s most dangerous sector (HSE, 2020). In Ireland too there are twice as many fatal accidents in agriculture as in construction (15 per 100,000) (Griffin P,, 2013).

According to Merisalu et al. (2019), under-reporting in some instances may be as high as 90 %. The under-reporting dilemma is illustrated in their paper by the examples of figures reported to Eurostat from Finland and Sweden, two neighbouring European countries with similar geography, agricultural production and prevention cultures. There is a 10-fold difference in accidents reported in agriculture, Finland providing figures of 5,331 non-fatal accidents per 100,000 workers and Sweden 554 non-fatal accidents per 100,000 workers.

Figure 1: The top eight killers in agriculture



Source: IAMZ - Prepared by the author based on data in EC (2011).

Merisalu et al. (2019) reported a great variation in reported fatal and non-fatal accident numbers and rates between Eurostat and national sources, which is explained by differences in farm structure, selection of reference populations, under-reporting of work accidents, inclusion/exclusion criteria and weighting in national and *European Statistics on Accidents at Work* (ESAW) reporting and finally interpretation by users of the data.

Some inconsistencies are structural due to a lack of social insurance schemes for farmers, family labour and undocumented workers in the participating countries. The ESAW definition of reportable accidents is hard to apply for example to family members, the officially retired and migrant workers, who often work without permanent job contracts and their employment and work accident numbers are likely to be under-reported. Age is also a risk factor. Farmers over 65 years of age make up 32 % of the EU farm workforce (EC, 2020c) and family work dominates the sector, with family farms accounting for around 80% of the labour force input (Eurostat, 2016). These inconsistencies in accident reporting should be addressed and improved. A partial solution may consist of including data on the self-employed in agriculture and forestry in compulsory Eurostat accident reporting. Considering that accident statistics are one of the most important tools for evaluating OSH measures and defining OSH priorities at the European level, severe structural under-reporting of accidents in agriculture and forestry does not provide policy-makers with the necessary reliable and accurate data to establish informed priorities.

5 Overview of occupational health issues

Comparable European data on health and well-being in the agriculture and forestry sector are quite limited. According to one European study, over 60 % of agricultural workers report a limiting chronic disease, and agriculture is the second highest occupation reporting chronic disease in general. According to the report, individuals with a chronic disease have reduced employment and earnings prospects, partly because they are more likely to leave the labour market early or because they find it more difficult to re-enter employment after an absence (Eurofound, 2019).

An EU survey from 2007 reported that 61.3 % of respondents from the agriculture and fishing sector reported that their work affected their health, which was significantly higher than for the construction sector, which was the next highest at 44.3 % (Eurofound, 2007). Eurostat (2010) also reports that work-related health problems most often occur in the 'agriculture, hunting and forestry' sector, along with mining and quarrying, which is related to the fact that less favourable job characteristics are more prevalent in these sectors, such as manual work and atypical working hours. In Ireland farmers have been shown to have higher levels of cardiovascular disease and cancers than other occupational groups. It would be fair to say that generally the health of farmers in most countries is of concern and that this occupational group faces significant health challenges (Van Doorn et al., 2020).

Below we highlight the present situation for a few of the key occupational health issues affecting the sector, such as pesticides, musculoskeletal disorders (MSDs) and noise exposure. Other key health-related issues are covered under relevant chapters, such as psychosocial issues and stress in Chapter 10 and others such as zoonotic diseases, biological agents and skin cancer in Chapter 8.

Pesticides and chemical-related health conditions

Farmers are exposed to **pesticides, fertilisers and a wide range of other** hazardous substances in farming, such as sheep dips. According to the US Occupational Safety and Health Administration, workers may be exposed to pesticides in a wide variety of ways, including working in a field where pesticides have recently been applied; breathing in pesticide 'drift' from adjoining or nearby fields; working in a pesticide-treated field without appropriate personal protective equipment (PPE); eating with pesticide-contaminated hands; eating contaminated fruits and vegetables; and eating in a pesticide-contaminated field. Workers may also be exposed to pesticides if they drink from, wash their hands in or bathe in irrigation canals or holding ponds, where pesticides can accumulate.

The health problems that can be caused by working with hazardous substances, such as pesticides, range from mild eye and skin irritation to severe effects, such as birth defects and cancer. Effects can be acute or long term, and some substances can have a cumulative effect. Some of the most common effects are allergies, skin diseases, cancers, reproductive problems and birth defects, respiratory diseases and poisoning. Some dangerous substances pose safety risks, such as risk of fire, explosion or suffocation.

One of the key challenges of occupational exposure to pesticides is in documenting the long-term effects on the health of agricultural workers (Tual et al., 2019). Most of the data available cover acute exposure, such as poisoning or skin damage. This is complicated by the atypical nature of the agricultural workforce, namely self-employed, family members, seasonal or temporary workers, and the lack of consistent occupational health monitoring in many instances.

Figure 2: Mechanised spraying operation

In France, according to the AgriCan study on cancer risks in farming, farmers suffer fewer cancers (- 3 %) than the general population, as they tend to smoke less (smoking is the leading cause of cancer). The figures are 41 % less for lung cancer in men and 32 % less in women. However, the differences could become smaller in the future, as men under 40 years old in farming now smoke more than men in general in society (Lemarchand et al., 2017). However, the study also found that farmers develop certain types of cancer more often than the rest of society owing to the use of pesticides (melanomas + 25 % in men and + 22 % in women; lymphomas + 47 % in men and + 55 % in women). Prostate cancer is also twice as high in farmers as in the general population, as there is a link to lindane, an

antiparasitic treatment used in livestock farming and arboriculture. Re-entering a sprayed area has been identified by experts as one of the most likely influencing factors.

In addition, findings by the French public health ministry point to a link between the use of pesticides and an increased level of Parkinson's disease among farmers (13 % higher than in other professions). (Santé Publique France, 2019).

The European Commission is actively promoting the reduction of pesticides through its integrated pest management (IPM) policy (under the Sustainable Use of Pesticides Directive (2009/128/EC). IPM is an agricultural management practice aimed at minimising or removing the use of pesticides in agriculture. The success of IPM in reducing pesticide use still needs to be proven, as pesticides use appears to have increased in some instances, as recently reported in France (Barbière, 2018). Nevertheless, in view of the EU's political commitment to eliminate some of the most dangerous pesticides and to reduce overall pesticide use by 50 % by 2030 through encouraging IPM, we would expect working conditions for farmers and foresters to improve over the coming decade in this regard.

However, EU legislation on pesticides and chemicals is complex, especially for small farms. There is an array of both pesticides and chemicals legislation and relevant OSH legislation. The Sustainable Use of Pesticides Directive places much emphasis on the protection and safety of the 'operator' using pesticides, but the link to EU OSH legislation on the use of dangerous substances is not entirely clear and the interface between the two legislative areas needs to be clearer. It is quite challenging for small farmers to understand all of the legislation, let alone map out a coherent approach to managing pesticides in the workplace. Fargnoli et al. (2019) proposed a simplified approach taking into account all relevant legislation and mapping out a coherent management tool for a preliminary risk assessment.

One of the elements of IPM is manual weeding, which could raise potential MSD risks in the future if not correctly managed. New technologies, (such as weeding robots or automated spray applicators/lasers and drones) also have the potential to limit the extent and frequency of exposure of farmers and farm workers to pesticides.

Musculoskeletal disorders (MSD's)

According to the European Commission guide on safety and health in agriculture, stretching while fruit-picking, bending for planting, weeding and picking from low-growing plants, lifting and carrying heavy weights, handling machinery, driving long distances, and various tasks that involve pulling and pushing are all tasks that almost always cause the farmer or farmworker to suffer from various MSDs, including lower back pain, strains and sprains within the spine, legs, hands, shoulders and neck (EC, 2011). **MSDs** are also of concern in forestry both in terms of chainsaw and manual tool use but also in terms of replanting damaged forest areas. Climate change will increase the need for and rate of reforestation of damaged areas and the task is still mainly a manual activity.

Eurostat reports that MSDs are the most serious work-related health problem in agriculture and appear to be more important in agriculture than in all other sectors (Eurostat, 2010; Figure 3)). The European Working Conditions Survey (EWCS) found that 57 % of agricultural workers report backache, 55 % upper limb pain and 46 % lower limb pain, farming being the occupation with the highest reporting levels (Eurofound, 2017b).

Data from the United Kingdom for 2017/2018 also show that the highest levels of work-related MSD were reported in the agriculture, forestry and fisheries sector (2,450 per 100,000 workers), ahead of the next nearest sector, construction (2,310 per 100,000 workers). In the United Kingdom, MSDs account for around half of all occupational illnesses in the sector (HSE, 2018). According to the Italian National Institute for Insurance against Accidents at Work (INAIL), data for the period 2014-2018 show that in agriculture occupational diseases with confirmed professional aetiology consist mainly of MSDs (73-75 % of all cases) (EU-OSHA and INAIL, 2020).

Figure 3: MSDs are prevalent in agriculture

According to Walker (2001), about 80 % of workers in agriculture have an MSD at some time, and Osborne et al. (2012) even point to a lifetime prevalence of any form of MSD among farmers of 90.6 %.

MSDs continue to be a major OSH challenge for the sector, as demonstrated by the attention given to this issue by the European Commission and the EU social partners. The Commission has funded a social partner cooperation project 'Livestock handling guide. Good practices in agriculture: social partners' participation in the prevention of musculoskeletal disorders' and the EU agricultural social partners have come to an agreement on MSDs (EFFAT, 2005; Hermans et al., 2012). EU-OSHA has also published a discussion paper jointly with INAIL, which presents INAIL's experiences of both assessing the biomechanical risks in agriculture and supporting companies to adopt prevention measures (EU-OSHA and INAIL, 2020).

However, as mentioned above, with ecological and organic farming practices set to increase as IPM methods replace the use of pesticides, we will need to be vigilant that MSDs do not increase owing to an increase in manual weeding practices, as smart farming practices are still not sufficiently well developed and commercialised to take up the strain of increased manual de-weeding tasks (Soto Mas et al., 2018). Further action to reduce the impact of MSDs on the sector is still very much needed, and MSDs will continue to be one of the major OSH challenges for the sector.

Noise and hearing loss

Noise-induced hearing loss is one of the most prominent recognised occupational diseases in the EU (Figure 4). EU-OSHA reported in 2005 that agricultural workers (along with the armed forces) are the occupational group most exposed to noise at work and that exposure in agriculture is higher than average (EU-OSHA, 2005).

Figure 4: Exposure to noise leads to hearing loss

According to the findings of the EWCS, over 20 % of agricultural workers suffer from noise exposure. This figure is estimated to be much higher (approximately 40 %) by other experts (Walker, 2001). According to a 2015 Australian study half of all farmers are at risk from excessive noise: 51 % of farm workers are regularly exposed to daytime noise levels above the accepted Australian exposure standard of (85 dB) known to produce long-term hearing loss (Williams et al., 2015).

Machinery, tractors, chainsaws, wood chippers, shotguns and livestock are just a few of the sources of potentially damaging noise exposure on the farm or in forestry, which often increases with ageing machinery. Updating machinery and adequate noise mitigation and protection measures are essential. According to the UK HSE, exposure to high noise levels can cause permanent hearing damage, often without the sufferer being aware of it until it is too late. It may lead to tinnitus (ringing in the ears) or deafness. Noise can also be a safety hazard at work, interfering with communication and making warnings harder to hear (HSE, 2017). In forestry, chainsaws are still a major source of noise, in particular older models.

Covid-19 and occupational safety and health risks

COVID-19 has raised public awareness about the importance of safety and health in the workplace. Although the healthcare sector has been most affected, high-profile outbreaks have occurred in the agro-food sector across Europe (e.g. in meat processing and fruit picking). The EU institutions reacted immediately at the beginning of the crisis by modifying the EU Biological Agents Directive ([11]) to include COVID-19 as a recognised biological agent and to protect workers from risks related to exposure to COVID-19. In addition, both the European Parliament ([12]) and the European Commission moved quickly to protect the health and safety (as well as general living and working conditions) of seasonal workers by issuing guidelines ([13]) on seasonal workers. The EU social partners also signed a joint declaration on the protection of seasonal workers (EFFAT, 2020b).

The vulnerability of animal production workers to COVID-19 have also come to light during the pandemic. For example, human-to-mink and mink-to-human transmission can occur with high profile cases reported in the Netherlands of an infected mink farm worker and 214 reported human COVID-19 cases infected with SARS-CoV-2 virus variants related to mink in Denmark (ECDC, 2020). There is therefore a need to be vigilant as to possible zoonotic cross-over infections between animals and humans in a similar way that Avian Flu has been a continuing a risk factor for poultry workers for many years (MacMahon, K.L. and Delaney, L.J., 2008)

In response to this emerging risk, EU-OSHA has prepared specific advice on COVID-19 prevention and OSH, bringing together a wealth of resources from Member States related to the agro-food sector and many Member States have issued guidance (EU-OSHA, 2020a). The OSH Wiki (2020) on COVID-19 provides a number of sector-specific examples at the national level covering various aspects of agriculture and food production.

([11]) Commission Directive (EU) 2020/739 of 3 June 2020 amending Annex III to Directive 2000/54/EC of the European Parliament and of the Council as regards the inclusion of SARS-CoV-2 in the list of biological agents known to infect humans and amending Commission Directive (EU) 2019/1833.

([12]) European Parliament resolution on European protection of cross-border and seasonal workers in the context of the COVID-19 crisis (2020/2664(RSP).

([13]) Communication from the Commission — Guidelines on seasonal workers in the EU in the context of the COVID-19 outbreak 2020/C 235 I/01 (OJ C 2351, 17.7.2020, p. 1-7).

Section A. Identification of major future trends and changes in agriculture and forestry

6 Main trends affecting agriculture and forestry

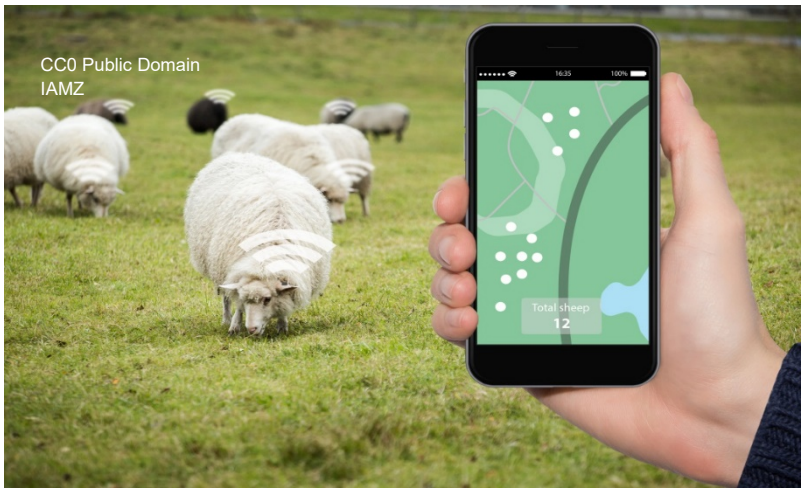
The report sets out the **main trends affecting agriculture and forestry** through providing a list of key drivers. For each trend, we have identified the resulting technological and organisational changes, and we subsequently assess **the impact of these changes on OSH in Section** B, 'Implications for the occupational safety and health of farmers, foresters and other workers'.

6.1 Technological innovation through science and technology

6.1.1 Digitalisation of agriculture and forestry

The digitalisation of agriculture or smart farming (Figure 5) are broad concepts used to cover the area of digital technological developments that, as in many other industry sectors, are being increasingly applied. These broad concepts include the use of drones (Figure 6), sensors, global positioning or satellite systems, automation and robotisation, big data, the internet of things (IoT), artificial intelligence (AI) and augmented reality. Another term commonly used is Agriculture 4.0, which involves precision or smart agriculture using a combination of information and communication technologies (ICT) and sensing devices to permit precise use of inputs to optimise food production and prevent environmental degradation and also to streamline data availability to assist farm management (Klerkx and Rose, 2020). Precision farming or precision agriculture are also widely used terms that refer to a more restrictive set of technologies, such as sensors, drones, data gathering and global positioning systems, coupled with decision support systems based on the collected data. According to a 2017 study commissioned by the European Parliament (Kritikos, 2017), 'Precision agriculture is about supporting farming decisions with a view to using the right amount of inputs in the right place at the right time.' For the purposes of this study, we will assess how the wider concept of 'digitalisation' affects the agriculture and forestry sector, using the digitalisation of agriculture, Agriculture 4.0 and smart agriculture/farming as interchangeable terms.

Figure 5: Smart farming app



According to a recent market study covering a number of countries, the precision farming market is expected to grow by around 15 % per year between 2019 and 2025 (Global Market Insights, 2019). However, many experts are reluctant to put a figure on the expected growth rate, focusing more on significant productivity and yield gains and fractional savings on the inputs and resources used in agricultural production as well as on environmental gains.

One of the most important challenges to digitalisation in the sector is the uneven spread of such technologies between different European regions and the lag in the uptake of smart farming techniques compared with other sectors, particularly among SMEs and small farms. Diffusion of technological innovation is a gradual process and takes time to achieve (Eastwood et al., 2017; Griffin et al., 2017). Large-scale transformation often takes more than a decade or even several decades to achieve, for the

adoption of precision agriculture in particular, which has been slow because of the complexity of the technology, its utility and cost-effectiveness (Elzen et al., 2012).

New or recent farm technologies, such as automated milking, have taken up to 20 years in some instances to be implemented across the sector. A 2011 study also supports the assumption that agricultural research can take up to 20 years to be fully realised on the farm (Alston et al., 2009).

In 2016, only 25 % of farms used technologies that included a precision agriculture component. According to an OECD survey, digital intensity in the agriculture, forestry and fisheries sector is 'low', agriculture being among nine other sectors in the least advanced quarter of all sectors. Another report even places the European agriculture sector second from bottom of all industrial sectors in terms of digitalisation (McKinsey Global Institute, 2016; Calvino et al., 2018). One report predicts that jobs in the European agriculture sector will be the second least affected of all sectors by automation, displacing only 13 % of jobs in the sector by 2030 (McKinsey Global Institute, 2020).

Figure 6: Agricultural drone

One of the principal reasons for low technological development and its uptake in the sector is the need to either build or adapt robot and smart farming and forestry systems to suit the very diverse nature of each and every specific farming context (i.e. adapted to each and every crop, animal production system and type of topography). In forestry, the terrain is often extremely difficult and unsuitable for new technologies. Equally, certain processes involved in farming and forestry are difficult to standardise. Sunlight in the open air is also a challenge for robotic systems that depend on light sensors.

The economic return on investment in robotic systems in agriculture is not always certain. According to an economic study by Lampridi et al. (2019), the cost of robotic systems in arable farming in many cases is higher than that of conventional machinery systems and, if we look at the trend in the increasing age of tractors over the last 30 years, we see that large technology investments are a challenge in this sector, particularly for resource-poor small farmers. Such farmers in particular suffer from low income, tight profit margins and limited financial collateral owing to the small size of their farms or their reluctance to mortgage their homes and only income bases/livelihoods. A significant number of self-employed farmers across Europe earn barely above EUR 1,000 per month. According to the French statistical office, 22 % of French farmers were living under the poverty threshold in 2017 (INSEE, 2019). This means that capital investments in new technologies for small farms are often inconceivable, particularly when the benefits are perceived as marginal. Small farmers' main concerns are keeping the balance sheet positive to ensure a minimum income for themselves and their families. There are, however, examples

of small family farms successfully making such investments, but this often involves a certain amount of risk and often younger farmers lead the way.

Experts fear that the digital divide will increase: large farms which will become larger and more sophisticated and small farms will experience limitations in adopting new technologies, further increasing the economic gap between the two.

For forestry, digitalisation and its degree of penetration varies significantly throughout the entire forest value chain and depends on a number of criteria: the types of forest ownership (state, private, communal, etc.), the sizes of the forest entities and differences between countries and within countries themselves. For example, digitalisation plays a greater role in Scandinavia than in southern countries with smaller forest holdings. Digitalisation already has a firm place in harvester technology in forestry with centres of expertise such as the Competence Centre Forest and Wood 4.0 (KWH4.0) ([14]). Several parts of the forestry processing chain are in the process of being digitalised, such as the processing of deeds (i.e. rights to cut and harvest timber) and the handling of wood after felling and transfer to sawmills (e.g. E-Dat-Smart).

The uptake of smart farming and forestry practices varies significantly throughout the sector, depending on each country´s cultural context, the level of education and income of farmers, farm size, sector-specific aspects, generational challenges (older farmers generally being more reluctant to engage) and the degree of access to broadband in rural areas (only 50 % of EU rural areas have adequate access to broadband).

The forthcoming reform of the common agricultural policy (CAP) ([15]) and national governments ([16]) have both committed to creating an environment conducive for digitalisation and smart farming. Fostering knowledge, innovation and digitalisation in agriculture and rural areas will be a cross-cutting objective of the reform that will encourage the uptake of technology and digitalisation through investment support for restructuring and modernising.

The digitalisation of agriculture and forestry will significantly affect the sector on the whole offering **numerous benefits**:

- increased agricultural production, productivity and yields as agricultural processes and practices become more efficient;
- reduced production costs as more effective monitoring and decision support systems enable more eco-efficient use of water, energy, fertilisers and pesticides, thus reducing the impact of climate change;
- improved food safety and quality through monitoring and traceability of the food chain;
- increased health and welfare of livestock (sensors to detect heat stress, noise, condition and behaviour of animals, feed applications and veterinary data);
- improved environmental protection by allowing farmers to monitor plant health more effectively through sensors and tackle plant diseases early on with fewer and more targeted pesticide applications or alternative practices (such as autonomous de-cropping machines and drones); this will also have a positive impact on working conditions as pesticide applications or weed reduction are increasingly automated and ‘at distance’, particularly for horticulture and greenhouse production;
- increased attractiveness of the profession, particularly to younger generations (Deter, 2020).

([14]) https://www.kwh40.de/

([15]) Proposal for a regulation of the European Parliament and of the Council establishing rules on support for strategic plans to be drawn up by Member States under the common agricultural policy (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and repealing Regulation (EU) No 1305/2013 of the European Parliament and of the Council and Regulation (EU) No 1307/2013 of the European Parliament and of the Council (COM/2018/392 final). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2018%3A392%3AFIN

([16]) European Commission (2019), EU Member States join forces on digitalisation for European agriculture and rural areas. 2019 Declaration by 25 EU Member States on ‘A smart and sustainable digital future for European agriculture and rural areas’. Available at: https://ec.europa.eu/digital-single-market/en/news/eu-member-states-join-forces-digitalisation-european-agriculture-and-rural-areas

The digitalisation of agriculture will also result in some **negative impacts**:

- a reduction in jobs in the sector that will particularly affect rural areas, although this could reduce the dependency of farming operations on seasonal labour and contribute to more predictability in farming;
- a decline in small family farms as they struggle to compete, lacking resources and the necessary economy of scale in their operations to make investment in new technologies profitable;
- farmers becoming more dependent on large multinationals and data and tech companies that increasingly gather sensitive farm company data in return for access to attractive on-line services;
- farmers potentially losing the right to repair their own machines, as smart-farming machines are often subject to a warranty agreement or licensing agreements forbidding farmers from carrying out repairs or accessing software (Solon, 2017);
- digital solutions complicating work practices and processes, implying a greater need for appropriate training;
- data security becoming a challenge and a stress factor for farmers.

Technological and organisational changes resulting from digitalising agriculture and forestry

At the same time, a number of these impacts will contribute to a series of technical and organisational changes in the sector.

Technological changes resulting from digitalising agriculture and forestry

- Agricultural production processes and practices will become increasingly digitised and automated through autonomous or semi-autonomous tractors, machines, cropping systems, monitoring and decision support systems.
- The application of pesticides and chemicals will become more automated, reducing the human risk factor significantly.
- The health, safety and well-being of farm workers will be better monitored through smart applications.
- Data security and cybersecurity challenges will increasingly affect the sector, as ‘hacking’ could become both an economic and a safety threat in the future.
- Farmers will also need to provide and maintain information technology (IT) infrastructures, adding to the complexity of an already complicated business model.

Organisational changes resulting from digitalising agriculture and forestry

- a significant reduction in jobs in the sector, as manual and seasonal workers in particular are gradually replaced by new technologies;
- less reliance on seasonal and temporary labour, thus reducing some of the uncertainty and vulnerability of the sector; the COVID-19 crisis has highlighted the dependency of many countries on seasonal and temporary workers and has added additional impetus to digitalisation in the sector;
- a need for manual agricultural workers to re-skill in IT-based systems or be replaced by a younger more ‘e-skilled’ and technologically versatile workforce’, which may in turn be more attracted to the sector owing to its increasingly technological nature;
- increased economy-of-scale benefits for larger holdings that can more easily afford investments in technology, inevitably contributing to the gradual replacement of smaller family farms with larger farming entities;
- digital management systems and automation reducing physical demands in the sector and offering more flexible management systems that can be managed remotely and at different times; these combined changes could enable farmers to improve their work-life balance, open up opportunities to a more diverse workforce and support the active ageing of farmers;

- an increase in lone working as digital technologies make it possible for fewer workers to manage multiple and increasingly complex tasks and as employers provide digital location and emergency systems to replace co-workers;
- in general, work tasks becoming more monotonous as machines do most of the physical and active work;
- technology also opening up more opportunities for direct access to customers through emerging online distribution channels, thus removing dependency on intermediate retail operators and increasing farmers' autonomy.

There has also been an increase in digital services and platforms for sharing and hiring equipment as the benefits of apps and digital services have spread to the agriculture sector. In the future, cooperatives could play a more active role in sharing expensive new technologies.

6.1.2 Crop genetic improvement and new breeding techniques

Crop genetic improvements have been identified as one of the technological innovations that can make a significant contribution to productive and sustainable agriculture (FAO, 2017). However, in Europe at least, the medium- and long-term contributions of such technologies to European agriculture is yet to be determined. The FAO defines agricultural biotechnology as 'any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use' ((UN Convention on Biological Diversity, 1992). According to Allard (1999), these include a range of technologies: tissue culture, mutagenesis, genetic transformation and a range of marker-aided selection methodologies. Genetically modified organisms (GMOs) and biotechnology are more commonly used terms for this type of technology. More recently, technology in this area has progressed quite rapidly with the development of new breeding techniques, such as CRISPR (clustered regularly interspaced short palindromic repeats) gene-editing techniques.

However, achieving societal acceptance of such technologies in Europe has proved challenging, with concern over potential impacts, such as the environment (genetic contamination of non-GM crops), biodiversity and human and animal health. At the same time, the EU approval process for GMOs has become longer and more uncertain, with a number of Member States voting against the approval of GM applications for food and feed. The debate about the use of innovative new genetic breeding techniques such as CRISPR continues in Europe. In 2019, the European Court of Justice ruled that the approval of CRISPR-based technologies should follow the full-blown GMO approval process despite many sectors from science and industry previously having advocated a simplified approval process, arguing that the changes to products generated through new breeding techniques are similar to those produced through conventional breeding techniques or those occurring naturally (Court of Justice of the European Union, 2018).

Genetic improvement technologies have the potential to:

- increase yields and crop quality, reducing the need for fertilisers;
- produce crops that are more resistant to certain diseases or pests (thus reducing pesticide use);
- reduce the need for water or other resources such as energy;
- reduce greenhouse gas (GHG) emissions through plants that either produce less emissions during their cultivation, actively reduce emissions by storing carbon more effectively or result in less GHG emissions during their digestion by animals.

Some negative impacts from the use of such technology have also been identified:

- Owing to the strictly controlled intellectual property of seeds and plants, there is concern that farmers may become dependent on multinational companies for continued access to both seeds and the specifically designed (and the only effective) pesticides for such crops, as we have seen in certain instances in developing countries.
- Although under EU legislation the European Food Safety Authority is responsible for evaluating the safety and environmental impacts of new breeding techniques, there is concern among non-

governmental organisations that there could be unintended ecological impacts on indigenous crops and local species.

Technological and organisational changes from crop genetic improvement and new breeding techniques.

Technological changes resulting from crop genetic improvement and new breeding techniques. As indicated above, the technological advantages of new breeding techniques are numerous but, owing to the legal and political uncertainty surrounding the use of such technologies, the technological impact on farming practices will be limited over the next 5-10 years, as few farmers are likely to take up such technologies on a wide scale. Many experts interviewed have supported this assumption. Also, only two GM products have been authorised for cultivation in the past 20 years (EuropaBio, 2011). Organisational changes resulting from crop genetic improvement and new breeding techniques.

Such technologies would have potentially offered solutions for an effective reduction in the use of pesticides. For example, the only GMO still to be cleared for cultivation in the EU, MON 810 GM maize, is resistant to the European corn borer pest. However, in addition to the challenges to obtaining approval and considering the high number of plant pests across Europe and the frequent emergence of new plant diseases, such technologies are unlikely to result in major organisational changes in the sector.

Similar to farmers' data dependency on multinationals for smart farming technologies, farmers also depend on plant-specific intellectual property patents held by large companies.

Therefore, although offering several potential benefits to European agriculture, the future contribution of genetic breeding techniques, including new breeding technologies, is still uncertain and their contribution to technological and organisational changes in the sector is likely to be limited.

6.2 Climate change and the environment

6.2.1 Climate change

Although GHG emissions from the EU agriculture sector fell by 22 % between 1990 and 2016, the rate of decline had levelled out and emissions have been stable since 2010. EU agriculture still represented 12 % of all EU GHG emissions in 2016 with 39 % of emissions being related to the enteric fermentation of ruminant livestock, 32 % to agricultural soils (fertiliser), 14 % to land use and land use change and 13 % to the management of manure. There is no doubt that pressure will continue on the farming and forestry sector, as on all other sectors, to contribute to mitigating GHG emissions and improve environmental performance in general. This is probably best illustrated by the forthcoming CAP reform, whereby at least 40 % of the CAP's overall budget will contribute to climate action between 2021 and 2027 ([17]), as well as already being responsible for ensuring cross-compliance with many environmental standards through the present CAP.

As well as contributing to climate change through GHG emissions, the agriculture sector itself is also subject to its effects (Figure 7). According to the Intergovernmental Panel on Climate Change (IPCC), the main effects of climate change on food production are changes in precipitation, temperature, periodicity and severity of extreme events and a rise in sea level. All of these factors will bring about a series of mostly negative changes on food production (IPCC, 2019).

([17]) The European Green Deal: Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, p. 12 (COM/2019/640 final, Brussels, 11.12.2019)

Figure 7: Climate change and agriculture

According to the European Commission (EC, 2017b), on the one hand, the impact of climate change on agriculture may increase crop yields in northern Europe, owing to higher temperatures, and certain crops may expand further northwards. On the other hand, heat stress on both plants and animals, changes in crop phenology and the extension of the ranges of pests and plant diseases will impact negatively on agriculture in other specific regions (WMO, 2020). With 51 % of Europe´s water going towards agricultural uses, changing precipitation patterns will also affect the sector's irrigation needs, increasing them further to unsustainable levels in water-stressed southern Europe and pushing drought stress further northwards. Extreme weather events, such as droughts and heatwaves, in the south and heavy rain, floods and gales in northern Europe are already taking effect, and will generally reduce yields while increasing unpredictability and uncertainty in the sector (Forzieri et al., 2016). More European countries suffered from larger forest fires in 2018 than ever before, and the unprecedented forest fires in several European countries in 2017 and 2018 coincided with record droughts and heatwaves in these years, and, as a consequence, a substantial expansion of the fire-prone area and longer fire seasons are projected in most regions of Europe (EEA, 2019). Forests are especially vulnerable to changes in precipitation, temperature, an increase in carbon dioxide concentration and extreme events such as storms or insect invasions. The recent hot and dry summers have increased the incidence of forest pests, such as the bark beetle. The rise in sea level will also result in the loss of valuable farming land, even in Europe where a number of countries, such as the Netherlands, already have a significant amount of agricultural land under sea level.

6.2.2 Environmental protection

Next to climate change itself, the agriculture sector is affected indirectly by environmental protection measures.

Reduction of Pesticide use

Environmental pressures affecting the agriculture sector include the **EU's commitment to reduce pesticide use** through the EU Sustainable Use of Pesticides Directive ([18]) and the Commission's general move towards IPM ([19]) practices. This has been reinforced by the ambitious pesticide reduction goals in the EU Farm to Fork Strategy ([20]), aiming to reduce the use of pesticides by 50 % before 2030. However, recent reports from France on pesticide use are not encouraging. France is considered one of the most active countries in attempting to reduce pesticide use, but in fact it increased by 24 % from 2017 to 2018 and by 25 % over the last decade.

([18]) Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides (OJ L 309, 29.11.2009, p. 71-86).
([19]) European Commission on integrated pest management): https://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides/ipm_en
([20]) Commission Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system (COM/2020/381 final).

Water pollution and soil conservation

Agriculture also has a significant impact on water pollution through fertiliser use (representing over 50 % of nitrogen discharged into surface waters), pesticides and animal excreta (EC, 2017b). Soil health is also a key issue for the sector, with soil erosion and contamination, reduction of soil organic matter, soil compaction and salinisation, and soil-sealing (covering of fertile land by impermeable material) all being issues of concern. Forests, in contrast, help protect the soil and also have a positive impact on air and water pollution.

Biodiversity and conservation

Agriculture and forestry have a profound influence on biodiversity conservation in Europe. Biodiversity in the EU is following the general level of decline in the world as a whole (EC, 2017b). 11 % of utilised agricultural area and 23 % of forest land in the EU are designated as Natura 2000 sites under the EU Habitats Directive (94/43/EEC), which aims to protect and conserve EU natural habitats. Biodiversity loss attributed to farming is often linked to intensification and specialisation, on the one hand, and abandonment of agricultural activity, on the other. Land use change (simplification of landscapes), intensive agricultural management and pesticide use are also some of the main drivers of the loss of pollinators (Science for Environment Policy, 2020). Agroforestry can have a positive effect on both biodiversity and conservation.

Technological and organisational changes from climate change and environmental protection

Climate change and environmental degradation will result in a number of technical and organisational changes in the sector. The changes will be brought about by the necessary adaptation methods to mitigate climate change and environmental degradation, while climate change and environmental degradation will increasingly impact on agricultural production methods and practices.

Sectoral adaptation to mitigate climate change and environmental impact

Farming will need to adapt to increasingly stringent environmental rules and regulations to reduce its impact on climate change and increase environmental protection. One of the most important organisational changes for farmers will be an increase in the depth and breadth of cross-compliance measures and control of environmental rules through the CAP. Cross-compliance, which aims to ensure that farms are complying with EU environmental rules before receiving CAP payments, is already a significant administrative burden for farmers under the existing CAP. With increasing pressure on agriculture to become greener, this burden is set to increase in the future through the additional targets in the EU Farm to Fork Strategy. This pressure to ensure cross-compliance and follow rules alone is often cited by many farmers as a major stress factor in the sector.

In addition, CAP payments will be increasingly linked to climate change mitigation and environmental protection measures changing what farmers produce, when and how. For example, there will be growing pressure for farming to reduce the impact of meat production on the climate. This may be achieved either by reducing meat production and moving to alternative protein sources, such as vegetable or insect-based protein, or by modifying the ingredients of animal feed to reduce the effects of enteric digestion on the climate. Likewise, certain vegetable crops produce more emissions than others during their cultivation, leading farmers to choose more climate-friendly species.

Carbon storage will also be promoted, whereby farmers leave land fallow in order to trap carbon or to preserve landscapes and biodiversity. This means that production practices will be affected and farmers will receive payments to leave land fallow. Sustainable forestry is itself a carbon trap considering that forests and other wooded land cover over 40 % of the EU's land area.

This is particularly the case when producing long-term growth wood (or "slow-maturing wood") and, for example, wood that is used to build houses. As long as the wood is not burned, the carbon remains trapped and stored.

Impacts of climate change and environmental protection on farming productivity

In order to manage the increasing impact of climate change on agricultural production, a number of technical and organisational changes will be necessary.

Technological changes from climate change and environmental protection

Farms will need to increase their water use efficiency across Europe to counter even longer seasonal drought conditions that will place considerable stress on water tables across Europe. However, access to water supplies will be a critical factor here, because water scarcity and salinisation will increase as water tables become depleted. Farms will also have to make investments in infrastructure for more efficient irrigation systems and build more structures to reduce the effects of heat (particularly on livestock farms and in greenhouses) with adequate ventilation and cooling systems and sun protection, such as areas of shade for both animals and farm workers. Farm structures and fields will also need to be designed to resist stronger winds or floods as extreme weather events become more common. Energy and water costs will also increase to cover the additional irrigation and cooling of animal and crop/food storage buildings. This in turn may encourage farmers to install more renewable energy systems on farms. In some parts of Europe, extreme cold weather events could also increase, making frost and freezing conditions an emerging challenge for agriculture and forestry.

Farmers will also need to modify the types of crops they grow, adapting cultivations and even animal breeds to the changing climatic conditions. In the forestry sector, technical measures such as more effective firebreaks and the consistent clearing of brushwood are necessary to mitigate forest fire risks exacerbated by extreme heat. Intense heat, risk of fire and changing rainfall patterns could all influence afforestation practices, resulting in the choice of tree species that are more heat or drought resistant or less flammable. Foresters are also concerned that climate change may cause the extinction of certain tree species, leading to less genetic diversity, particularly as trees take many years to grow.

Organisational changes from climate change and environmental protection

Farmers and foresters will be forced to manage increasing and unpredictable risks to their production. The reform of the CAP envisages significant support for risk insurance and risk management systems to manage the effects of crop and livestock losses from extreme weather, drought, fires and damage to infrastructures, etc.

Owing to heat and sun exposure, working methods will have to be revised to protect both animals and farm workers from extreme conditions. In certain regions, working patterns may need to be modified to avoid the hottest and sunniest periods of the day, and night working may increase. Farmers will have to manage an increasing number of animal disease risks for both their animals and themselves as milder winters and increasing temperatures contribute to the number of vector-borne diseases affecting Europe.

As part of the EU's drive to reduce the use of pesticides in farming, the EU Sustainable Use of Pesticides Directive is driving a growing practice of IPM, which implies a series of actions, such as crop rotation, use of resistant cultivars, mechanical or manual weeding and biological controls. IPM's push towards alternatives to pesticides and more organic farming could lead to an increase in manual weeding. The ergonomic impact on workers could be offset by using more automated robotic weeding systems.

6.3 Food and energy demand (food security)

The world's population is expected to grow to almost 10 billion by 2050, which will increase the demand for agricultural production by 50 % (FAO, 2017). Greater food demand will increase the pressure to achieve higher yields and efficiency, which will be partially achieved through larger and more efficient farms, new technologies and improved breeding techniques.

This increased demand for food may lead to higher EU food prices. It will also provide EU farmers with a potential increase in export markets. The EU is the largest global exporter of food (EU, 2019).

According to the OECD and FAO (2020), COVID-19 will exert a shock on final food demand by lowering overall purchasing power, especially for an increasing number of unemployed people. The actual impact on food demand will depend on numerous factors, including the depth and length of the macroeconomic shock, the availability of savings and access to credit and financial safety-net mechanisms. However, according to OECD predictions, at present COVID-19 is expected to have a time-bound impact or lag effect on the growing demand for food, although the full impact remains uncertain.

Taking into account the expected COVID-19-related economic impacts, at the global level, income could still increase over the long term in low- and middle-income countries, creating a higher demand for meat, fruits and vegetables (rather than cereals, as at present), as well as more high-value and -quality food products (15 % of EU food exports have EU geographical indication quality labels) (EC, 2017). Global meat production is also projected to be 13 % higher in 2028 (OECD and FAO, 2020), although a higher global demand for meat may be offset in the EU by changing consumption patterns influenced by societal trends (see section 6.5.2.Consumer, health and societal demands). COVID-19 has also affected consumer patterns, with the restaurant sector collapsing in many countries, leading to a change in the way that people obtain their food, e.g. the growth in home delivery services, more shopping for alcohol and luxury foods or sugary treats in some countries, and notable drops in sales of certain types of meat and wine in a number of countries (Teagasc, 2020).

In addition to producing more and better quality food, in terms of food security the drive to combat food loss and waste is an important trend that will also affect farming, as farmers are increasingly encouraged to develop more circular approaches to food production. Food loss primarily concerns the primary sector (as opposed to food waste, which is further downstream in the food chain). Food loss and waste represent 20 % of the EU's (and one-third of the world's) food production (Fusions, 2016). This also implies that the water, energy, pesticides, GHG emissions and pollution resulting from lost EU food production are also literally being wasted.

Alternative protein supplies are also being developed, such as insects, laboratory-generated meat, and farmed fish and shellfish, the latter set to grow globally by 28 % by 2028 (OECD and FAO, 2019) .

Energy production will also continue to compete with food production. A significant share of maize, sugarcane and vegetable oil is used to produce renewable fuels in the EU, although growth in the EU will be limited according to the OECD, in spite of global growth being set to increase by 18 % (OECD and FAO, 2019).

Technical and organisational changes from food and energy demand

Increased food and energy demand will result in a few technical and organisational changes in the sector.

Farmers will increasingly be encouraged or pressurised to reduce food loss on the farm as the CAP and the European Commission push ahead with EU policies on food waste and food loss under the forthcoming Farm to Fork Strategy. Although 70 % of food waste (Fusions, 2016) occurs at household, food service and retail levels, pressure will also increase on agriculture to modify farming practices and modernise production and storage facilities or even cultivate alternative crops that result in less food losses, as the EU will most probably link CAP policies and payments to performance in this area.

As alternative protein sources are sought, more and more farmers may change their production to alternative proteins, such as insects, probably for animal feed in the first instance, or even add aquacultural production to their farming activities.

6.4 Trade and economy

6.4.1 Trade

The EU is the world's largest food exporter, achieving a value of EUR 142.9 billion in the period from June 2018 to May 2019, and has continued to have a healthy surplus food trade balance for the last 10 years (EC, 2019). The EU has continued to make progress in recent years on multiple bilateral trade negotiations and on implementing a number of free trade agreements (EC, 2019b). While international trade agreements can have positive impacts on farm income, food exports and employment, there can also be challenges for domestic EU producers from competition from cheaper imported produce (which is often not subject to such stringent EU environmental and safety rules). Likewise, trade protectionism can create significant challenges for the sector, as we have seen with the Russian ban on agro-food imports and recent trade measures against agricultural imports from the US government. The vulnerability of export markets has also been highlighted by the COVID-19 crisis. Although food production and trade have been protected as essential sectors during the crisis, borders have been

closed, to some extent even in Europe, and demand patterns have been modified, with consumers favouring stockable items and 'comfort' foods during the global 'lockdown'. However, the impact of COVID-19 on consumer patterns and the subsequent trade disruptions appear to have been temporary, and food trade flows are beginning to return to pre-COVID levels after experiencing a few months of disruption. Nevertheless, the full impact remains to be evaluated and there may be lasting effects of COVID-19 on both consumer demand and trade flows.

The impact of volatile price fluctuations on international commodity markets and currency fluctuations should not be underestimated, as agricultural produce is traded globally. Market pressures on energy prices and other input costs (chemicals, machinery, etc.) should also be taken into account.

Digitalisation is expected to have an impact on trade, as new marketing platforms and other online trading opportunities are being developed that can help smaller producers undertake trade actions and negotiate transactions without using an intermediary. This could also help in reducing food waste, as smaller producers will have more independence and incentive to manage their surplus food. In contrast, regulations or food labels created to assure food safety and to ensure traceability may decrease farmers' access to certain markets if they are unable to comply with the regulations. Blockchain technology could also become important for agricultural trade, as it will be easier to monitor and manage food stocks and estimate production needs.

6.4.2 Economy

The amount of land that is used for agricultural production remained broadly unchanged at 173 million hectares in 2016, increasing by 0.2 % between 2005 and 2016, despite the sharp reduction in farm numbers (see below). Agriculture contributed 1.1 % to the EU's gross domestic product in 2018 and employment fell from 5.7 % in 2005 to just over 4 % in 2016 of the total active EU population. The farming population represents more than 8 % of the total working population in the following countries: Romania (23 %), Bulgaria (17.5 %), Greece (10.7 %), Poland (10.1 %) and Portugal (9 %). The majority (55.1 %) of the standard agricultural output across the EU was produced by farms in France (16.8 %), Italy (14.2 %), Germany (13.5 %) and Spain (10.5 %) in 2016 (Eurostat, 2018).

Agriculture, like all sectors, is not immune to global economic downturns. The 2008 recession reduced the availability of credit in the sector. For example, young farmers in particular still experience significant difficulty in accessing investment finance and credit. The effects of the COVID-19 economic recession will still need to be assessed.

The number of farms in the EU decreased by about one-quarter in the relatively short period between 2005 and 2016, reaching 10.5 million agricultural holdings. This suggests losses of up to 4.2 million farms across the Member States, the vast majority of which (about 85 %) were small farms under 5 ha, although farm sizes have continued to increase (gradually replacing smaller family-run farms).

Income in agriculture is also generally low compared with that in other sectors (representing only 40 % of the average EU wage). Income is also volatile, with up to 20 % of farmers experiencing drops in income of more than 30 % each year (EC, 2017d).

The economic model for food production has also developed over the last 20 years, with primary sector agricultural produce decreasing in significance in the food value chain, as food has become increasingly processed, developed, marketed and re-packaged throughout the extensive value chain (e.g. processed foods, ready meals and high-value delicatessen products). This has reduced the significance and influence of farmers in the food value chain. In addition, owing to their weakening bargaining power against large retailers, EU farmers are faced with decreasing prices for agricultural produce and lower profit margins. The food distribution market is highly concentrated, with supermarkets, hypermarkets and discounters accounting for 54 % of total edible grocery sales in the EU (EC, 2017d). According to the European Commission, '11 million farms in the EU deal with much fewer and often more powerful processors, distributors, and retailers' (EC, 2019f). The EU recently adopted the Directive on unfair

trading practices in the agricultural and food supply chain ([21]), which is aimed at alleviating abuses in the sector. In fact, one of the nine objectives of the forthcoming CAP reform aims to rebalance the power in the food chain through increasing market transparency and ensuring effective mechanisms against unfair trading practices.

Organisational changes in trade and economy

Developments in both EU trade and the economy will result in a number of mainly organisational changes in the sector. As mentioned in the previous section on smart farming, as farm sizes increase, there will also be an increase in investment in new technologies as the return on investment becomes more interesting owing to economies of scale.

Considering the weakening position of farmers in the food value chain and decreasing profit margins, smaller farmers in particular will find it increasingly difficult to invest in infrastructure developments, new technologies and other innovations. However, in the case of larger farms, investments in smart farming technologies may become more economically viable.

With the vulnerability of global supply chains and exports highlighted by the COVID-19 crisis, the unpredictability of farming will increase and some farmers will have difficulty in managing large stocks of agricultural goods or in finding alternative markets as global consumption patterns are modified during the crisis.

Farm management will also become more challenging as farmers continually juggle multiple economic and part-time activities, particularly with the growth in pluriactivity. Smaller farmers often develop their own business and financial models to survive by increasing their product variety, accessing niche production, converting to organic production, selling their products in a farm shop, offering other services such as tourist accommodation or producing energy, or even finding a part-time job in an unrelated sector.

6.5 Policy and people

6.5.1 Labour market trends

In 2016, the total full-time equivalent agricultural workforce was estimated at 9.7 million workers by Eurostat, but owing to the widespread part-time activity in the sector a total of 20.5 million workers are estimated to contribute to its output (Eurostat, 2018a). The EU agricultural workforce has nevertheless declined steadily by 35 % over the last decade, and the workforce projected to drop to 7.9 million in 2030 (EU, 2019c). This downward trend has been driven by several factors including the declining number of smaller family farms and an inter-related drive for economies of scale through larger more efficient agricultural holdings, as well as increased growth in machinery and technology (Schuh et al., 2019).

Part-time work dominates the sector with 83 % of the workforce being part-time or carrying out a secondary activity (Eurostat, 2018a).

Family work also dominates with 9 out of every 10 (89.5 %) people who worked regularly in agriculture in the EU being the sole holder (farmer) or members of their family in 2016. Many of these are also themselves often part-time and pluriactive).

Women account for 35.1 % of the agricultural workforce (Eurostat 2017a) and account for only 28.4 % of farm managers but represent 41.8 % (Eurostat 2018a) of family workers (representing as much as 55 % of non-holder family farmworkers) (EC2020c).

Farmers over 65 years of age make up 32 % of the EU farm workforce (Eurostat 2018d). The ageing agricultural workforce and generational renewal are key challenges for the sector with only 5.1 % of

([21]) Directive (EU) 2019/633 of the European Parliament and of the Council of 17 April 2019 on unfair trading practices in business-to-business relationships in the agricultural and food supply chain (OJ L 111, 25.4.2019, p. 59-72). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1557237500431&uri=CELEX:32019L0633

farmers being younger than 35 years (Eurostat, 2018a). Fewer farmers' children are taking over their farms, confronted with multiple challenges, such as high land prices, inheritance, limited access to finance, declining rural services, declining profit margins for small farmers and a decline in the attractiveness of the sector and little recognition of the role of the farmer in society ('farmer bashing', agriculture being perceived as a hard and lonely profession). All this is complicated by the fact that older farmers tend to invest less in their farms and in new technologies and have significantly lower levels of training.

Temporary or seasonal workers are more frequently found in agriculture than in other sectors. In 2016, nearly 31.7 % of all employees in agriculture were in temporary employment, compared with 14.2 % across all sectors of the economy (Williams et al, 2018).

Between 2011 and 2017, for the EU overall there was an increase from 4.3 % to 6.5 % in the share of migrants in the total employed in the agriculture sector. In 2017, migrant workers contributed 6.5 % of the EU agricultural workforce (4 % non-EU and 2.5 % EU). In the majority of Member States, the share of migrants among the total workforce employed in agriculture is lower than their shares in all other sectors pooled together, with the exception of Spain (25 % of agricultural workers), Italy and Denmark (both 20 %) (Natale et al., 2019).

The agriculture sector is more likely to have illegal work practices than other sectors owing to the proportion of self-employed, family members, part-time, seasonal and migrant workers (Eurofound, 2016). The 'European platform tackling undeclared work' provided input through a study of the farming sector during the establishment of the European Labour Authority (Williams et al, 2018). According to the study, a range of employment relationships associated with undeclared work are more prevalent in the agriculture sector than in the wider economy: no written contract of employment (5 % all workers in the economy versus 15 % of the agricultural workforce and 32 % of all employees in the agriculture sector); self-employed (4 % of all workers versus 27 % of the agricultural workforce and 51 % of all self-employed in the agriculture sector).

Long working hours tend to dominate in the sector. The average working week in agriculture is 46 hours compared with 38 hours, the average for the EU-28. Atypical working (weekends, evenings or nights) is more than twice as prevalent in agriculture as the average for the EU-28, and on average workers in agriculture report having much less regular working hours than the average EU-28 worker (Eurofound, 2012a).

According to a study by the European Foundation for Living and Working Conditions (Eurofound, 2016), 'it is likely that unionisation rates tend to be relatively low in agriculture' owing to the high incidence of migrant, seasonal, casual and informal work and self-employment as well as the high proportion of small and family enterprises in the sector. There is also a degree of overlap between trade unions and employers' organisations in the sector, with many farmers' professional organisations promoting interests that in other sectors are defended by trade unions, thus playing a more far-reaching role by catering for the wider social and economic interests of their members than in other sectors (Eurofound, 2005). This reflects the prevalence of self-employment in the sector, with employees in the minority in most countries. In addition, in several countries, agricultural advisory and extension services cover a wide range of regulatory, social and economic advisory services for farmers.

Organisational changes resulting from labour market trends

Labour market trends will result in a series of mainly organisational changes in the sector. From an organisational perspective, there will be a move towards larger agricultural undertakings owing to the gradual reduction in the number of small farms (and family workers). Equally, through economies of scale, the increase in larger undertakings will support the decline in the EU agricultural labour force. With fewer people employed in the sector in general and with fewer family members active in farming, employment relationships will change as family members are replaced by employees or contractual workers. According to the European Commission, it is expected that the number of hired workers will remain stable or possibly rise slightly, due to the labour organisation transition in the sector (EC, 2019c).

However, at key times such as harvest, the existing need to resort to seasonal workers could become even more acute. The COVID-19 crisis and Brexit in the United Kingdom have highlighted the dependency of crop cultivation on seasonal workers in particular. During the COVID-19 crisis, at least

at the beginning, many EU farms seriously lacked seasonal labour from neighbouring non-EU countries, as borders were closed and labour movements restricted. This vulnerability will no doubt increase the existing move to adopt smart farming applications. In the United Kingdom, farmer organisations are actively engaging in digital farming solutions in an attempt to reduce their vulnerability and dependence on non-UK seasonal workers, a trend that will no doubt increase if technology developments and their economic viability support this movement.

As mentioned earlier, one key organisational change that continues to increase, especially among smaller enterprises, is the move towards pluriactivity in the sector, which is related to the high level of part-time work. From an organisational perspective, the role of women in farming and forestry is gradually increasing, particularly in management positions. The share of female farm managers increased slightly from 26.3 % in 2005 to 28.4 % in 2016 (Eurostat, 2018a). There are many challenges for women farmers and foresters, such as inheritance and traditional male attitudes and roles in society limiting the full potential of women to operate on an equal footing in the sector. Nevertheless, although progressing at an unsatisfactory rate, new technologies will support this trend enabling more remote on-line management of farm technologies and reducing manual tasks.

One of the most important organisational changes to affect farming and forestry will be generational renewal or rather the lack of it. As the average age of farmers and foresters increases and as increasingly fewer young people are attracted to the sector, an important element of the CAP reform is to support generational renewal through modernising the agriculture sector by attracting young people and improving their business development.

Linked to generational renewal is the matter of rural depopulation, which is also a major issue dealt with in the CAP reform. With only 12 % of jobs in rural areas related to agriculture (EC, 2017c), rural depopulation is a growing concern in many countries and is set to continue, possibly undermining the economic viability of farming in some regions if there are insufficient labour and support services.

6.5.2 Consumer, health and societal demands

According to the Commission's *EU agricultural outlook 2019-2030*, 'Societal demands will continue to shape agricultural markets over the next decade. People have increasingly pressing and at times conflicting expectations towards food. These expectations extend beyond food affordability to issues such as health, origin, convenience, environment, climate change and animal welfare' (EC, 2019b). There are a growing number of societal issues influencing food policy trends that can be divided into either regulatory or consumer driven.

Regulatory-driven demands

Food safety has dominated the EU health and consumer agenda since the BSE (bovine spongiform encephalitis) or 'mad cow' crisis of the 1990s and continues to be of significant importance. According to the *2019 Eurobarometer on food safety in the EU* (EFSA, 2019), food safety is almost as important to consumers as origin and cost (where the food comes from 53 %; cost 51 %; food safety 50 %). Closely related to food safety are animal health and welfare standards, pesticide residues in food and consumer attitudes to GMOs. Environmental standards have also increased over the same period. All of these issues have influenced public policy-making over the last 30 years and have translated into a vast array of EU rules and regulations that European farmers ultimately have to implement at the field and farm levels. The CAP already places a large responsibility on farmers through its cross-compliance policy ([22]). In order to receive payments farmers have to demonstrate that they are implementing a number of EU environmental, food safety, and animal health and welfare standards.

Pressure on farmers from regulators is set to continue as several EU policies, such as the CAP reform and the EU Farm to Fork Strategy adapt to evolving societal trends. Both policies aim to promote a more sustainable and circular farming strategy and will include measures such as the further reduction of

([22]) European Commission on cross-compliance — linking income support to respect for European Union rules: https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/income-support/cross-compliance_en

antibiotics in animal farming and of chemical pesticides and fertilisers, as well as improving animal welfare standards.

Consumer and societal demands

However, the pressure on farming from animal health and welfare and environmental measures has not been limited to regulation. Consumer and societal demands continue to drive many food-oriented policies and trends. Nevertheless, the 2019 Eurobarometer on consumer attitudes to food ranks ethics and beliefs (animal welfare, environmental concerns or religion) as lowest in importance (19 %) compared with other issues (EFSA, 2019). This seems to indicate that many of these issues are either led by influential interest groups or are still in their infancy in terms of public awareness and that they could take on even more importance in the future.

The demand for organic food continues to outstrip supply despite a 5.5 % increase in organic farming every year for the last 10 years, and is expected to continue to grow at a sustained rate until 2030 (EC, 2019c). The EU Farm to Fork Strategy will also support the growth of organic farming (EC, 2020b).

Consumers are increasingly making food purchase choices based on animal welfare and feed practices employed in animal production (such as free range eggs and poultry). Meat consumption and production is also coming under combined pressure from a growing vegan movement and increasing public awareness of the potential to reduce GHG emissions through consuming less meat. The number of vegetarians and vegans is particularly high in the younger generation (above 8 % in Germany, France, Italy and Poland), and the number of flexitarians (consumers eating less meat) is increasing across all generations (Schierhom, 2017). The number of vegans in the United Kingdom doubled between 2016 and 2019 to 600,000, which nevertheless is still less than 1 % of the population. According to the *EU agricultural outlook 2019-2030* (EC, 2019b), meat consumption is expected to decrease slightly by 8 % in the EU by 2030; however, the impact on meat production in the EU may be limited by the growth in exports, as global meat demand is projected to increase by 13 % in 2028 (OECD and FAO, 2019).

A number of more extreme environmental and animal welfare campaigners are also exerting increased pressure on farmers and foresters through public relations pressure and shame campaigns (farmer bashing) or even carrying out direct action or physical attacks on both farmers and farm installations, particularly against farms engaged in intensive farming practices.

In addition to farmer bashing and attacks on farmers, the societal challenge of crime is increasingly migrating to rural areas. Depopulation has created sparsely populated rural areas, where criminals can often operate with impunity. There is a growing trend towards increasing rural crime in a number of countries. Valuable items stolen include new (digital) technologies and sensors, livestock (with some carcasses worth several hundred euros), machinery, raw materials, fencing and metal parts and wiring (often stolen for scrap). Vandalism is also a worrying trend, with some members of the public apparently amusing themselves through intentionally or unintentionally destroying or distressing livestock, often resulting in physical damage and financial losses.

Two rather contradictory trends in food quality are also driving the sector. On the one hand, consumers' preference for good-quality food continues to grow, with an increase in quality labels and systems, as well as consumers increasingly favouring local supply chains or food produced at 'zero km' ([23]). On the other hand, owing to increasingly busy lifestyles, the sales of prepared and processed food, as well as snacks are increasing (EC, 2019c). During the COVID-19 crisis there has been an increase in home delivery consumption as consumers avoid eating out in many cases. This has also had an impact on the type of food consumed, and typical restaurant dishes and food items, such as expensive meat cuts or wine, have seen a reduction in some instances.

The wider concept of labour standards (working and living conditions and fair remuneration), particularly concerning migrant and seasonal workers in the EU agriculture and food-producing sector, have also gained public attention over recent years through high-profile media cases. Although, these instances are generally not widespread, a recent study by the EU Fundamental Rights Agency (FRA, 2019) documented a number of first-hand accounts in the agriculture sector. Recent COVID-19 infections of

([23]) Zero km food is the term used to describe food produced, sold and eaten locally — food that has travelled zero kilometres.

seasonal workers have also raised awareness of both policy-makers and the public about the importance of decent living and working conditions for seasonal workers in the sector. The European Commission and the European Parliament, as well as national governments, have responded swiftly to these challenges and further information on the measures taken is provided in Chapter 5. In addition, the EU Farm to Fork Strategy has now recognised for the first time the importance of mitigating the socio-economic consequences affecting the food chain and the need to ensure that the key principles enshrined in the European Pillar of Social Rights are respected, especially when it comes to precarious, seasonal and undeclared workers.

Technological and organisational changes resulting from consumer, health and societal demands

Farmers are increasingly acting as stewards, managers, enforcers and service providers in reaction to these increasing demands. Food safety, animal welfare, climate change and environmental standards will continue to increase, as will a growing trend in voluntary food quality and ecological labels, placing farmers under pressure to modify their working practices and comply with a growing number of rules, regulations and schemes. The role of farm managers will continue to change from a hands-on agricultural job to that of a management job involving increasing paperwork, implying the need for better management skills, reform of working practices, investments in farm processes and enhanced knowledge. All of this will increase the pressure, stress and psychosocial challenges in the sector. Increased regulation and administration are issues that are frequently mentioned by farmers as key stressors in surveys (Davies et al., 2019). As a result, there will be a need to improve farmer training (Eurostat 2018a), and farm workers will be expected to have increased knowledge and advisory expertise to deal with a very complex regulatory and technical environment.

Some farmers will also either cease meat production completely or modify their production techniques (i.e. move from intensive farming to more extensive environmentally friendly production methods). Owing to the increase in activism and direct action against farms, there will also be a need to invest in enhanced security on farms to protect both farms and farmers from physical damage or harm. This will add to the psychological stress on farmers, as well as undermining the attractiveness of the sector.

Section B. Implications for the occupational safety and health of farmers, foresters and other workers

The major trends affecting the agriculture and forestry sector have resulted in a number of technological and organisational changes. These changes in turn have an impact on the safety and health of farmers, foresters and workers in the sector. The impact of these changes is now considered in this section.

7 Health and safety implications of technological innovation through science and technology

7.1 Smart farming, smart forestry and OSH — general considerations

Smart farming and smart forestry are general terms used to refer to the use of digital technologies such as drones, sensors, global positioning or satellite systems, automation and robotisation, big data, the Internet of Things (IoT), Artificial Intelligence (AI), augmented reality, etc.. While robotic milking parlours have been in use for some time, more recent developments such as robotic harvesters, mechanical fruit pickers and weeding machines are just some examples of the technological revolution taking place in agriculture. Smart agriculture (incorporating precision agriculture, the internet of things and automation) is a component of overall 'technology' adoption (e.g. mechanisation and infrastructure) and has the potential to improve OSH in agriculture.

A study by Issa et al. (2019) indicates that agricultural engineering developments in the United States played a substantial role in reducing the number of fatal incidents by 63 % between 1992 and 2015 by removing and reducing workers' exposure to hazardous environments.

Technological product design (e.g. collaborative robots) should meet exacting OSH specifications and thus have the potential to enhance the OSH standard of the work environment. Standards for technological innovation and OSH in agriculture are associated with standardisation of such items as machinery, equipment and materials. EU directives (89/392/EEC and amending directives) specify a mandatory procedure for the testing and approval of goods and equipment in terms of their OSH standards. Goods and equipment that conform with the directives' requirements are marked with the CE designation and a declaration is issued to the purchaser that essential OSH requirements are complied with.

Tractors are covered by a specific directive (2003/37/EC([24])) and pesticide application equipment also has its own specific amending directive (2009/127/EC)[25], while towed, pushed, mounted or semi-mounted machinery, whether these are designed and fitted during the production process or fitted as aftermarket accessories are covered by the Machinery Directive, just as well as any fixed machinery used on the farm or in the forest (2006/42/EC ([26])). The Machinery Directive, applicable since 2009, has the dual aim of harmonising the OSH requirements applicable to machinery on the basis of achieving a high level of protection of safety and health, while ensuring the free circulation of machinery on the EU market. However, the diversity of national legislation stemming from the Machinery Directive complicates effective implementation. The European Commission's assessment of its implementation identified several areas for improvement relating to the enforcement of the Directive, including the

([24]) Directive 2003/37/EC of the European Parliament and of the Council of 26 May 2003 on type-approval of agricultural or forestry tractors, their trailers and interchangeable towed machinery, together with their systems, components and separate technical units and repealing Directive 74/150/EEC

([25]) Directive 2009/127/EC of the European Parliament and of the Council of 21 October 2009 amending Directive 2006/42/EC with regard to machinery for pesticide application.

([26]) Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast) (Text with EEA relevance) (OJ L 157, 9.6.2006, p. 24-86).

number and the extent of market surveillance activities, the approach to determining compliance, the measures to withdraw or prohibit non-compliant or unsafe machinery, and the establishment of effective and proportionate penalties for infringements ([27]).

By building **safety and ergonomic features** into the development and design of smart farming technologies, there will be great potential to increase safety and health in the workplace. However, safety and ergonomics through design will need to go much further in the agriculture and forestry sector, even influencing the way that farms are designed, crops are planted and animals are kept and handled. One example of in-built safety design thinking is being led by WSU Extension at Washington State University, which is developing fruit picking management systems. To reduce falls and ergonomic risks for fruit pickers, apple orchards have been re-laid to provide easier access to safer mechanised platforms rather than ladders (Lewis, 2020). This redesign of the crop's layout has meant an investment of USD 45,000 per acre to install and the loss of 2 years' apple production before apples can be picked again. This type of investment has been motivated principally by long-term economic arguments (a reduction in labour costs of 30-40 %) in the first instance with OSH factors as additional advantages.

7.2 Smart farming and OSH improvements

Smart farming developments have the potential to reduce OSH risk factors and improve the working environment, although a number of OSH risks, such as psychosocial issues, can result from the introduction of new technologies (see section 7.3).

Technological solutions, including smart agriculture, have the potential to reduce workload by **substituting labour with capital** and minimising risk exposure. This capacity has been outlined in a range of papers, e.g. Noguchi (2013), related to crop production, and Jago et al. (2013), related to dairy farming. Thus, by replacing labour, the risk of workplace injury is removed, thereby improving OSH. Examples include mechanical harvesting of crops (e.g. potatoes and fruit), automated milking of dairy cattle, and forestry harvester technology. However, working in a technological environment demands a more technologically skilled workforce and may entail other psychosocial challenges, as demonstrated by the experiences of automated milking systems over the last 30 years (Lunner Kolstrup et al., 2013).

Technological adoption, such as telecommunications, automation and precision agriculture, will foster **more efficient management systems**, including time management, and increase farm profitability, minimising adverse environmental impacts and improving the sustainability of agricultural production (Wang and Lee, 2013) while improving OSH standards. In particular, technology can help farmers save time and dedicate more time to management issues that are at the heart of effective OSH management. Examples might include the use of a drone fitted with a sensor to scan crops for foliar disease or sensors to detect cows in heat.

Smart farming solutions have the potential to simplify work systems and improve **process control** and **safety systems management**. This will improve work organisation and as a result lead to OSH improvements. However, challenges remain in many areas of agriculture owing to the irregularity and unpredictability of the work environment (soil, topography, flora and fauna, weather, etc.), making sensing particularly challenging (Wang, 2013). An intermediate step will most likely be the use of 'co-robotics' or 'cobots' — designing robots to work alongside human workers, with the robots handling simple tasks while people continue to perform the more complex and delicate actions (Downing, 2018). One example is the use of co-robotics for fruit or vegetable harvesting. An additional OSH challenge, however, will be managing the interaction of various cooperative robotic systems, all working in the same environment, while preserving the safety of human operators.

However, the farm safety experts who were consulted for this report also made the point that new technologies alone will not bring safety and health improvements without **adequate training** in using the machines effectively and reinforcing the general **prevention culture** in the sector. The very way that work is organised will have to be reconsidered to include effective OSH management practices.

([27]) Commission Staff Working Document — Evaluation of the Machinery Directive (SWD/2018/0160 final of 7 May 2018, p. 21.

As we have seen with automatic milking system technology, the farmers' **work-life balance** will improve, as they will be able to manage and monitor machines and systems virtually, at a distance and at different times, e.g. monitoring pig or poultry building environments via mobile phone, using a remote camera to monitor livestock around calving time or automated irrigation systems determining when and where to irrigate and how much to apply (Wang et al, 2013). This will not only reduce work and travel time for farmers but will remove unpredictability and stress from these work situations, ultimately improving well-being and OSH. However, as illustrated through the development of automated milking systems, new technologies may contribute to increased stress during early phases of implementation owing to technological bugs and teething problems.

Preventing **MSD**s through ergonomic improvement will be one of the most important benefits of the introduction of smart technologies in farming and forestry. MSDs are one of the most prevalent ill health conditions suffered by farmers (Osborne et al., 2012), while the EU directive on the topic (Directive 89/654/EEC) requires the adaptation of the workplace to minimise this risk. Considerable potential exists through design and technological solutions to minimise the risk of MSDs. Examples include the use of mechanical means or robots to move loads or the reduction in repetitive movements during fruit and vegetable harvesting. It will be important, however, to monitor the transition to these new digital workplaces so that traditional MSD risks are not replaced with other, more psychosocial, risks associated with the use of digital technologies.

Smart precision spraying equipment (such as remote spraying using drones or field-based robotic equipment) which can spray at distance and reduce the quantity of chemicals used provides the opportunity to reduce **occupational exposure to hazardous substances**, such as pesticides, as well as reducing their impact on the environment. Precision spraying equipment leads to integrated control of droplet size and nozzle flow rate to maximise the transfer of the substance to a crop (Karkee et al., 2013), and in some instances manufacturers claim that they can reduce pesticide use by up to 80-90 % (Wipro, 2019). Some smart technologies under development even remove the use of pesticides completely and depend on weed pulling or laser weed zapping technology. All of these developments are effective technologies that could contribute to the implementation of the EU Sustainable Use of Pesticides Directive (2009/128/EC ([28])) which advocates IPM (Flint, 2012).

With new smart agricultural machinery, it is likely that **noise levels** will decrease through the gradual introduction of quieter machines and better noise insulation and reduced vibration. In addition, farmers and foresters will be able to employ more remote smart technologies, creating a safer distance between the source of the noise and themselves. Even precision livestock farming (PLF) practices will enable farmers to be exposed for less time to animal noise and hopefully manage animal distress ahead of time, thus reducing overall noise exposure.

Contact with machinery (unguarded moving parts) and transport accidents (being run over or crushed by overturning vehicles) are both listed among the top eight killers in agriculture (EC, 2011). Vehicles and machinery on farms are responsible for 36 % and 8 %, respectively, of farm fatalities in the United Kingdom (HSE). In France, work equipment accounts for one-third of fatal accidents in agriculture (Moreau, 2019). In Germany 17 % of the injuries in forestry are related to equipment. New technology will provide the opportunity to improve **machine and vehicle safety**, e.g. force-torque sensors, tactile and pressure sensors, safe maximum speeds, proximity sensors, area detectors and cameras, and emergency stop buttons (Vasconez et al., 2019). Surroundings sensors and vision technologies, as developed in the motor industry, have the potential to enhance OSH standards but are not as well developed and widespread in the agricultural vehicle and machinery industry or in forestry harvesting technology at present. In 2019, 23 % of UK fatal agricultural accidents occurred through the handling of livestock (attacked or crushed by animals), also listed among the top eight killers in agriculture (HSE). Technology used in PLF offers great potential to improve **livestock safety**. Animal production management, along with animal health and welfare, is very closely linked to the safety and health of farmers. The use of innovative approaches, such as the use of biosensors for animal health management, has gained recognition (Steeneveld et al., 2015). Hostiou et al. (2017) reviewed PLF

([28]) Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides (OJ L 309 24.11.2009, p. 71-86).

being developed in dairy farming to manage increasing herd sizes and decreasing workforce availability. PLF can facilitate herd monitoring and reduce the drudgery of repetitive tasks. Their review indicates that time savings are achievable because robots and sensors take on recurrent physical tasks (milking, feeding) while simplifying the monitoring of animals (heat, health problems, etc.), while farmers have additional flexibility to organise their work. Mental workload can be reduced by anticipating events (insemination, health problems) but it can also increase because of the complexity of the information involved in managing the multiple alarms or alerts and dealing with equipment failure. The relationship between farmers and their animals is also modified. The authors conclude that PLF can have a positive impact on dairy farmers' work and can be attractive to young people. However, if the tools are not adapted to farmers' needs and skills, PLF can also lead to negative impacts on farmers and animals. It is therefore critical to consider the different dimensions of farmers' work to facilitate the adoption of these new technologies. Further information on the breadth of research on PLF can be found at the European Association for Precision Livestock Farming ([29]). Application of modern technologies offers potential to increase **gender parity in agriculture** as a result of fewer physical demands, ergonomic design and more flexible work arrangements (Chen and Holden, 2017). For instance, Kallioniemi et al. (2015) noted higher levels of farm workplace injury among female livestock farmers, which can be partially alleviated by applying technological solutions.

New technologies can **support disability management** in farming. Disability among farmers and farm family members can arise from a wide range of both farming and non-farming sources and has potential to affect a person's lifestyle, capacity to farm and on-farm income (McNamara et al., 2007). New technologies offer potential to assist people with disabilities with their lifestyle and to enable them to continue to farm. Examples can be seen in the work conducted by Agrability ([30]), a US organisation that focuses on enhancing quality of life for farmers, ranchers and other agricultural workers with disabilities.

Considering that farmers over the age of 65 years represent one-third of the EU agricultural workforce (See section 6.5.1. on Labour market trends), new technologies offer the potential to increase **older worker engagement** and employability in a safe and healthy manner. In order for intervention programmes to be successful in reducing injuries, older workers need to be encouraged to participate in the design of the programmes and be involved in specific physical and cognitive age aspects (Nilsson, 2016). Thus, new technologies, such as computer-aided controls and emergency stop systems can help older people to work more safely.

New smart monitoring technologies could improve safety and health on the farm and in the forest, particularly through the use and wearing of smart devices, such as smart watches and smart PPE (EU-OSHA, 2020b). Examples include:

- GPS (global positioning system) devices and apps ([31]) that monitor the movement and position of lone workers and include emergency call systems, particularly in isolated rural areas;
- smart watches and other similar devices that could monitor health vital signs (heat stress, heartbeat and blood pressure, etc.) as well as MSDs and exposure to hazardous substances, although ethical and privacy issues would need to considered, as well as user acceptability;
- safety app tools are already available for monitoring OSH hazards, such as heat stress (OSHA-NIOSH Heat Safety Tool ([32])), general safety and location apps and generic OSH apps on chemicals, noise, ladder safety, etc.

Reviews of issues associated with use of smart PPE and associated technologies have been published by EU-OSHA (2020b) and Podgórski et al. (2017). KAN, the German Commission for Occupational Health and Safety and Standardisation, has raised a number of issues that still need to be addressed before the full potential of smart PPE can be realised. Challenges remain on ergonomics and comfort, smart PPE creating possible new risks, no agreed smart PPE standardisation testing methods, privacy and security challenges, and the need to modify existing legislation on PPE, electromagnetic frequency

([29]) http://www.eaplf.eu/
([30]) http://www.agrability.org/
([31]) An example supported by the German KWF: https://play.google.com/store/apps/details?id=de.intend.android.hilfeimwald&hl=en
([32]) https://www.cdc.gov/niosh/topics/heatstress/heatapp.html

and radio equipment. Likewise, the cost of smart PPE could also be a limiting factor for small farmers. The UK HSE also has an ongoing research project on wearable devices (HSE, 2019c).

Although potentially controversial owing to privacy and ethical challenges, the on-farm installation of precision monitoring and sensor applications similar to those used in PLF applications could be effectively re-purposed or adapted to improve the safety of the farm environment. Smart farm buildings and yards installed with video monitoring, movement, heat, noise and emergency sensors could be used to monitor the safety and well-being of farmers and farm workers. Existing PLF applications might also be able to be adapted to care for the farmers as well as for the animals. Cost may be a challenge, but a basic system based on video movement sensors could provide other family members with the potential to check regularly on the well-being and safety of family members.

Smart technologies may also have an unintended positive impact on machine safety by restricting self-maintenance of farm machinery. In the same way as we have seen with modern cars, increasingly smart technologies will create two clear barriers for farmers wanting to repair their own machinery. Firstly, as we saw under key driver 1, farmers are losing access to and the right to repair farm machinery themselves owing to intellectual property and warranty protection, and, secondly, the increasing technical complexity of smart machinery means that farmers will be less likely to attempt their own repairs. Considering that a number of farm accidents result from machinery maintenance, ironically this unintended consequence may result in safety improvements, in spite of its unpopularity among rather independent farmers.

In forestry, safety improvements will result from an increase in **mechanised wood harvesting.** However, a lot of manual work still needs to be carried out with chainsaws, which present the most important risk in forestry, and their use will not be eliminated any time soon, particularly on difficult terrain and in countries with small-scale forestry operations. Increased mechanisation will also probably bring about a shift in the causes and types of accidents, through either machine-related accidents or maintenance-related incidents. Similarly, accidents involving falling and tripping while getting on and off machines will increase. Despite mechanisation, nature conservation regulations (‘skidroads’ or lanes fixed at 20 metres) also have an impact on safety. Mechanical harvesters have a maximum reach of 10 metres and cannot penetrate sufficiently into the tree canopy to crop all the trees effectively. It is therefore necessary for a forest worker to cut in between the machine-cropped areas with a chainsaw. This cooperative space between workers and machines constitutes a significant risk, which is made worse by the limited visibility. As a result, forest workers need to work close to the machines or even in the risk zone. They may not be seen properly by the driver of the harvester and can also be injured by falling trees cut by the harvester. This in turn significantly increases the risk of injury for the forestry manager/forestry worker. **Remote-controlled felling wedges** can reduce risk in felling operations. Although their use is not yet widespread, they are likely to be employed more frequently in the future, as with advancing climate change there will be a need to remove damaged or dying trees.

Another application of new technologies, such as drones and satellite imaging, could be the precision inspection of OSH conditions by labour inspectorate and insurance companies, particularly in rural and isolated areas. Although controversial, similar developments have taken place; car insurance companies are already offering lower premiums to drivers agreeing to satellite monitoring of their driving habits. On a voluntary basis, based on a system of incentives, such as lower insurance premiums, this could help improve the OSH risk prevention culture on farms. This is, however, unlikely to work at present in a sector in which most farmers are resistant to perceived outside interference.

New improved digital technologies and apps are also being developed for **recording and managing (farm) safety risks** and **supporting OSH training**. Examples include farming-specific hazard identification tools, tools for risk assessments, OSH audits, and a number of simulator training devices for tractors ([33]). In view of the independent, rural and small-scale working environment of many small

([33]) Examples include the tractor overturn simulator from the Spanish National Institute for Safety and Health at Work (INSST) and the University of Cartagena (https://www.insst.es/el-instituto-al-dia/tu-vida-sin-vuelcos) and the tractor driving simulator of the Department of Agriculture, Environment and Rural Affairs in Northern Ireland (https://www.daera-ni.gov.uk/news/minister-poots-launches-nis-first-tractor-driving-simulators).

farms, easy-to-use self-help risk assessment apps could offer real solutions for improving farm safety if appropriately endorsed and tested by competent OSH authorities.

In summary, enormous potential exists for using technological solutions (including smart agriculture) to reduce OSH risk factors. However, **smart farming solutions** will not offer an immediate improvement in safety and health in the sector. The key challenge that remains is the effective adoption of such technology, which is associated with variables such as farm income and scale, farmers' age and education, the usability of specific technology, and industry and extension support for farmers. With the uptake of technology workers' skill levels will also need to be improved to keep pace with change.

7.3 OSH challenges from smart farming technologies

The uptake of technology tends to be challenging and stressful and support is needed, particularly at the early development phase (Klerkx and Rose, 2020). As described in Chapter 6, the uptake of new technologies tends to be relatively slow (e.g. seatbelts in cars took over 20 years to become established practice) so benefits will be neither widespread nor universal nor immediate. Low farmer income is a major barrier to quick adoption and the uptake of new technologies. Low EU and national food prices mean that many small farmers struggle financially and are unable or reluctant to invest in what they may see as 'unproven' technologies with unclear returns on investment. As a result, smart farming solutions will take a number of years to improve OSH levels in the sector and will not offer an immediate solution to the high accident rate and occupational health challenges the sector faces.

Training will also need to be adapted to the use of new technologies, particularly in terms of the need for digital skills, to ensure that workers know how to use new technologies effectively but also with confidence in order to avoid additional psychosocial pressures related to the introduction of new technologies.

New technologies also need to be evaluated to see if they bring any **new or additional risks** to the workplace. For example, the sensors of autonomous robotic agricultural vehicles have a function based on multiple sensor inputs that enables them to make a decision on whether it is safe to continue or if there is a danger of collision. However, the level of safety that needs to be achieved before a robot can be released onto the market is not just a technological question but also a question requiring community consensus (Noguchi, 2013). In the future, a further example could be a spraying drone working in close proximity to agricultural workers in a field. There is a need to establish safety protocols and OSH evaluation/certification systems for smart farm technologies. Furthermore, the use of several artificial intelligence systems together could potentially 'clutter' the farm workplace with a number of interacting technologies and multiply the risk of malfunction or injury if the various systems or 'fleets or swarms' of robots do not work effectively together. According to the UK-RAS (Robotics and Autonomous Systems) network (2018), human supervision of farm robots will be needed for the foreseeable future to ensure safety at least until the technology becomes more autonomous. So-called 'cobots' will most likely be the first intermediary step in farming robotic development (Huelke, 2016). The UK HSE is presently carrying out research on the safety and health implications of cobots (HSE, 2019).

Furthermore, there does not appear to be much evidence of **OSH experts** being involved in the development of smart farming technologies, which is mainly driven by large multinational concerns, agricultural research institutes or tech start-ups. The Central Agricultural Mutual Fund through the local Mutual Agricultural Funds (CCMSA) ([34]) in France and the Social Insurance Fund for Agriculture, Forestry and Horticulture (SVLFG) in Germany are involved to some degree in smart farming technological developments, but this is only a fraction of the smart farming revolution driving the industry. However, smart technology OSH research and development in relation to cobots and wearable devices in other sectors could also be relevant. The involvement of OSH experts in such developments is complicated by the multitude of technological solutions, the pace of development and the lack of reliable implementation data. This is of real concern, considering that it can take a number of years to modify

([34]) CCMSA has a research and development agreement with the French agricultural research body IRSTEA (Institute national de recherche en sciences et technologies pour l'environnment et l'agriculture) on new technologies in agriculture.

equipment once approved and on the market. The CCMSA has taken a long-term policy approach of investing time and energy in new machinery developments and standardisation that have been the most relevant and effective in improving safety and reducing risk exposure (Moreau, 2019).

Although new technologies provide us with opportunities for improving safety, they will also reduce the workload and the number of workers necessary to carry out certain agricultural tasks (and as a result have a direct impact on rural depopulation). This may increase the number of **lone workers** in forestry and agriculture, who will be at greater risk without direct supervision or anyone to help them if things go wrong, even though in certain countries there are strict rules on lone working. More so than in other sectors, many farm and rural areas are isolated and far away from the nearest help and medical attention. Farm entities may also be tempted to rely on cheaper technological solutions for oversight and emergency support, rather than providing accompanying workers. The high risks of accidents in forestry work mean that lone working puts the person at particular risk should they suffer an accident or injury. For this reason, lone working is usually restricted in certain circumstances (e.g. when working with chainsaws). Workers who work alone should be able to request help by radio, mobile phone or emergency call systems.

Psychosocial challenges such as **monotony and stress** are both associated with the introduction of new automated technologies in farming and forestry. Stress and frustration have been experienced by farmers faced with malfunctioning automated systems during their initial implementation periods, such as false alarms and malfunctions, and older workers have been experiencing more stress related to the introduction of new technology (Kartunnen, et al., 2016; Holte et al., 2018; Lunner-Kolstrup et al., 2018). Kartunnen et al. (2016) found that in some instances mental stress associated with automated milking systems increased because of the demanding management of such systems, nightly alarms, lack of adequately skilled hired labour or relief farm workers and being on call 24/7. The impact of job insecurity resulting from the feeling of being displaced by technology can also lead to psychosocial challenges such as work-related stress. Frustration also arises because of reliance on equipment that the operator is unable to fix themselves owing to the complicated technology and the risk of forfeiting the warranty (Waldman and Mulvany, 2020), making farmers reliant on outside technical assistance, which results in lost production time, additional costs and a feeling of loss of autonomy. Additional psychosocial risks can emerge from the feeling of monotony. Machines increasingly take on physical work and human operators are reduced to overseeing automated systems and experiencing the feeling of 'loss of control', sense of purpose and utility. In a similar way to automated milking systems, the work on forwarder and harvester vehicles in forestry are jobs that provide little variety or alternation in tasks, creating both psychological and physical challenges. Task diversity is important in both farming and forestry work and is key to avoiding operators being compelled to stay in fixed positions operating machinery for long periods of time. Equally, as farm sizes increase, task diversity for workers is often reduced and there is an over-reliance on equipment. All this ultimately leads to increased sedentarism and a higher risk of MSDs and cardiovascular disease.

'**Hacking' and interference** could become a real safety and security threat in the future. According to a US study (US DHS, 2018), there are a number of risks that need to be managed in smart farming, such as the possibility of confidential data being stolen, systems subjected to ransomware, agricultural production disrupted and the integrity of livestock threatened. In addition, a robot tractor could be hacked and could run amok, and there is a risk of people deliberately interfering with robots, either for 'fun' or with malicious intent. The fear of data misuse can also hinder the acceptance of new technology, as witnessed by a German survey (Deter, 2020).

As mentioned above under 'New smart monitoring technologies', monitoring of **workforce performance and pace** through new wearable technologies could raise ethical concerns and contribute to worker stress if not implemented properly. This risk would be most relevant in activities in the horticultural sector, for example, where farm workers are monitored depending on their pro-rata performance. However, the impact here could potentially be positive, if managed effectively through collective bargaining, considering that seasonal crop workers are already monitored based on the amount of fruit they pick. These systems could add value in safety and health terms, with monitoring systems able to monitor and evaluate aspects such as heat stress and repetitive movements. As this sort of technology becomes cheaper, the business case for implementing such technologies will improve.

Using mobile phones while operating machinery, particularly among young people, has added additional risk factors in some instances, owing to distraction by and misuse of new technologies while operating farm and forestry equipment (similar to the risk associated with the use of a mobile phone while driving) (Gorucu et al., 2018).

7.4 OSH challenges from traditional and emerging machinery use

7.4.1 Farm vehicles and machinery

Farm vehicles and machinery are a major source of workplace fatalities in agriculture, accounting for 48 % of all workplace deaths in Ireland, for example. Tractor and farm vehicles account for the highest proportion of fatalities (29 %) and, of these, being crushed (67 %), vehicles overturning (14 %), being struck by (12 %) or falling from the vehicle (7 %) are the causes of most farm tractor or vehicle fatal workplace incidents (Figure 8). Machines are associated with 19 % of total fatalities, accounted for by being crushed (38 %), struck (35 %), entangled in the power drive to the machine (power take-off) (11 %) or machine mechanism (11 %) or falling from the machine (5 %). Quad-bike incidents are associated with about 10 % of fatal farm workplace accidents in Ireland, annually (HSA, 2017).

Figure 8: Tractor safety is a key concern

Fatal farm accidents in the United Kingdom show a similar picture with 44 % associated with farm vehicles or machines. Thirty-six per cent of victims were killed when struck by moving vehicles, including tractors, trailers, telescopic handlers, farm vehicles and all-terrain vehicles (ATVs). A further 8 % were associated with contact with machinery (HSE, 2020).

The data generally indicate that the fatal accident arises when the farm vehicle or machine comes into contact with a non-driver, such as a bystander, or when the operator is in close proximity to the machine to make adjustments or to carry out maintenance. This strongly suggests that, from a vehicle and machine design perspective, features such as maximising visibility, braking and securing when the vehicle or machine is stationary and machine guarding are important safety features. Regarding the future design of farm tractors, vehicles and machinery, technological means of improving safety, including the increased use of cameras and the use of sensors to detect and warn of people in the vicinity of a machine, could enhance farm safety. The data also strongly indicate that human behavioural

factors related to safety are crucial when in the vicinity of machines. Appropriate training in the use of machinery is a key factor in prevention, as well driving and operating licences, and models such as the European Chainsaw Certificate could be explored further.

Tractor overturns

Tractor overturns remain a stubborn problem in several European countries. According to one recent Spanish study (Ramos et al., 2020), there have been 595 deaths by tractor overturn in the last 10 years, approximately one death per week. Ninety-one per cent of these deaths involved tractors either without a roll-over protection system (ROPS) or with the system not engaged (Figure 9). Over half (54 %) of these deaths involved farmers over 60 years old. The study in question was based on newspaper cuttings, as many of the accidents were not reported in official statistics, as the farmers involved were not officially registered as 'workers' in the national reporting system, usually owing to their age or labour conditions. An overall level of under-reporting was estimated at 60 % of such fatal accidents. A study in Italy points to a similar problem with 71.7 % of fatal tractor-related accidents involving non-ROPS-equipped vehicles (Rondelli et al., 2018). Again just over one-third of these fatalities involved machines originally mounted with a ROPS that had been removed or which was folded down and inoperative during the roll-over event. Although, retro-installation of ROPS is not a major financial investment (approximately several hundred euros), it is still an added expense that economically marginal farmers would need to consider. Likewise, ROPS installation is yet another task for a very busy farmer. Incentive schemes have been successfully used in the United States in which a substantial component of the cost of ROPS installation was refunded (Hallman, 2005).

Figure 9: Tractor fitted with a roll-over protection system

Quad bike safety

Quad bikes or ATVs have been used in agriculture for about 35 years (Figure 10). In design, they are similar to a motorbike, with the driver sitting astride, but they have four wheels and weigh approximately 300-400 kg. Unlike a motor car or tractor, they are typically not fitted with a differential mechanism, which means that they can overturn more easily when turning, especially at speed on roads. They can travel at speeds of up to 50 km per hour. Accidents may also occur because farmers adjust these vehicles to their needs in a way that can reduce their safety.

Figure 10: Quad bike used in agriculture

Side-by-side ATVs are small utility vehicles in which the driver and passenger sit alongside each other in a conventional manner, providing an alternative to using a quad bike. Most side-by-side vehicles are capable of carrying two occupants, and the majority have a capacity of four and a cargo bed behind the seating area. Side-by-side ATVs are sometimes referred to as utility vehicles (UTVs) or rough terrain utility vehicles (RTVs). Side-by-side vehicles generally have a roll-over structure (ROPS) and driver and passenger seat belts.

Quad bike injuries in agriculture

Injury can occur in numerous ways, such as the quad bike overturning sidewards on a slope, when turning due to speed or because of an uneven surface. They can overturn rearwards on a slope or if the wheels engage with solid material at speed. If a machine turns over either sidewards or rearwards, the driver will be thrown off the quad bike and may suffer multiple injuries. High accident rates have been observed in a number of countries, including the United Kingdom, Ireland, Sweden and Australia.

Fitting of a quad bike **roll-over/crush protection device** has been a controversial issue for some time internationally. Research in Australia has indicated that fitting these devices reduces injuries (Lower and Trotter, 2014). In contrast, manufacturers consider that fitting such devices to quad bikes does not enhance safety (Lower, 2013). In Europe, research on quad bike protection is unavailable. It is possible in Europe, however ,for a farmer to purchase a CE-marked roll-over/crush protection device and fit it to a quad bike without the manufacturer's approval.

The safe use of quad bikes depends to a considerable extent on the driver's competence and on wearing a **helmet** of an approved standard and ensuring that a **seatbelt** is installed and used.

McBain et al. (2014) consider that quad bike safety is a 'wicked' problem, as the causes of injury may be multifactorial, and therefore the solutions are complex or require individual responses. The problem of quad bike safety is compounded by the number and variety of types of quad bike available, the locations of their use and the demographics of users. Quad bike safety needs to be addressed by a comprehensive approach to the development of solutions involving technical and behavioural aspects (Lower et al., 2012; Lower, 2013).

In an effort to address this issue quad bike safety guides and standards have been drawn up in various countries, including Australia ([35]), France ([36]), Ireland ([37]) and the United Kingdom ([38]).

7.4.2 Forestry vehicles and machines

Forwarders are tractor-like extraction vehicles that carry log loads off the ground. They usually have a mechanical or hydraulic crane for loading and unloading the logs. Accidents with forwarders are similar to those involving tractors and other forestry machines, such as skidders and tractor crawlers, and they involve risks such as overturning, being struck or impaled by vehicles, slips and trips and falling objects. Health and safety hazards also include vibration and noise.

Chainsaw use will continue to be the most important risk in forestry for some time (Figure 11. In addition to cutting and felling-related accidents, there are additional risks from vibration, noise, exhaust fumes and the use of fuel (risks of burns and dangerous substances). Modern chainsaws are equipped with a number of ergonomic features, e.g. anti-vibration handles, and generally, if they conform to the appropriate standard, provide significant safety and ergonomic improvements. However, a large number of older chainsaws are still in use, particularly in lower income countries, and there are also reports of unapproved or substandard machines being used, thus increasing risks.

Figure 11: Chainsaw in use

([35]) *Safety of quads and side-by-side vehicles on Australian farms — A practical management guide*. Available at: https://aghealth.sydney.edu.au/wp-content/uploads/2019/05/Safe_Use_Of_Quads_and_SSU.pdf

([36]) French guide by the CCMSA on the driving of quads in safety on a farm (*Conduire un quad en sécurité sur une exploitation agricole*). Available at: https://ssa.msa.fr/wp-content/uploads/2019/05/MPN-SST-017-Conduire-un-Quad-en-s%C3%A9curit%C3%A9-05-2019.pdf

([37]) *Safe quad skills and operation*, DVD produced in Ireland by FBD Insurance, Health and Safety Authority and Teagasc: Agriculture and Food Development Authority, 2014. Available at: https://www.youtube.com/watch?v=MVGYOy8cmDE

([38]) UK HSE guide: *Safe use of all-terrain vehicles (ATVs) in agriculture and forestry*. Available at: https://www.hse.gov.uk/pubns/ais33.pdf

In line with the machinery directive 2006/42/EC the European Chainsaw Certificate of the European Forestry and Environmental Skills Council (EFESC) ([39]) provides information and training on safe use, adjustment and maintenance operations and training on protective equipment, such as head, hearing and eye protection.

The ECC therefore offers a guaranteed uniform European standard for chainsaw operators and includes significant safety and health elements, thus significantly reducing the risk for those who are qualified.

8 Climate change and the environment — occupational safety and health

As indicated in Chapter 7, as well as agricultural practices directly affecting climate change, climate change will also have repercussions on agriculture, which will ultimately have a direct impact on the working conditions and well-being of farmers and foresters (Adam-Poupart et al. 2013; Applebaum et al. 2016; Levy and Roelofs, 2019). Successful adaptation by farming and forestry demands constant learning and a the flexibility to change, but the fact that the weather will be unpredictable in the long term reduces the control that farmers and foresters have, exerting more pressure on them and adding to psychosocial stress factors in the sector.

8.1 Extreme weather events and fires

Figure 12: Calamitous weather conditions

As severe weather events increase, this will result in more adverse and unsafe working conditions as floods, fires and extreme weather all increase in mainly rural environments. Not only will farmers and foresters be directly at risk, but they will be faced with increased professional risk if surprised by rapid changes in conditions while working in isolated rural areas and/or when attempting to salvage crops, protect property and save livestock from imminent and unpredictable weather. In addition to the physical risks from falling trees or objects, drowning, burns, frostbite, etc., from severe weather conditions, there is also significant risk from toxic gases, explosions, extreme heat and fighting fires. It is not only the immediacy of risk that affects farmers and foresters but the clean-up in the aftermath can also be hazardous, as farms in particular may contain ageing buildings and structures, machinery, chemicals and disposed of waste. Debris from wind damage is one of the most hazardous operations in forestry, which requires expert knowledge of managing the situation, competence and operational skills. The clean-up after a flood can involve risky operations that need caution, knowledge and high operational skills. Farm structures and fields will need to be designed to resist stronger wind conditions and/or floods, as extreme weather events become more common. Smart monitoring forecasts of meteorological conditions could also help to reduce unpredictability and manage the risk of extreme

([39]) www.efesc.org

weather events (Figure 12). A growing number of OSH resources are being published as these incidences generally increase, with, for example two specific agricultural OSH-related examples from the United States on flood recovery ([40]) and wildfires ([41]).

8.2 Heat exposure

Firstly, in terms of workplace accidents, a number of studies point to a link between extreme ambient temperatures and increased risk of occupational injuries (Bonafede et al., 2016; Martinez-Solanas et al., 2018)). According to Kjellstrom et al. (2016), exposure to high temperatures can lead to physiological and psychological changes associated with heat strain, which in turn can decrease workers' performance and lead to impaired concentration, increased distractibility and fatigue. In addition to the increased likelihood of accidents, heat is a major health risk for those working outside. It can cause dehydration, heat exhaustion and heatstroke and can even result in loss of consciousness and heart attacks in extreme circumstances. Older workers are also more vulnerable to such risks and ,considering that one-third of EU farmers are over 65 years old, this also increases the severity of risk for the EU farming population. California has published a heat illness prevention standard ([42]) for outdoor work.

One of the OSH consequences of climate change and increased heat will be the likely increase in night-time work or in early morning and late evening working. California has recently brought in a law on night work, which applies to agricultural workers who harvest, operate vehicles and carry out other tasks between sunset and sunrise. The law([43]) focuses primarily on workplace hazards caused by poor visibility.

We will need to adapt workplaces to protect farmers and workers from heat exposure, e.g. sufficient shade for workers and sufficient ventilation and cooling systems. Dark surfaces will also need to be avoided, as they can increase the heat in buildings. There will be a need to raise general awareness of dehydration and working in hot weather conditions. Work patterns will need to be varied to reduce the impact of exposure to extreme heat, e.g. longer breaks, working during the night and at different times of day or year (changing seasonality) and supplying water (or even monitoring water consumption) to ensure that workers drink enough.

The use of PPE in extreme heat conditions is also particularly challenging, especially in forestry where it is difficult to wear for long periods during hot weather and adds to the effort and stress of the job. The PPE itself can contribute to heat stress, and both farm and forestry workers have been observed frequently removing PPE in excessively hot conditions to alleviate heat stress. The integrity of the PPE may also be jeopardised by perspiration in hot conditions. Furthermore, in forestry, the full PPE is seldom worn by non-professional foresters or by farmers who sometimes work in wood production.

A number of good practice guides exist on how to best manage heat stress, with examples from France ([44]), the United Kingdom ([45]) and Australia ([46]).

([40]) https:/www.agrisafe.org/flood-clean-up
([41]) https://www.agrisafe.org/wildfires
([42]) California Code of Regulations, Article 10, Personal safety devices and safeguards, Heat illness prevention in outdoor places of employment. Available at: https://www.dir.ca.gov/title8/3395.html
([43]) Department of Industrial Relations, State of California (2020), 'California adopts first in the nation workplace safety standards protecting nighttime agricultural workers from hazards', Press release No 2020-55, 24 June. Available at: https://www.dir.ca.gov/DIRNews/2020/2020-55.html
([44])https://nord-pasdecalais.msa.fr/lfy/documents/11566/48457/D%C3%A9pliant+-+Pr%C3%A9vention+des+risques+chaleurs+et+canicule+-+m%C3%A9tiers+agricoles
([45]) https://www.hse.gov.uk/temperature/heatstress/index.htm
([46]) https://aghealth.sydney.edu.au/wp-content/uploads/2019/05/19.-Heat-Stress.pdf

8.3 Exposure to solar ultraviolet radiation

Farmers and fishermen are among the workers at the highest risk of developing skin cancer, since they are exposed to the sun on a daily basis (Adam-Poupart, 2013). Foresters are also very much exposed to the sun when working in open areas. Very high skin cancer rates have been reported in the United States in farmers and seasonal farm workers (Arcury et al., 2006). Solar/UV radiation exposure is known to be associated with various skin cancers, accelerated skin ageing, cataracts in the lens of the eye and other eye diseases, and may have an adverse effect a person's ability to resist infectious diseases (WHO, 2001).

Figure 13: Shade for workers

The German Agricultural Social Insurance Organisation SVLFG ([47]) reports over 2,000 suspected cases in Germany per year, and UV radiation skin cancer is also recognised as an occupational disease by the German authorities. Most of these health concerns could be avoided by reducing exposure to solar UV radiation. Although exposure to UV radiation may also have benefits for health through the production of vitamin D in the skin and modulation of the immune function, it is essential to manage the benefits and adverse effects of sunlight by increasing awareness and providing information. In addition to increasing awareness, a number of measures, such as reorganising work patterns to avoid peak periods of sunlight, reducing reflective surfaces and providing adequate shade protection and sunscreen will need to be implemented to protect workers from exposure to the sun (Figure 13). A number of resources exist concerning how to manage UV radiation exposure in agriculture with examples from Australia ([48]), Canada ([49]), Germany ([50]) ([51]) and the United States ([52]).

8.4 Animal and insect-borne disease and invasion of predatory species

In the EU, there is increasing exposure to animal and insect-borne diseases from neighbouring regions as mild winters encourage their spread. For example, tick-borne diseases (such as Lyme disease and tick-borne encephalitis) continue to spread from central and Weastern Europe to the west, encouraged by milder winters (Figure 14).

([47]) https://www.svlfg.de/enasp
([48]) https://aghealth.sydney.edu.au/wp-content/uploads/2019/05/20.-Sun-Safety.pdf
([49]) https://www.ccohs.ca/oshanswers/diseases/skin_cancer.html
([50]) https://www.svlfg.de/sonnenschutz
([51]) https://www.dguv.de/ifa/fachinfos/strahlung/genesis-uv/index-2.jsp
([52]) https://www.cdc.gov/niosh/topics/sunexposure/default.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fniosh%2Ftopics%2Fuvradiation%2Fdefault.html

Figure 14: Tick, a carrier of Lyme disease

The spread of chikungunya, a mosquito-borne virus, has been modelled for the forthcoming decades to inform public health authorities' preparedness planning, owing to the projected imminence of such risks (Tjaden et al., 2017). Other diseases, such as West Nile fever can also enter from neighbouring regions. High temperatures in the summer of 2010, for example, have been associated with the epidemic of West Nile fever in south-eastern Europe, and outbreaks occurred as recently as the summer of 2020 in Spain.

According to EU-OSHA (2009), zoonoses represent three-quarters of all human emerging diseases. Farmers, foresters and workers in the sector are among the professions most affected by the risk of zoonotic diseases and are at risk of exposure to biological hazards. Ticks, insect bites and stings are a particular risk for foresters and forestry workers (Haeberle, 2020). Likewise, there appears to be a significant under-reporting of zoonotic diseases in the sector and lack of health surveillance among farmers, particularly on small and family farms (Rabozzi et al., 2012).

Although globalisation in trade and travel are often responsible for the importation of these viruses, climatic conditions strongly affect the efficiency of transmission in local settings. Increasing globalisation and international travel (both passenger and freight) constitute a risk for farmers and foresters from both animal and plant species that ultimately find their way to the rural environment. For example, Asian hornets are now an additional safety problem for farmers and rural dwellers in northern Spain. Allergenic plants such as *Ambrosia* and other biogenic hazards (viruses, pathogens, neophytes) are spreading, and higher temperatures may be providing a fertile environment for their growth.

The increasing public health concern about MRSA (meticillin-resistant *Staphylococcus aureus*) is also mirrored in terms of OSH in the sector. According to Neyra et al. (2012), exposure to antimicrobial-resistant pathogens, such as MRSA, may represent an emerging health risk for workers in animal production. The EU Farm to Fork Strategy has called for a reduction in the use of antimicrobials by 50 % by 2030. This should be welcomed, not only from a public health perspective but also in terms of protecting farmers from developing antimicrobial resistance to zoonotic diseases, as in pig farming in particular MRSA can be transferred from pigs to humans (EU-OSHA, 2019a).

Much public attention and resources tend to focus on either protecting animals from disease or protecting the general public from human-to-human zoonotic infection. However, it is often the farmer who is on the front line of potential transmission from animal to human species. By placing emphasis on the occupational safety of key front-line workers, such as farmers, veterinarians and meat and livestock handlers, we could create an effective barrier to the development of human-to-human transmission of future zoonotic diseases.

8.5 Exposure to dust and pesticides

Figure 15: Dust exposure during soil preparation

According to Schenker (2000), exposure to inorganic (mineral) dusts among farmers and farm workers may be substantial. Respirable quartz exposure in agriculture commonly exceeds industrial standards. Significant exposure to inorganic dust results in allergic diseases, specifically occupational asthma and hypersensitivity pneumonitis and, if the dust contains crystalline silica, can result in chronic lung disease and even lung cancer. These very high concentrations of inorganic dust are likely to explain some of the high levels of chronic bronchitis reported in many studies of farmers. The highest levels of dust exposure occur during soil preparation activities (Figure 15). Tractors pulling soil preparation equipment (e.g. ploughing, discing, planing) generate large dust clouds. Processing of agricultural produce on or off farm can also be an issue of concern (EU-OSHA, 2019d).

The mixing of animal feedstuffs and feeding exposes workers to organic dust and silo dust. Farm workers can develop organic dust toxic syndrome, farmers' lung disease, chronic bronchitis and other respiratory problems. A particularly hazardous activity is cleaning out silos containing animal feedstuffs, as it combines work in confined spaces and exposure to organic dust.

Occupational respiratory diseases are common among agricultural workers. Respiratory problems in agricultural workers are double the average in the general population (Walker, 2001). The most important diseases are asthma and rhinitis and, although common, they are not generally life-threatening. In certain cases, more serious respiratory diseases can be life-threatening such as hypersensitivity pneumonitis and respiratory infections.

Dust exposure is most frequent in dry climate farming regions. As the climate becomes increasingly dry in Europe, there will be an increase in silicate dust exposure in farming. However, as tractor technological developments increase, improved cabin ventilation and even driverless tractors may offer benefits for workers' protection. In addition, carefully planned ploughing activities to reduce soil disturbance and take advantage of ground moisture and optimal weather conditions could be of benefit. Organic dusts are also a major health challenge in agriculture, and drier conditions resulting from climate change will also increase the amount of organic dust in the atmosphere on farms, although part of this risk could be counteracted by drier conditions neutralising some of the risks associated with mouldy hay (i.e. farmer's lung).

Rising temperatures are expected to increase the development and growth of pests and in consequence is likely to increase the use of pesticides (Boxall et al., 2010). Climate change may lead to more generations of pests per year, which — in combination with prolonged exposure to pesticides over longer growing seasons — may make pests more resistant to pesticides (Matzrafi, 2019). According to Gatto et al. (2016), climate change is also likely to result in changes in pesticide use in terms of larger amounts, doses and types of products applied, and higher temperatures, and heatwaves in particular, may also affect workers' susceptibility to pesticide absorption.

8.6 Specific forestry related risks from climate change

Climate change will cause widespread forest destruction, bringing droughts, insect invasions, fires and storms. In addition to the obvious drought, fires and extreme weather conditions, warming summer and winter temperatures are driving outbreaks of beetle infestations in susceptible forests and allowing them to persist in habitats previously constrained by cold temperatures. There has never been such large-scale death of trees due to bark beetle infestation and drought as there is at present (Figure 16).

Figure 16: Beetle damage to trees

In terms of OSH, this will lead to increased risk from clearing up dying or damaged trees from drought or insect damage, fire or extreme weather. While falling branches and breaking trunks have already been major causes of accidents in the past, they increase drastically when the trees die, and particularly so in extreme weather and wind conditions. The behaviour of dead trees during felling is also largely unpredictable. Forest managers are hesitant to send foresters and forest workers into damaged forest areas under calamitous weather conditions. For example, clearing windblow is one of the most hazardous operations in forestry. Only workers fully competent in felling, removing hung-up trees, debranching and cross-cutting stems under tension should be employed to work with windblown trees. Forestry work is also far more dangerous in mixed operations, where operators have neither the practical experience nor sufficient tools and supporting machinery (tractors, winches, remote felling wedges, etc.).

The need for reforestation following the death of trees will bring another serious OSH challenge, with increased risk of MSDs and increased OSH risks from the use of manual tools. Most of this work will have to be done manually, as mechanical reforestation will probably only be possible on a fraction of the reforested area.

8.7 Impact of climate change on mental health

Managing the mental distress caused by climate change, adapting production to the changing temperatures and rainfall patterns and finally coping with heat, new diseases, droughts or natural disasters are future challenges for OSH (Vins et al., 2015).

Studies show that the stress that climate change places on farmers and foresters is also linked to psychological disorders such as anxiety, mood disorders, stress, depression or the feeling of hopelessness. Similarly, fear, despair, suicide ideation, increased drug abuse and heat-related deaths have been linked to adverse climatic changes (Fritze et al., 2008; Page and Howard, 2010; Swim et al., 2011; Honda et al., 2013). The relationship between climate change and the mental health of farmers is still under-investigated. Weather events may cause different emotional responses. Extreme weather events are associated with increases in aggressive behaviour and may lead to increased use of alcohol to cope with stress as well as increased suicide rates.

9 Trade and Economy – Occupational safety and health considerations

9.1 Trade and OSH impacts

Trade is often considered from the economic perspective in most policy areas. However, there are often public health and OSH aspects that are overlooked, particularly those involving **biological agents** and **invasive species**. As far as the agriculture and forestry sector is concerned, global trade may increase the movement of alien species, vectors and pests that can have novel or emerging impacts on farm and forestry workers' health, if these species take hold among the local fauna and flora. For example, the spread of ash dieback disease and elm bark beetle have both resulted from international timber and tree movements. For this reason, containers of plants and trees are often heavily fumigated with pesticides, in itself creating a risk for operators and for those workers ultimately moving or handling the imported plants, trees and timber. The invasion of African bees in Spain and the tiger mosquito in southern Europe are good examples of such risks from increasingly globalised trade.

It is also noteworthy that, in the same way as environmental standards may differ in non-EU countries, the working conditions related to food products imported to the EU may also differ. Agricultural organisations have raised concern about weaker environmental and food safety standards for food imports, and **OSH standards in non-EU countries** can also be significantly lower. The EU Farm to Fork Strategy aims to address environmental and food standards in food imports, and it will be important to include the implementation of International Labour Organization (ILO) standards for working conditions in that concept.

9.2 Farm economic trends and their impact on safety and health

The increase in farm size and the consequent reduction in the number of small farms explained in Section 6.4.2 may have a significant impact on farm safety. As farm sizes increase, there will also be an increase in investment in new and inherently safer technologies, which will help increase efficiency and profitability through economies of scale. According to Issa et al. (2019), by removing and reducing labour and exposure to hazardous environments, engineering developments could have contributed to the 63 % reduction in the total number of fatal farm accidents in the United States from 1992 to 2015. Larger farms also tend to have more structured and professional OSH services, owing to more available know-how and resources but also owing to explicit legal obligations for dependent workers under the EU OSH Framework Directive (89/391/EEC). With the predicted fall in family members working on farms and the increase in farm workers, more and more of the agricultural workforce will fall under the OSH Framework Directive. Furthermore, OSH monitoring and labour inspection in larger entities will have

more impact, and the labour inspectorate will find it easier to inspect large commercial operations and optimise use of scarce resources.

However, the abovementioned potential safety improvements are not uniformly transferable to the whole sector. The growing economic and digital divide between larger more profitable and increasingly digitalised farming operations and smaller less well-resourced farms is likely to disproportionately affect safety and health levels on smaller farms. Owing to the weakening position of farmers in the food value chain and decreasing profit margins, smaller farmers in particular will find it increasingly difficult to invest in infrastructure developments, new technologies and (OSH) training. This is particularly concerning if we take into account that workers from micro and small enterprises (all sectors) are disproportionately likely to suffer as a result of poor OSH, with 82 % of occupational injuries and 90 % of workplace fatalities happening in SMEs according to EU-OSHA (2014).

In addition, the increasing financial pressures in farming today are often cited by many farmers among the many stressors to which they are subject and which affect their mental health and stress levels (see section 10.11 in Chapter 10).

10 Labour market trends and impacts on occupational safety and health

Existing and evolving risks resulting from organisational characteristics and changes in the agricultural and forestry workforce

The agricultural workforce has several structural characteristics that strongly influence safety and health risks in the sector. In response to COVID-19, the importance of critical staff, such as agro-food workers, was further reinforced by the EU Farm to Fork Strategy, which stated that it is 'particularly important to mitigate the socio-economic consequences impacting the food chain and ensure that the key principles enshrined in the European Pillar of Social Rights are respected, especially when it comes to precarious, seasonal and undeclared workers. The considerations of workers' social protection, working and housing conditions as well as protection of health and safety will play a major role in building fair, strong and sustainable food systems.'

There are several types of atypical worker (temporary/seasonal workers, part-time workers, family workers, etc.) as well as other structural aspects of the labour force, such as gender and age, that influence OSH outcomes. In this chapter, we will look at a number of such factors and evaluate their impact upon safety and health in the sector and evaluate how these trends are likely to evolve over the coming years.

10.1 Temporary and/or seasonal workers

Over 30 % ([53]) of all employees in agriculture are in temporary employment. According to an ILO report (Quinlan, 2015), temporary workers (all sectors) are at increased risk of work-related injury and illness, and temporary employment is associated with a number of adverse OSH outcomes, most consistently with regard to injury rates.

Because of a lack of experience, either in the job or in the company, and because of a lack of training and mentoring, temporary workers are more exposed to work-related injuries (Weiler, 2005). Researchers have also shown that temporary agency workers and short-term contract workers are more at risk of accidents in industrial sectors than permanent workers (Goudswaard, 2002). Temporary workers on average face more difficult working conditions (shift work, more hazardous tasks, etc.) and worse ergonomic conditions than permanent workers and, therefore, are at higher risk of developing musculoskeletal disorders and work-related health problems (Belin et al., 2011). EU-OSHA reports that

([53]) See section 6.5.1 on key driver 5 — Policy and people — Labour market trends.

temporary workers are likely to be more exposed to risks related to awkward postures, intense noise, repetitive movements and short, repetitive tasks (EU-OSHA, 2010).

Temporary workers often do not have the same level of knowledge of the workplace and of the working and safety and health practices in the workplace, which implies that they are at an inherent disadvantage in terms of safety and health. Over time, this lack of knowledge may be remedied, but temporary (agricultural) workers usually have limited access to (OSH) training and are not usually considered to be first in line for receiving company resources, materials and even protective equipment (McLaughlin et al., 2014).

Health monitoring is also another challenge for temporary workers. In many cases, seasonal workers arrive in significant numbers at the place of work only hours before the official starting date and are unable to undergo often mandatory health surveillance checks before starting work. This creates problems for both workers (difficult to monitor and protect their health) and employers, who may experience legal complications if ill health and accidents occur. COVID-19 has highlighted the vulnerability of seasonal workers to health impacts resulting from poor living and working conditions.

The situation of temporary workers in the sector is continually raised by agricultural trade unions, particularly concerning adequate training and health monitoring. One suggestion has been to address temporary agricultural workers' training deficit through some form of 'safety training passport' scheme, which would be transferable with the worker. There is no doubt that with the increasing use of online systems it would be possible to establish some form of online safety training passport scheme. In the forestry sector, there is a similar model for competence and safety training in chainsaw use (European Chainsaw Certificate). Such online systems could also include a record of occupational health monitoring.

10.2 Migrant workers

Between 2011 and 2017, for the whole EU there was an increase from 4.3% to 6.5% in the share of migrants in total employment in the agricultural sector (Natale et al., 2019). This trend is likely to continue or accelerate owing to the growing pressures of climate change and the expected COVID-19 induced global recession. Although migrant workers represent approximately 6.5 % of the total EU agricultural workforce, this level is as high as 20-25 % in Spain, Italy and Denmark ([54]). According to a European Parliament study (Belin. A. et al, 2011), 'while EU-wide statistics are not available, country studies confirm that migrant workers (all sectors) suffer higher levels of work-related accidents and disease. Health and safety risks are believed to be higher for undocumented migrant work.' A Spanish study also supports the conclusion that foreign workers have an increased risk of non-fatal and fatal occupational injury compared with national workers (Ahonen and Benavides, 2006).

Migrant workers are often exposed to greater risks than national workers in agriculture owing to several inherent factors. They are usually prepared to take on dirty and unhealthy jobs in return for economic reward (known as '3D jobs' — dirty, dangerous and demanding), in a number of cases even unregulated work. They also often work long hours over short seasonal periods and under considerable pressure, pushed by the need to make as much money as they can in a very short period. They are often reluctant to declare occupational accidents or make themselves known to the authorities, often preferring to stay 'under the radar', (whether documented or undocumented). COVID-19 has also had a significant impact on migrant workers in the sector, who have been particularly vulnerable in cases where living and working conditions are of an insufficient standard.

Migrants also lack trade union representation and tend to speak up less, out of fear of losing their jobs, making them more vulnerable to safety and health risks. These issues are compounded by the lack of access to health screening and OSH training owing to their temporary status. Language barriers and a difference in safety culture can also influence the vulnerability of migrant workers in agriculture (García-Arroyo and Segovia, 2020).

([54]) See section 6.5.1 on key driver 5 — Policy and people — Labour market trends.

In the agricultural sector, the risks associated with pesticide use and of MSDs are of particular concern, as both of these occupational health risks have long-term implications, which are most likely to affect the health of the migrant workers concerned later on in their lives.

10.3 Part-time nature of farming and forestry work, linked to a high degree of pluriactivity

According to Pyykkönen and Ahern (2012), 'the main farmer may have a secondary occupation, which can lead to excessive burdens on the farmer or the farmer's spouse. Part-time farming can result in long working hours and inadequate rest, for example during the harvesting season. Hurry, fatigue or stress were often mentioned as the primary contributing factor in most injuries.' Rautiainen et al. (2004), Farms in Ireland where both farmer and spouse have off-farm employment have been identified as having a 3.44-fold increased risk of accidents among all farm operators.

In addition to the burden and demands on the farmer's time mentioned above, pluriactivity also brings with it incremental risks owing to cumulative risk factors from other sectors and activities. The risks encountered by a pluriactive farmer will be more complex. For example, if farmers are engaged in the bioeconomy and green growth industry, they will need to assess the associated risks.

10.4 Self-employed farmers

According to Merisalu et al. (2019), collection and reporting of agricultural injury and illness data is challenging worldwide, particularly among self-employed farmers. Merisalu et al. concludes that the majority of the workforce in agriculture consists of self-employed family labour and collection of agricultural injury and illness data is characterised by non-collection due to a lack of statutory requirements or gross under-reporting. The European Statistics on accidents at work implementing Regulation[55] (see section 5.2 Quality assessment) requires that Member States send data on accidents of 'employees'. Data on accidents of self-employed, family workers and other employment types are voluntary. A recent paper (McNamara et al, 2020) provides further information on challenges related to agricultural injury data collection among farmers who are mainly self-employed.

According to Lundqvist and Svennefelt (2012), 'the self-employed do not have the same propensity as employees to report accidents and injuries.' This has been clearly shown by Jansson and Svanström (1989) and confirmed by others. According to one UK study (Solomon, 2002), over half of all fatal agricultural accidents in the United Kingdom were attributable to the self-employed, and in addition 'there is thought to be gross under-reporting of non-fatal injuries, particularly in agriculture and by the self-employed' with completeness of reporting estimated to be less than 5 %.

According to Merisalu et al. (2019), only a few countries have statutory accident insurance schemes for self-employed farmers. Without an incentive, such as insurance benefits, farmers are unlikely to report their injuries, even if reporting is mandatory. Lundqvist and Svennefelt (2012) attributes under-reporting to the fact that 'the self-employed often have longer waiting periods during which they will not get any sickness benefit. Often they do not have the possibility to report themselves sick. Despite illness and injuries they still have to take care of their business etc.'

At EU level, the OSH Framework Directive on safety and health at work does not cover the self-employed. In addition, a specific 'individual' directive on (fisheries and) agriculture, initially envisaged in its annex to supplement the Framework Directive ([56]) was never adopted to cover agriculture and remains the only individual directive, from a list of seven originally envisaged in the Framework Directive not to be adopted. Nevertheless, certain countries, such as Ireland and the United Kingdom, have

([55]) https://ec.europa.eu/eurostat/cache/metadata/en/hsw_acc_work_esms.htm
([56]) Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work (OJ L 183,, 29.6.1989, p. 1-8).

adopted national provisions and systems that provide significant OSH legislative coverage for self-employed farmers. However, it is challenging to develop a clear picture of how many EU Member States have implemented sufficient legislative coverage of self-employed farmers in their national OSH legislation.

In 2003, the Council of the EU issued a recommendation on improving the protection of the health and safety at work of self-employed workers ([57]), stating that 'the recommendation by the ILO accompanying the Convention concerning health and safety in agriculture ([58]) stipulates that Member States must progressively extend to self-employed farmers the protection applicable to workers, taking account of the views of representative organisations of self-employed farmers if necessary.' ILO Recommendation 192 ([59]) on safety and health in agriculture (together with its base, the ILO Convention on safety and health in agriculture), if fully implemented, would provide significant coverage for self-employed farmers. According to the ILO recommendation, 'taking into consideration the views of representative organisations of self-employed farmers, members should make plans to extend progressively to self-employed farmers the protection afforded by the convention — national laws and regulations should specify the rights and duties of self-employed farmers with respect to safety and health in agriculture.' The recommendation includes provisions on occupational health services, recording and notifying occupational accidents and diseases, educational programmes and advice and training, including the risk of MSDs, chemicals and biological agents, PPE and machinery. However, it is worthy of note that only six EU countries (as of 10 December 2020) have ratified the main ILO Convention C184 on safety and health in agriculture upon which the specific recommendation depends. Nevertheless, a similar ILO convention on work in the fisheries sector, which includes health and safety provisions, was adopted by a Council Directive in 2016 ([60]).

At the expert meeting organised for this report, the overall consensus was that:

- Agriculture is a neglected area of OSH policy.
- Self-employed farmers are not covered by the EU OSH Framework Directive.
- There is no reliable register of accidents or fatalities for self-employed farmers.
- Farms are very rarely inspected.
- There is no adequate insurance for self-employed farmers in a number of countries.

Considering that self-employed farmers form the majority of the EU agricultural workforce; that reliable data for one country mentioned above seems to point to over half of fatal accidents being attributable to the self-employed (as well as gross under-reporting of non-fatal accidents); that there is inadequate legislative OSH coverage at EU level and most probably at national level in a good number of Member States; and that EU agricultural policy and spending still represent the largest EU industry sector; it would seem that there is sufficient imperative for the EU to take action in this area, particularly concerning the self-employed.

10.5 Farming is very much a family concern

Family workers dominate, with 9 in every 10 (89.5 %) people who work regularly in agriculture in the EU being the sole holder (farmer) or members of their family ([61]). Although there could be stronger moral imperatives to protect fellow family members, the informal nature of employment relationships means that OSH roles and responsibilities are generally less professional, as family members often turn up to provide a helping hand. This may mean that OSH risks are under-estimated, that there is an inconsistent

([57]) Council recommendation of 18 February 2003 concerning the improvement of the protection of the health and safety at work of self-employed workers (OJ L 53, 28.2.2003. p. 45-46).
([58]) ILO Convention C184 — Safety and Health in Agriculture Convention, 2001.
([59]) ILO Recommendation R192 — Safety and Health in Agriculture Recommendation, 2001.
([60]) Council Directive (EU) 2017/159 of 19 December 2016 implementing the Agreement concerning the implementation of the Work in Fishing Convention, 2007 of the International Labour Organisation, concluded on 21 May 2012 between the General Confederation of Agricultural Cooperatives in the European Union (Cogeca), the European Transport Workers' Federation (ETF) and the Association of National Organisations of Fishing Enterprises in the European Union (Europêche) (OJ L 25, 31.1.2007, p. 12-35).
([61]) See section 6.5.1 on key driver 5 — Policy and people — Labour market trends.

approach to managing risk (instead depending on each family's own risk perception and culture) and that there is a blur between family/home environment and the workplace, particularly on small farms.

In addition, a large proportion of farmers who run or own family farms are self-employed and therefore do not fall under the OSH Framework Directive. According to the European Commission OSH guide for agriculture, 'It is quite common for spouses, children, and relatives to work on the farm, often regardless of their age, competency, training or safety. As a result, agriculture has the highest incidence of accidental deaths of children' (EC, 2011).

Rural children are twice as likely to die in accidents as urban children (data refer to all types of accident). An Irish study (Boland, M. et al., 2005) of age-specific unintentional injury rates in males and females in the under-25 age groups showed that mortality is higher in rural males and females compared with their urban counterparts. The vast majority of children killed in farm accidents are the farmers' children, rather than visiting children. Although child deaths on farms are not included within the remit of this report, it is important to note that a high proportion of child deaths and injuries occur on farms owing to the family nature of farming. In Ireland, over the last 10 years about 1 in 10 fatal farm workplace accidents have included children.

10.6 Role of women in farming

Women account for 35 % of the agricultural workforce and 41.8 % of family workers (ILO, 2016). The major part of accidents in farming is attributable to male farmers, as men make up the majority of the agricultural workforce. However, a recent Finnish study indicates that the risk of injuries for male and female workers is virtually equal, given equal work time (Karttunen et al., 2019) Therefore, gender is an indicator of different work exposures in farming, rather than a risk factor for injury.

Nevertheless, there is a need to take account of certain gender aspects in OSH practices in the sector. In terms of exposure to pesticides, maternal occupational exposure (as well as the man's exposure) to chemicals in the workplace before and during pregnancy could lead to the development of congenital anomalies (Snijder et al., 2012; Spinder et al. 2019).

There is also a general perception and in fact several studies that indicate that women are less likely to take risks than men (Sundheim, 2013). However, a Scottish Government report on women in agriculture did not find this to be the case, instead indicating that women sometimes take risks to prove that they are as able to farm as men, often trying to disprove gender stereotypes, resulting in increased safety and health risks. The same report also found that women farmers do not have the right equipment to farm safely (e.g. suitably sized protective clothing, equipment that requires less physical strength to operate safely) and that there was a need to plan farmyards for women farmers (Shortall et al., 2017).

These findings are in line with those of the EU-OSHA report on gender and OSH, which highlights that work equipment, such as machinery and PPE is still designed for the average-sized male worker and takes less account of the ergonomic needs of women. The gender-sensitive risk assessment proposed in Annex 3 of the EU-OSHA report would also go part of the way to meeting this need to plan farmyards for women farmers (EU-OSHA, 2018b).

EU-OSHA recommends improving women's participation in OSH decision-making in order to improve women's safety and health at work. It is worthy of note that the Scottish study found that women remain under-represented in farming organisations. This may be an area for further study in the future.

10.7 Retirees and farmers over 65

Farmers aged over 65 years make up 32 % of the EU farm workforce. According to the UK HSE (2019b), farmers over 64 are 2.45 times more likely to have fatal accidents than the average for all agricultural workers aged 16 years upwards, while 47 % of farm fatalities occur in people aged over 60 years. In Ireland 43 % of farm fatalities occurred in people over 65 years old in the period 2010-2019 (HSA, 2019). In Canada, farmers aged 60 and over suffer 34.6 % of all agricultural fatalities and 23.8 % of agricultural hospitalisations, although they represent only 13.2 % of the farming population (Golonka et al., 2007).

According to the US Bureau of Labor Statistics, in 2017, older farmers (over 55) in the United States accounted for 80 % of workplace fatalities in this occupation (Smith and Pegula, 2020).

According to a European Parliament report (Belin et al., 2011), ageing workers are also more at risk of occupational health problems than younger workers, because they have been exposed for longer to certain hazards. Older workers report more work-related health problems than younger workers, with backache and muscular pain reported by more than 70 % of workers aged 55 years and over. According to one in-depth Canadian study (CAISP, 2007), 'older farmers may have limitations in reaction time, weakened muscular strength, and conditions that limit mobility', and, according to Pyykkönen and Aherin (2012), elderly people are often not sufficiently aware of the onset of the physical and mental ageing processes. They often fail to recognise or underestimate potential new hazards because of their habits and routines. The most frequent causes of accidents among older agricultural workers are slips, trips and falls.

However, there are several challenges to documenting the occupational accidents and illnesses of elderly workers in the agricultural sector in Europe. In a number of countries, many are no longer officially part of the workforce, and accidents and illnesses may be under-reported altogether or reported as non-occupational accidents owing to various sanctions and incentives. In terms of OSH prevention, all this is complicated by the fact that older farmers tend to invest less in the farm and in new technologies, as well as having significantly lower levels of training in general. According to Eurostat (2018), older farmers are less likely to have any formal agricultural training, and this trend most probably reflects the situation concerning OSH training.

10.8 Young workers

A US study reports that farmers with less than 5 years of experience are at great risk of job-related injury, lacking both safety training and emergency preparedness skills (Byler et al., 2013). According to statistics provided by the British Safety Council (2010), compared with older adults, young workers under the age of 19 years working in the agriculture and construction sectors have a higher than average risk of being killed or injured.

Young workers usually lack experience, tend to be impulsive and also tend to demonstrate more risky behaviour. EU-OSHA (2019b) has highlighted that for new or young workers there is a heightened risk from a series of factors in the workplace: lack of experience of working in an industry or workplace; lack of familiarity with the job and the work environment; reluctance to raise concerns; being unaware of existing or potential risks; lack of maturity; and eagerness to impress workmates and managers. Young workers need appropriate training and close supervision. The risks to young workers in farming are complicated by the family connection to farming, as many young farm workers would have been brought up with the risks during their childhood and they may have normalised them, paying them less attention than they deserve. The United States Department of Labor has developed a specific e-tool ([62]) for young people in agriculture.

10.9 Long working hours and OSH impacts in the sector

A review of 12 studies covering all industry sectors showed that the risk of occupational injury was 15 % higher for 10-hour working days than for 8-hour working days. Working 12-hour days increased the risk of occupational injury by 38 %. When working more than 12 hours per day, four studies showed a 147 % increase in occupational injury (Salminen, 2016).

Long working hours tend to dominate in the agriculture sector. Workers in agriculture on average work 46 hours per week compared with the EU-28 average of 38 hours. Atypical working (weekends, evenings or nights) is more than twice as prevalent in agriculture as in the general working population and, on average, workers in agriculture report having much less regular working hours than the average

([62]) https://www.osha.gov/SLTC/youth/agriculture/

EU-28 worker. However, in some Member States farmers are reported to work much longer hours. For example, a UK poll of farmers reported average working hours of 65 hours per week for farmers — much longer than the national average of 37 hours. In addition to the obvious effects of fatigue and stress and on the general well-being of farmers, with such a busy work schedule and competing priorities, it is unlikely that OSH management issues will occupy much of farmers' time (Tasker, 2018).

10.10 Rural depopulation and OSH risks

Rural depopulation is a growing concern for the European Commission's Directorate-General for Agriculture and Rural Development and for many national agriculture ministries and is an important element of the CAP reform. However, little attention has been paid to the link between rural depopulation and OSH. Rural depopulation means that in many rural areas there is probably limited access to rural health services, including OSH health monitoring, as well as OSH advisory, training and support services. One Irish study identified farmers' reluctance to seek help in carrying out difficult tasks as a major risk factor for accidents and near-misses. One may conclude from this that busy farmers in rural settings may just want to get on with the job, rather than interrupt their work and wait some time for the right support to arrive, as well as thinking of the economic costs involved (Watson et al., 2017). Moreover, emergency response times in the event of accidents are usually longer in rural areas. Likewise, national labour inspectorates are unlikely to be in the position to dedicate the same resources to rural workers as thy do to urban workers, not only because of the travel time needed but also because of the low concentration of workers, making per capita inspection rates less efficient.

10.11 Stress and psychosocial risks

Farming today is a profession under pressure and is possibly one of the most stressful occupations. The idyllic vision of farming as a relaxing healthy outdoor life among nature is not the modern-day reality of farming. There are a growing number of demands, expectations and pressures on farmers, as we expect them to provide healthy, ethically and safely produced food, look after our climate and environment and be good resource managers and administrators. The profession also faces a number of inherent psychosocial pressures, such as long working hours, isolation, financial uncertainty, and administrative and regulatory demands. Research among Irish dairy farmers (Furey et al., 2016) indicates that both financial and non-financial farm stressors lead to mental distress, which in turn leads to a predisposition to injury. Mental distress also leads to both anxiety and depression. Social support can alleviate mental distress.

According to a yearly poll, 84 % of UK farmers under 40 years old believe that mental health is the biggest challenge facing the industry (Tasker, 2020). In Finland, a 2002 postal survey of 555 farms found that 55 % of respondents experienced stress in farm work (Ristiluoma and Sipilainen, 2003). In addition, international and French data point to a higher suicide rate among farmers. The suicide rate of male French farmers is 20 % above the average national suicide rate of other professions (Santé Publique France, 2017).

A recent survey of the mental health and well-being of Welsh farmers listed a number of key mental health challenges for the sector, which included the viability of the farming sector; succession planning; regulation, administration and digitalisation; farmer health; farming culture and self-reliance; and isolation and loneliness (Davies et al., 2019).

According to an OSHwiki article (Hassard et al., 2017) , 'a number of research studies have found that the main contributing factor for depression and suicide in farmers was financial difficulty. The role of financial uncertainty as a contributor towards work-related stress is seen in the findings of two research surveys that identify finances as the biggest source of stress amongst farmers.' The link between psychosocial issues and accidents at work is another issue that may also affect the sector. According to research, individuals who are stressed are more likely to have an accident in the workplace because of a propensity for cognitive failure (Day et al., 2012).

Farmers are subjected to a many 'stressors', as depicted in Figure 17.

Figure 17: Stress factors for farmers

Source: IMAZ

- **Climate change — uncertainty and unpredictability:** seasonality, weather, extreme weather, loss of crops and planning challenges.
- **Financial pressures:** reduced influence of farmers in food value chain; weak bargaining power against large retailers, decreasing prices for agricultural produce and lower profit margins.
- **Growing regulatory and administrative pressures:** food safety, animal health and welfare, biotechnology and GMOs, environmental standards, CAP cross-compliance practices, CAP reform and EU Farm to Fork Strategy (reduction in use of antibiotics and chemical pesticides and fertilisers, as well as improved animal welfare standards.)
- **Increasing consumer and societal demands on food production:** increasing demand for quality — increase in quality labels and systems (organic food, GMO-free) — changes in animal welfare and feed practices, declining meat consumption and production.
- **Farmer bashing and lack of attractiveness of farming:** farmers are held responsible for ethical and environmental aspects of farming and the working conditions are considered unattractive by many young people.
- **Emerging public health issues and animal/plant emerging disease/pest calamities:** COVID-19 has highlighted the impact that diseases and public health issues can have on agro-food production, emerging and re-emerging plant and animal diseases and pests, such as foot-and-mouth disease, African swine fever, antimicrobial resistance, *Xylella fastidiosa*, bark beetle in forests and many others.
- **Physical attacks and threats:** more extreme environmental and animal welfare campaigners are exerting increased pressure on farmers and foresters through public pressure and shame campaigns (farmer bashing) or even taking direct action or carrying out attacks, particularly on intensive farming practices.
- **Rural crime:** theft (sometimes with violence or threat of violence) of livestock, agricultural goods and machinery, which causes feelings of insecurity and financial losses and has an impact on insurance costs.

A wide range of initiatives has been published to help farmers manage psychosocial and mental health issues. In France the Agri'écoute section ([63]) of the MSA website offers an online suicide prevention programme, whereby farmers can access information and receive professional psychological support. In Germany, the social insurance company for agriculture, forestry and horticulture (SVLFG) implements online health and wellness training for farmers ([64]). In Ireland, the Agriculture and Food Development Authority (Teagasc) has published a booklet ([65]) to help farmers cope with the mental pressures in farming. And in Australia the Rural Adversity Mental Health Programme has produced the *Glove box guide to mental health* ([66]), issued annually through *The Land* rural newspaper. Further information is also readily available from the OSHwiki article 'Psychosocial issues in the agriculture sector' (Hassard et al., 2017).

([63]) https://www.msa.fr/lfy/solidarite/prevention-suicide
([64]) https://www.svlfg.de/online-training
([65]) https://www.teagasc.ie/media/website/publications/2018/Coping-with-the-pressures-of-farming.pdf
([66]) https://www.crrmh.com.au/news-item/survey-feedback-glove-box-guide-mental-health/

Section C. Next steps and future actions

11 Conclusions

EU agricultural policy has played a key role in the EU's development and today still represents one of the most important EU policy and budgetary areas. The increasing global demand for food production and the EU's role as the largest food exporter in the world have also reinforced its importance. The CAP and farming practices (under the EU Farm to Fork Strategy) have come under increasing environmental and ethical pressure over the last few years as climate change, the environment, public health and animal welfare have grown as key societal concerns and as a result have become important policy areas. The importance of agriculture and food production has been further underlined by the COVID-19 crisis, which has also affected safety and health and the wider working conditions of food and farm workers.

Farming and forestry remains one of the most dangerous occupational sectors in Europe. High numbers of occupational accidents and illnesses are reported in the sector. However, many occupational accidents and work-related diseases are not recorded consistently (leading to significant under-reporting of workplace accidents and ill health) and we do not have a full or transparent picture of how serious the safety and health situation of farmers and foresters is today. The EU Farm to Fork Strategy has recognised the importance of the European Pillar of Social Rights and its application to the sector; however, there is still a major social-economic deficit in farming today, owing to the marginal profitability and low income of many small farmers (who make up the majority of farmers) undermining the social sustainability of farming and forestry. This socio-economic deficit affects the ability of the sector to fully embrace and manage the growing trends, such as digitalisation, climate change, societal pressures and labour market developments, and is very much linked to the poor level of OSH protection in the sector.

Taking into account these developments and the resulting changes in the sector, the aim of this report was to carry out an expert review of the future of agriculture and forestry and its impact in terms of OSH in order to support policy-makers at EU and national levels in developing OSH strategies, regulation, enforcement, guidance and support measures. Therefore, this report has identified the major trends affecting the sector, evaluated them to assess how they will bring about changes in both technological and organisational terms and, ultimately, assessed the impact on the OSH of farmers, foresters and workers in the sector. In a short report the authors have distilled a wide range of trends and changes that will ultimately have impacts on the safety and health of farmers, foresters and workers in the sector over the coming years.

Smart farming (digitalisation and new technologies) has been the subject of much attention in the sector, having been identified as one of the few innovations that could potentially bring about a paradigm shift in productivity and increased food production. However, our findings have pointed to a very gradual change in the adoption of these technologies, especially compared with other sectors. Overall, agriculture and forestry are likely to lag behind other sectors in the uptake of digitalisation, owing to physical, topographical and land constraints; complications in the automation of production processes, such as fruit picking; access to investment capital; a skills deficit; a history of slow uptake of new machinery and technologies; lack of support to adopt new technologies; and a general cultural resistance to change. However, the most important impediment appears to be the profitability of the sector, particularly for small farmers who are struggling to balance the farms' books and who under such circumstances find it extremely difficult to contemplate major investments.

However, larger more profitable farms will be able to embrace digital technologies more easily through economies of scale and digitalising their more intensive labour practices, combined with the advantages of a highly skilled and specialised workforce. Small farms will be the last to adopt digitalisation but, as use increases and smart machinery prices decrease, most of them will eventually come on board. In the meantime, however, the technological gap between more profitable larger farms and smaller farms will increase, further stretching the economic and social divide between large and small in the sector.

Concerning the **impact of smart farming on OSH**, smart farming and digitalisation will offer a number of potential improvements in workplace safety and health that are identified in this report. However, the slow uptake of new technologies in general will not offer an immediate solution to the high accident rates and OSH challenges in the sector. Smart farming will improve OSH by removing risks (e.g. vehicles and machinery use and livestock handling), managing risks more effectively, reducing MSDs and exposure to pesticides, as well as offering solutions for smart PPE and smart OSH monitoring and training systems. The report offers a long list of up-and-coming digital solutions and practices that could improve safety and health significantly, but the general lack of digital uptake in the sector combined with OSH being low on the long list of priorities of most farmers, means that initially the impact on safety and health will be limited.

There will also be a need to evaluate new and emerging risks from new technologies, such as ergonomic and general safety considerations. Safety and health features should also be introduced during the design phase, to be most effective and avoid lengthy and often less effective add-on corrective measures, if OSH issues were to arise. This challenge is complicated further by the fast pace of digital developments in the sector, led by small start-ups, universities, and machinery and data companies, and the little evidence we found of OSH experts' involvement in the digital farming revolution. The effectiveness of in-built design in reducing OSH risks is not limited to the machinery and applications themselves but also applies to the re-design of fields, farms and crop layouts to better accommodate smart and safe working practices. One example given in this report is the planting of apple trees so that safer smart platforms can be used, rather than ladders, allowing safer working practices to be employed.

Likewise, the stubborn long-standing risks in the sector (such as accidents related to tractors and machinery and animal handling) remain largely untackled. New technologies will bring only moderate solutions to these very serious risks, as there is a general lack of a prevention culture in the sector as well as a number of other inter-related issues, such as farmer income and OSH training and advisory services.

Climate change will bring about significant developments in the sector. Farming and forestry practices will need to adapt to the changing weather conditions and the resulting EU environmental and climate change-based regulations. There will be substantial **impacts on OSH from climate change**. Extreme weather events, heat and sun exposure, insect-borne diseases, dust and pesticide exposure, increased use of pesticides to combat the increase in insect pests and specific forestry risks (extreme dangers involved in clearing up trees damaged by weather and insect damage) are just a few. Farm and forestry working practices will need to be adapted to minimise the impact of these risks, such as modified working hours and planning work to avoid high temperatures, extreme weather and more hands-on monitoring of workers' condition, such as water consumption and body heat. Other measures could also help, such as more predictive weather system forecasts and health promotion and awareness programmes on exposure to sun and insect-borne diseases.

Societal trends are influencing the way farmers produce food to meet the demands of consumers, civil society and environmental policies, which in turn influence production practices. The EU Farm to Fork Strategy will bring about additional changes in farming practices and place further administrative and regulatory demands on farmers and foresters. In terms of OSH, this will mainly impact on the well-being of farmers and foresters, adding increased pressure and stress. The present debate on the future of farming is dominated by a linear approach to climate change/environmental protection and animal welfare which distracts attention significantly from other equally important inter-related socio-economic issues affecting farming today, such as OSH and working conditions and fair prices and payments for farmers.

According to the EU Farm to Fork Strategy the 'protection of health and safety will play a major role in building fair, strong and sustainable food systems', and we must 'ensure that the key principles enshrined in the European Pillar of Social Rights are respected'. The major organisational challenges in the sector point to long-standing structural issues related in particular to **the labour market, farm organisation and profitability**, which are all closely intertwined socio-economic considerations affecting the overall **social sustainability of farming and forestry**. Many of the labour market deficiencies (high numbers of self-employed people, temporary, seasonal, migrant and family workers, older workers) that affect the OSH conditions in the sector are difficult to remedy while the overall

profitability of small farmers (low incomes and food price margins) remains unsolved. The lack of a decent revenue and income for small farmers undermines inclusive and preventive management approaches, such as effective OSH management practices, and limits investment in new safer technologies, (OSH) training and skills development and decent salaries and working conditions for seasonal workers. Widespread financial worries in the sector also cause high stress and psychosocial pressures on farmers as well as affecting farmers' general health and well-being. A number of farmers and foresters find it difficult to manage financially and they have limited hours in the day to focus on all the competing issues, meaning that OSH is usually low on their list of priorities (linked to lack of a prevention culture).

The self-employed, who form the majority of the agricultural workforce in most countries, will continue to dominate the OSH agenda in farming and forestry, particularly as so many of their accidents and episodes of ill health are not reported, meaning that the true picture of safety and health in the sector is officially unknown. Most self-employed farmers and foresters are not covered by OSH legislation, they are very rarely inspected, their occupational accidents and ill health are very rarely reported, and they have limited access to OSH resources and training and lack resources to invest in new, safer machinery. However, this problem will not be solved until the true extent of occupational accidents and illness in the sector is accurately reported. For example, reporting data on the farming and forestry sector to Eurostat is not mandatory for the self-employed and family members, as they are not 'employees'. Although for the first time in 2020, Eurostat will start collecting data from Member States on the existence of farm safety plans[67]. The authors of this report do, however, propose exploring a solution that has already been implemented in the fisheries sector, where the EU social partners came together to prepare a joint proposal for EU Member States to adopt the relevant ILO conventions. The ILO Convention on agriculture and its annexed Recommendation on the self-employed are at present still only ratified by four EU Member States.

The COVID-19 crisis and the treatment of seasonal workers have highlighted the social vulnerability of the sector and the dependency of the agriculture sector on cheap seasonal labour to maintain affordable food prices for consumers. Smart farming and new technology applications are being progressively developed to reduce the sector's dependency on cheap seasonal labour, but new technologies will not be replacing seasonal workers any time soon. Therefore, many challenges still exist to ensure fair and healthy working conditions for seasonal and temporary workers. However, the **systematic** application of existing national health and safety regulations, the EU Framework Directive on health and safety (which covers employees) and the EU Directive on seasonal workers would be sufficient to cover many seasonal workers. In addition, the food supply chain is dominated by large competitive retailers that have a tendency to push food commodity prices down, placing farmers in a challenging situation to maintain decent working conditions for themselves and their workers. The role of the supply chain in ensuring decent working conditions in the sector should also be explored further.

Holistic health and **One Health** strategies should include OSH for farmers and foresters. This report has summarised a number of occupational health risks that affect workers in the sector. Pesticide-related risks, MSDs, zoonoses, stress and psychosocial issues are all major emerging and continuing risks for the sector, which either have not been adequately managed or have been underestimated owing to lack of accurate data over the years. These diseases, along with other non-communicable diseases, continue to burden the farming and forestry communities and undermine the long-term social sustainability of the sector, reducing both the employability of older farmers and the attractiveness of the sector for younger people. EU pesticide reduction activities and zoonose-related activities could include an OSH component in order to fully integrate OSH into these EU policy areas. MSDs and psychosocial issues in agriculture and forestry should also be prioritised by EU-OSHA in its planned activities, and Horizon Europe research programmes could dedicate resources for research.

(67) Member States will now be asked to collect for 2020, 2023 and 2026 information on the following question: "The farm has carried out a workplace risk assessment with the aim of reducing the work-related hazards, resulting in a written document (such as a 'farm safety plan')."., EU Integrated farm statistics, Section 3.2.1.3.1,, p.80, https://ec.europa.eu/eurostat/documents/3859598/11495053/KS-GQ-20-009-EN-N.pdf/6f2e2660-9923-4780-a75c-c53651438948

To conclude, the technological and organisational changes resulting from the major trends in the sector will produce a number of OSH developments and challenges, which are also strongly linked to a number of structural or long-standing issues in the sector. To successfully tackle future OSH challenges in the sector, it will be important to address all of the following issues in a comprehensive and cohesive manner:

- a lack of investment in and uptake of new smart and safer technologies and machinery;
- a growing number of climate change related risks and occupational health challenges;
- a lack of transparent and wholly inaccurate occupational accident and ill-health reporting, particularly for the self-employed;
- no clear OSH regulatory framework to protect farmers and foresters and manage OSH, particularly for the self-employed;
- a lack of a prevention culture (farmers and foresters tend to give low priority to OSH over other competing issues) as well as a strong skills and training deficit, particularly in OSH;
- widespread atypical, and sometimes irregular, employment practices;
- lack of appropriate labour inspection resources to combat undeclared work and ensure adequate protection for seasonal and migrant workers in the sector;
- insufficient farm income and quality management time with which to prioritise OSH issues, particularly on small and family farmers.

12 Recommendations for policy-makers

12.1 OSH policy level

As outlined in several places in the report, the positive impact of new technologies and machinery on OSH will be limited unless accompanied by the development of a **genuine prevention culture** in the sector. There is a need for all tripartite partners to work together and drive to secure behavioural change. Farm management will be at the centre of this prevention culture, along with training, education (agricultural colleges), advisory and extension services, and awareness-raising activities. There is a number of international initiatives aimed at improving the prevention culture in the sector; such as SACURIMA ([68]) and ISSA's Zero Vision, the latter of which aims to set prevention goals for the agriculture sector (ISSA, 2019). Activities such as a specific sectoral prevention campaign ([69]), a dedicated European network for agricultural safety and health or the development of a model OSH plan ([70]) could contribute to building this culture.

There is a need for training to keep pace with technological progress and **safety and health training** will also need to be adapted to incorporate the use of digital technologies, robots and artificial intelligence. **Risk assessment techniques** will also need to be adapted to new technologies, such as robots and cobots, particularly concerning artificial intelligence and transparency in decision-making to avoid the risks of harm caused by misunderstandings/misinterpretations between robots/cobots and human workers (EU-OSHA, 2018).

As illustrated by the example of fruit-picking management systems from WSU Extension, there is a need to **integrate OSH considerations** into the development and design of new precision and smart farming equipment and technologies, as well as farm and crop layouts, from an early stage in order to eliminate or reduce risk. A strong 'prevention through design' approach that integrates a user-/worker-centred design approach was also identified in EU-OSHA's report on OSH digitalisation EU-OSHA, 2018).

([68]) https://www.sacurima.eu/

([69]) National farm safety weeks are presently held in some form in a number of countries worldwide (e.g. United Kingdom, Ireland, United States and Australia).

([70]) Only 14 % of farms in Canada have a written safety plan, and this figure is likely to be similar in a number of EU countries. A model OSH plan (https://www.casa-acsa.ca/en/resources/canada-farmsafe-plan/) for EU farms would provide a sound basis for developing a European OSH prevention culture in the sector.

The impact of **climate change** will continue to be felt in the sector, and training, risk assessment, workplace design and awareness raising will all need to be adapted to these changing circumstances, with risk assessments in particular needing to be responsive to sometimes extreme environmental conditions from one moment of the year to another.

The role of the **supply chain** in the agriculture sector as a tool for improving working conditions is one area that would benefit from further research. Large companies and intermediaries dominate the supply chain in Europe, which is subject to tight pricing mechanisms and low profit margins. The sector has much experience of developing quality and ecological/ethical standards and labels. The ILO has also carried out some work on this issue concerning global agricultural supply chains (ILO, 2017). There are a few examples of holistic quality and management schemes in the agro-food area that incorporate standards on safety and health and working conditions, such as the Norwegian 'Matmerk' ([71]) and the New Zealand GAP ([72]) systems. Likewise, there is an interesting development of a voluntary label ([73]) in Italy to protect seasonal and migrant workers in the horticulture sector.

The **self-employed** are highlighted as a key risk group in this report's section on labour market trends and impacts on OSH. A number of actions could be considered. Firstly, we have reported that a large number of farm and forestry accidents and illnesses are excluded from EU data collection (owing to the exclusion of the self-employed, retirees, irregular workers, etc.). In order to provide decision-makers with the full picture of accident and illness rates in the sector, there is an urgent need to tackle the serious challenge of **under-reporting of accidents and ill health** in EU statistics collection, starting with accurate reporting of accidents and ill health affecting the self-employed. Secondly, in line with the EU recommendation on the self-employed ([74]) and considering that a large number of EU farmers, particularly the self-employed, are not covered by EU OSH legislation, policy-makers could consider the EU-wide adoption of the **ILO Convention on safety and health in agriculture** (and its Recommendation on the self-employed). In the fisheries sector, a similar initiative led by the EU social partners was endorsed by the EU Member States through the Council Directive on work in the fisheries sector ([75]).

Agriculture and forestry as a high-risk sector could be included in the **forthcoming revision of the EU OSH strategy** ([76])**.** The initial 2015 assessment for the 2014-2020 EU OSH strategy identified agriculture as a key high-risk sector not specifically addressed, and at the time no specific action was incorporated into the 2014-2020 EU OSH strategy, although a specific non-binding guide was prepared by the European Commission (EC, 2011). Section 5.5 of the present EU OSH strategy 'Synergies with other policy areas' includes references to a number of sectors, such as environment, public health and education, but no specific reference to agriculture. In view of the importance of agriculture within the EU policy and budget portfolio and as a recognised high-risk sector, there is now the opportunity to include the policy area of agriculture in the new EU OSH strategy. Several countries, such as the United Kingdom, Australia, New Zealand (forestry) and the United States, have included sector-specific strategies in their national OSH strategies (HSE, 2018; MBIE, 2018; NIOSH, 2019). A **roadmap for improving OSH in agriculture and forestry** could be developed, consisting of a comprehensive review of the state of OSH in the sector and dedicated activities to tackle high accident rates and poor occupational health.

([71]) KSL: https://ksl.matmerk.no/no
([72]) NZGAP: https://www.nzgap.co.nz/
([73]) International No CAP Association: https://goodland.network/en/partners/associazione-internazionale-no-cap/
([74]) Council recommendation of 18 February 2003 concerning the improvement of the protection of the health and safety at work of self-employed workers (OJ L 53, 28.2.2003, p. 45-46).
([75]) Council Directive (EU) 2017/159 of 19 December 2016 implementing the Agreement concerning the implementation of the Work in Fishing Convention, 2007 of the International Labour Organisation, concluded on 21 May 2012 between the General Confederation of Agricultural Cooperatives in the European Union (Cogeca), the European Transport Workers' Federation (ETF) and the Association of National Organisations of Fishing Enterprises in the European Union (Europêche) (OJ L 25, 31.1.2007, p. 12-35).
([76]) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on an EU Strategic Framework on Health and Safety at Work 2014-2020 (COM/2014/0332 final).

12.2 EU health policy

More than ever during the COVID-19 crisis, we have seen the vital role played by farmers and farm workers in supporting Europe through a major health crisis. We have also seen the health impacts of such diseases and how fundamental the safety and health of farmers and farm workers is in ensuring the security of the food supply. Farmers also play a key role in the successful implementation of One Health (Figure 18) and holistic health concepts, as well as being the overseers and implementers of many of the EU's food- and agriculture-related health and environmental policies through ensuring cross-compliance with EU environmental and animal health regulations under the CAP. We depend a lot on farmers to deliver for us in these areas, while often their own health and well-being is neglected. Incorporating the health and well-being of farmers into the European Commission's approach to **holistic health concepts** would increase further the support and buy-in of the farming community. For example, specific activities covering farm workplace health promotion ([77]) could be undertaken on cancer in farmers and farm workers, zoonotic diseases and antimicrobial resistance among farmers, psychosocial issues, chronic health diseases and non-communicable diseases, digital health, health surveillance and healthcare provision in rural areas, nutrition and physical activity, alcohol, social determinants, etc. The forthcoming EU Thematic Network (Horizon 2020) on farmers' health and well-being, FARMWELL, could focus on a number of these issues.

Figure 18: One Health concept

Source: IMAZ

12.3 EU research into safety and health in agriculture and forestry

Although it is difficult to make like-for-like comparisons between the EU and its major trade partners, it is fair to say that in the United States, Canada and Australia notable public research programmes have existed on OSH in the agriculture and forestry sector, with an estimated spend of USD 16 million per year for 'intervention' research by NIOSH (2008). At national level in the EU, some countries, such as the United Kingdom, France and Sweden, have dedicated research funds to OSH research in agriculture and forestry over the years. However, in spite of EU agricultural policy representing the largest segment of the EU budget and the EU agricultural and fisheries research budget representing approximately

([77]) Workplace health promotion is a well-established concept in many countries underpinning the vital link between health and well-being and workers' performance (https://www.enwhp.org/) and in this case to the sustainability of farming itself.

EUR 500 million per year, as yet, limited funds have been dedicated from the Horizon and previous Framework Programme research programmes to OSH research in agriculture and forestry.

However, the forthcoming Horizon Europe research programme ([78]) does include for the first time 'Health and Safety in agriculture and forestry, aiming to enhance the health and well-being of workers in agriculture and forestry' under the key R&I Orientation 4.3 Agriculture, forestry and rural areas. There is a need to now build on this and develop a **specific research call** under Horizon Europe for OSH research in agriculture and forestry. This research could be linked to the CAP priority of digitalisaton in agriculture, and potential areas for Horizon Europe research could be on agricultural cobots and safety and health integration (similar to the HSE cross-sectoral project; HSE, 2019a) and smart wearable PPE for worker protection in agriculture (HSE, 2019c). Other target areas for Horizon Europe research could include MSDs and stress and psychosocial issues.

In line with the information provided in this report on the risks related to farm vehicles and machinery, further research could be carried out on the OSH risks arising from **tractor overturns** and **ATV/quad bike accidents**. This would be particularly relevant to this report, as new technologies may provide us with new safety tools and solutions in the same way that we have seen the development of new safety technologies in car manufacturing over the last 20 years.

12.4 EU agricultural policy — ensuring the social sustainability of farming

According to the EU Farm to Fork Strategy, protection of safety and health will play a major role in building fair, strong and sustainable food systems, and it is particularly important to mitigate the socio-economic consequences affecting the food chain and to ensure that the key principles enshrined in the European Pillar of Social Rights are respected. To implement this vision of the 'social sustainability of farming' into both the CAP reform and the Farm to Fork Strategy, it will be important to **i**ntegrate **specific actions to promote OSH**. Within the framework of the CAP reform, the following specific measures could be considered:

- Include a link between EU OSH legislation covering agricultural workers to the conditionality of CAP direct payments/cross-compliance regulations. Pesticides, environmental and animal welfare legislation are already subject to EU CAP cross-compliance. As the position of agricultural employers and workers' organisations is likely to differ on this point, this should be negotiated.
- Training has been highlighted throughout this report as a major success factor in adapting to digital technologies and in building a strong prevention culture. In line with the request from the European Parliament ([79]), Member States could include safety measures and training under CAP Pillar II Article 15 of Regulation 1305/2013 ([80]), which includes training and advice on occupational safety standards or safety standards linked to the farm as eligible for funding when included in national CAP plans.
- In relation to the living and working conditions of seasonal workers, in accordance with the recommendations of this report, ensure that the Seasonal Workers Directive ([81]) is fully implemented.

([78]) Annex 6: Horizon Europe Cluster 6, Food, Bioeconomy, Natural Resources, Agriculture and Environment, p. 12. Available at: https://ec.europa.eu/research/pdf/horizon-europe/annex-6.pdf

([79]) Report on the future of food and farming (2018/2037(INI) for the Committee on Agriculture and Rural Development by Herbert Dorfmann: https://www.europarl.europa.eu/doceo/document/A-8-2018-0178_EN.html#title1

([80]) Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) and repealing Council Regulation (EC) No 1698/2005 (OJ L 347, 20.12.2013, p. 487-548).

([81]) Directive 2014/36/EU of the European Parliament and of the Council of 26 February 2014 on the conditions of entry and stay of third-country nationals for the purpose of employment as seasonal workers (OJ L 94, 28.3.2014, p. 375-390).

- According to the EU Farm to Fork Strategy, the EU will strive to promote international standards and encourage the production of agro-food products complying with high safety and sustainability standards. To avoid social dumping from of imports into the EU, as highlighted among the OSH considerations in section 6.4 of this report, it will be important to also include the implementation of ILO conventions and standards on safe working conditions within the Farm to Fork concept of high safety and sustainability standards.
- Considering the significant number of deaths and injuries detailed in this report resulting from the overturn of farm vehicles (in particular tractors and in some countries quads and similar vehicles), policy-makers could consider establishing a rebate scheme for retro-fitting roll-over protection (ROPS) systems (and seatbelts), as used in the United States ([82]) and Australia (Day et al. 2004).
- EIP-AGRI and EUFRAS, supported by Directorate-General for Agriculture and Rural Development are actively fostering an approach to improve advisory and extension services in the EU food and agriculture area. Teagasc in Ireland has included OSH and the wider concept of promoting farmer health in its strategic objectives goal to improve the competitiveness of agriculture. We would also recommend all EU actors working in this area to include OSH and the health and well-being of farmers within the wider concept of advisory and extension services. This measure will be important to support the role of these key agricultural intermediaries in implementing OSH-related training and advice throughout the sector, which are underlying themes throughout this report.

([82]) https://www.ropsr4u.org/

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APPENDICES

Annex 1: Keywords used to identify technological and organisational changes and OSH concepts in agriculture and forestry

Table 1: Systematic literature, review based on 17 keywords and phrases, to identify resulting technological and organisational changes

Organisational
Change role farmer
Change labour agriculture
Change workplace agriculture
Society expectation agriculture (farming)
Work practice agriculture
Farming practice
Work organisation agriculture
Farming structure
Economic structure agriculture

Physical
Natural and physical environment agriculture
Technology use agriculture
Pesticide chemical agriculture
Evolution animal diseases agriculture
Animal breeding agriculture
Livestock production
Crop production practices
Crop breeding practices

Table 2: Keyword search for OSH farming concepts

Farm
Occupational risk
Occupational safety health
Worker safety health

Farm safety
Accident
Injury
Incident
Hazard
Machine
Human robot interaction
Human robot interface
Smart farming
Digitalisation
Precision
Automation
Artificial Intelligence (AI)
Robot
Power drive
Livestock Injury
Slip, trip, fall
Overturn
ROPS
Collision
Drown
Asphyxiation
Manure
Fall, height

Farm safety
Collapse

Farmer health
One Health (often relating to animal welfare)
Anti Microbial Resistance (AMR)
Disability
Musculoskeletal disorder (MSD)
Backache
Ergonomics
Mental Health
Respiratory Disorder
Zoonosis
Biological hazard
Stress
Suicide
Psychosocial
Heat stress
Sun exposure
UV exposure
Climate change
Ecology
Noise exposure
Personal Protective Equipment
Pesticide

Farmer safety
Rural crime
Road safety

Annex 2: Key OSH prevention resources in agriculture

- European Commission guide: *Protecting health and safety of workers in agriculture, livestock farming, horticulture and forestry* ([83])
- Irish Health and Safety Authority *Code of Practice for preventing injury and occupational ill health in agriculture* ([84])
- UK Health and Safety Executive *Farmwise. Your essential guide to health and safety in agriculture* ([85])
- EU-OSHA guide on safe maintenance — fact sheet in all official EU languages ([86]) and full report in English: *Maintenance in agriculture — A safety and health guide* ([87])
- Forestry sources: European Commission guide as above, OSHwiki ([88]) and EU-OSHA fact sheet ([89])
- *Safety and health in forestry work: An ILO code of practice* ([90])

([83]) https://osha.europa.eu/en/publications/protecting-health-and-safety-workers-agriculture-livestock-farming-horticulture-and/view
([84])https://www.hsa.ie/eng/Publications_and_Forms/Publications/Agriculture_and_Forestry/Code_of_Practice_for_preventing_injury_and_occupational_ill_health_in_agriculture.pdf
([85]) https://www.hse.gov.uk/pubns/priced/hsg270.pdf
([86]) https://osha.europa.eu/es/publications/factsheets/99/view
([87]) https://osha.europa.eu/en/publications/reports/maintenance-in-agriculture-a-safety-and-health-guide
([88]) https://oshwiki.eu/wiki/Forestry_operations_and_OSH_issues:_from_the_past_to_the_present
([89]) https://osha.europa.eu/en/publications/e-fact-29-occupational-safety-and-health-europes-forestry-industry/view
([90]) https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/normativeinstrument/wcms_107793.pdf

Annex 3: List of experts consulted on the major trends and changes in agriculture

List of experts consulted on the major trends and changes in agriculture

Name	Country	Institution
Sonoko Bellingrath-Kimura	Germany	ZALF, Technical University Berlin
Donagh Berry	Ireland	VistaMilk Science Foundation
Philippe Chemineau	France	INRA
Emilio Gil	Spain	Universitat Politècnica de Catalunya / H2020 INNOSETA
Tom Kelly	Ireland	Teagasc
Erich Koch	Germany	SVLFG; ENASP
Kevin McDonnell	Ireland	Biosystems Engineering, University College Dublin
Michael Moroney	Ireland	CEO, Association of Farm & Forestry Contractors
Bernd Schuh	Austria	OIR — Austrian Institute for Regional Studies
Robin De Sutter	Belgium	Prevent Agri; COPA COGECA
Arnd Spahn	Germany, EU	EFFAT, SVLFG
Andrea Teutenberg	Germany	KWF
Sjaak Wolfert	Netherlands	Wageningen Economic Research
SACURIMA experts	EU	COST action CA16123

Annex 4: List of experts participating in the expert meeting on OSH in agriculture and forestry

List of experts participating in the expert meeting on OSH in agriculture an forestry

Name	Country	Institution
Isaac Abril	Spain	National Institute for Safety and Health at Work
Guillaume Bocquet	France	CEN
Susan Brumby	Australia	NCFH
Steven Carter	United Kingdom	Rolls-Royce
Massimo Cecchini	Italy	University of Tuscia
Helle Birk Domino	Denmark	SEGES
Laura Girdzuite	Lithuania	Vytautas Magnus University
Pat Griffin	Ireland	Health and Safety Authority
Adrian Hodkinson	United Kingdom	HSE
Kari Anne Holte	Norway	NORCE
Erich Koch	Germany	SVLFG; ENASP
Peter Lundqvist	Sweden	Lund University
Shengli Niu	Switzerland	ILO
Risto Rautianen	Finland, United States	LUKE
Robin De Sutter	Belgium	Prevent Agri
Arnd Spahn	Germany, EU	EFFAT, SVLFG
Petja Stavreva	Bulgaria	United Agrarians
Bernadette Ruetsch	France	CEN
Andrea Teutenberg	Germany	KWF
Magdalena Wachnicka-Witzke	Poland	KRUS
Anette Wester	Sweden	ABB

Annex 5: Glossary

Term	Definition
AMS — automatic milking system	Automated systems that complete the whole milking process without the direct assistance of milking staff
ATB Leibniz	Institute for Agricultural Engineering and Bioeconomy (ATB)
CCMSA/MSA — Caisse Centrale de la Mutualité Sociale Agricole/Mutualité Sociale Agricole.	France's social protection system for the agricultural professions, run by the central agricultural social mutual fund and the local agricultural social mutual funds
CIHEAM	International Center for Advanced Mediterranean Agronomic Studies
Cobots	Collaborating robots intended to physically interact with humans in a shared workspace.
Digitalisation	Use of digital and information technologies to improve processes
Digitisation	Conversion from analogue to digital format
ESAW — European Statistics on Accidents at Work	Project launched in 1990 to harmonise data on accidents at work for all accidents resulting in three days' absence from work.
EU SACURIMA — Safety Culture and Risk Management in Agriculture	An EU-funded COST action to explore safety culture and risk management in agriculture
EU-OSHA — European Agency for Safety and Health at Work	The EU's information agency for occupational safety and health
Farmer/forester	Employers, self-employed farmers/foresters, agricultural and forestry workers or any combination of these terms, as well as anyone operating in a professional or productive capacity directly related to the agriculture and forestry sectors
Food loss	Decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retailers, food service providers and consumers
Food waste	Decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers and consumers
Forwarder vehicle	A forestry vehicle that carries large felled logs from the stump to a roadside landing
PPE — personal protective equipment	Products that the user can wear or hold, to be protected against risks at work, at home or while engaging in leisure activities

Term	Definition
Precision agriculture	A farming management concept using digital techniques for monitoring and optimising agricultural production processes. Also known as precision farming
Seasonal worker	A national of a non-EU country who retains their principal place of residence in that country and stays legally and temporarily in the territory of an EU Member State to carry out an activity dependent on the passing of the seasons
Skidder	Any type of heavy vehicle used in a logging operation for pulling cut trees out of a forest in a process called 'skidding', in which the logs are transported from the cutting site to a landing
Smart agriculture	Use of digital technologies such as drones, sensors, global positioning or satellite systems, automation and robotisation, big data, the internet of things, artificial intelligence and augmented reality
SVLFG — Sozialversicherung für Landwirtschaft, Forsten und Gartenbau	German social insurance fund for agriculture, forestry and horticulture
Teagasc	The Agriculture and Food Development Authority — the Irish national body providing integrated research, advisory and training services to the agriculture and food industry and rural communities
Temporary worker	A worker engaged only for a specific period of time, including fixed-term, project- or task-based contracts, as well as seasonal or casual work, including day labour
UK HSE — Health and Safety Executive	The United Kingdom's independent regulator of work-related health, safety and illness
Zero km food	Food produced, sold and eaten locally

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The European Agency for Safety and Health at Work (EU-OSHA) contributes to making Europe a safer, healthier and more productive place to work. The Agency researches, develops, and distributes reliable, balanced, and impartial safety and health information and organises pan-European awareness raising campaigns. Set up by the European Union in 1994 and based in Bilbao, Spain, the Agency brings together representatives from the European Commission, Member State governments, employers' and workers' organisations, as well as leading experts in each of the EU Member States and beyond.

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