A Sustainable Mechanization for the future

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Abstract

The world population is increasing at a growing speed. Availability of natural resources for the food production however are limited. Additional factors such as wars, political instability, climate change also impact the capability to increase the production of food. The recent events showed once more how critical the supply with agricultural products is to maintain social peace and political stability. New technologies can improve the production of agricultural products. Agriculture could be one of the sectors where Artificial Intelligence (AI) can produce the most benefits. AI has the capability to enhance existing technologies and help in the development of new targeted products and solutions. The new technology could provide the key advantage in reaching the goals to ensure food security during the coming years. To create a legal framework, foster confidence in AI and the adoption of new technologies the European Union has published an Artificial Intelligence Regulation Draft (AI Regulation Draft). The new rules help to provide a framework for the usage of the AI technology but may require an additional ad hoc legislation targeted for agricultural solutions and imply an intensive work for a compliant application of the upcoming regulations.

A changing world

In the last decades the world experienced a strong trend leading to changes in dynamics and production in agriculture. The world population is growing exponentially and estimations range from 9 to 11 billion people by 2050 (Fig1). This drastic population growth is accompanied by important changes in the production of food and energy where the demand is shifting more and more to a higher protein diet, higher quality of the products and a higher demand for agricultural product in non-food sectors. FAO estimated that demand for cereals for both food and animal feed uses is projected to reach some 3 billion tons by 2050, up from today's nearly 2.1 billion tons. The advent of biofuels has the potential to change some of the projected trends and cause world demand to be higher, depending mainly on energy prices and government policies [01]. This all is paired with a request for sustainable production and a more ecological footprint for producers, contractors and farmers.

Missing to respond to those challenges may represent a risk for sustainability in production and social peace. Slowing productivity growth that fails to keep pace with increasing food demand may lead to rising food prices. It may also put pressure on low-income households as they spend a greater share of their income on food [02]. In addition, the agricultural sector needs to cope with climate changes, political instability, wars, water shortage and urbanization of the society where people are moving towards cities causing a growing shortage of agricultural labor availability. (Fig 2). Urbanization is foreseen to continue at an accelerating pace with urban areas to account for 70 percent of world population in 2050 (up from 49 percent at present) [03]. Climate changes are more and more proving to impact the quality of arable soil and water supply availability.

At the actual level of production, the demand for agricultural goods at the current peace can only cover a low amount of the increasing demand in terms of quantity and quality of food. To maintain today's level of food availability with such an intense growth in the population will require to increase production up to 70%, without a decrease in quality. To reach a significant and sustainable improvement in the optimization and enhancement of global food production, it is necessary to implement innovative strategies and means.

Technology response to meet the goals

At the European Commission level Agriculture plays an important role in the future of the European Union: The Common Agricultural Policy (CAP) [04], the EU Green Deal [05], The Farm to Fork strategy [06] and the Biodiversity Strategy for 2030 [07] point out how emerging technologies will play a growing role to ensure to reach the objectives of a more sustainable Agriculture while underlying the importance of a food security strategy at European level. In addition, the Coordinated Plan on Artificial Intelligence published by the European Commission in April 2021 covers actions to support the development of Artificial Intelligence systems for sustainable agriculture [08].

The EU Green Deal emphasizes the objective of sustainability that our society is looking forward to reach. The balance of several factors (climate, soil, seeds, pests etc.) plays a crucial role for successful productions in agriculture. During Covid 19 early months some countries experienced the effects of lack of agricultural products due to the perception of a shortage. It showed once more the critical role of agriculture and the impact of shortages on the socio-economic stability. It is mandatory to improve the resilience of the food production systems as well as establish a strong

reaction plan to impacting event such as soil degradation, water availability and quality degradation and biodiversity impoverishment. To meet the strong increasing demand and the request for better, healthier and sustainable products the farmers are required to step into a transformation process.

The technology for advanced production has already entered the agricultural market: Eg. automatization and autonomous functions on the field are already a reality. Crop protection technology is moving toward the optimization of the distribution, dosage and targeted treatment of fields and plants. Machines equipped with individual nozzle control are capable to recognize weeds and spray only unwanted plants keeping the crop safe, healthy and sustainable. Nutrient managing systems are able to manage the ideal quantities for each plant and each type of soil, enhancing yield growth but protecting at the same time ground water. Machine monitoring, synchronization and connection avoid efficiency loss in the production flow reducing energy costs, emissions and waste. Data analysis and comparison allow to learn from previous experiences and forecast events, prevent losses and enhance best practices to reproduce success.

Digitalization, Automation to Autonomy and Precision Agriculture enhanced by Artificial Intelligence (AI) (Fig 3) are the keys to allow a smooth transformation in the next years preventing unexpected shortages and increasing the production to grant the sustainability of the agriculture of tomorrow. The availability of new technology on a large scale may provide a better economic return for farmers. Thereby fostering a positive development in rural areas.

At the moment factors like the cost of initial investments, uncertain liability, usage of a disrupting technology are impacting the large scale use of AI powered technologies. AI powered solutions encounters resistance in their adoption as they are intrinsically difficult to understand due to the complexity of the parameter interaction, the probabilistic predictions and the gap in skill and knowledge of the users. Education in the use of the technology not only support understanding and acceptance but enhances the use of it and promotes investments. Larger producing companies already started to adopt new technologies, but smaller businesses are still in a transformation phase. The generational change has seen new farmers opening and approaching more and more of those technologies.

The legal framework

Artificial Intelligence is the key to enhance, foster use and develop the already existing capability in mechanization, automation, and data analysis. However, while the AI capability is increasing its speed and providing more and more ranges and types of application the legal framework to allow a secure and foreseeable risk allocation is still permeated by uncertainty. The need of a legal framework for AI embedded products was clearly addressed by the Commission and started the discussion over the last years. The Commission acknowledged the need to increase public confidence in those new technology. In this sense the discussion led to the publication of several documents and position papers such as among others the White Paper on Artificial Intelligence on February,20 2020[08] and the publication of the draft for an AI regulation in April, 19 2021[09] (AI Draft Regulation).

The new AI Draft Regulation is a first step to provide a legal framework for producer, distributors, users, and farmers. The regulation addresses the risk related to the adoption of the AI technology rather than entering in the detail of the nature of the technology itself. It is conceived as a risk

assessment and compliance framework addressing a very large sector providing an utmost important base for the ethical understanding of AI use in our society. It aims to provide a guidance for a compliant AI that fulfills the principles of certainty and transparency. At the same time the new regulation needs to align and harmonize with the existing and the upcoming legislations (eg. GDPR, Machine Regulation Draft, tractor regulation etc.) and opens the discussion in order to define the liability for producers, distributors and users.

The disruptive effect that is immanent to AI technologies has indeed also the power to disrupt the legal application of basic law principles. That renders the allocation of responsibility and liability a specific challenge at legal and also societal level. Due to the indeterministic character of the technology it disrupts one of the basic law principles that involves for example a link of causality between action and effect. Thus, it leads to several questions in the assessment of the liability. With a consequent uncertainty for producers and users. In the equation of the factors the secure control of data structures and processing becomes an x factor that cannot be easily solved without taking out the indeterministic nature of AI. Particularly, when human intervention, the source of data, the parameter and the variable start to multiply and increase complexity (eg. multiple stakeholders in data collection, differences in data types and sources, variability of possible models). This becomes evident in sectors like Agriculture where multiple stakeholders play a role in different phases of production. And where the data collection and parameters are so variable and heterogenic that an ex-ante (but to a great extent also the ex-post) evaluation of the actions and predictions result in a challenge.

Autonomous drive on the road represents just a small part of the activities in Agriculture where the largest and diversified part of operations is performed on the field or in the farms. The risk associated with each step in the agricultural production phases results in a huge variability. Eg. Even if both may be equipped both with safety components a seeder may imply a different level of risk than a harvester. In this sense it appears important to differentiate and target the effective and dynamic risks related to the various agricultural operations. That implies providing a framework that allows an efficient development, production, introduction on the market of AI powered solutions. It surely calls for an ad hoc legislation in the agricultural sector that takes account of the complete picture and different range of risks.

Furthermore, the legislators may witness a fast transformation in the nature of the products itself. Is a tractor without a driver still a tractor? This question may make the difference in the legal application of the appropriate law and impact the relationship between the AI Draft Regulation and the other regulations that touches directly or indirectly the subject. Other jurisdictions in different parts of the world may solve the issue by providing a different approach to the risk immanent to the AI technology. This can mean transferring the risk completely at governmental level, delaying the evaluation of the risk ex post (punitive damages) or quantifying the risk in commercial terms.

Conclusion

To meet the goals to feed a fast-growing population in a changing world requires to foster the adoption of new technologies and increase confidence for users and society. For companies investments in AI technologies may represent a growing opportunity but there are still many open questions in relation to the embedding of the technologies in the products and putting them on the market.

The new AI Draft Regulation represents a step in the right direction to provide a legal compass in a fast-growing and promising Artificial Intelligence applications field. However, the burden for some application that may fall under the high-risk AI Draft Regulation are high. Agriculture requires a dynamic risk evaluation that considers several factors and different level of risks that differentiate Agricultural from other fields of application. Furthermore, harmonization with existing laws may require additional attention in order to avoid uncertainty and foster societal acceptance, investments, adoption, and development of the AI enhanced technology in the Agricultural sector.

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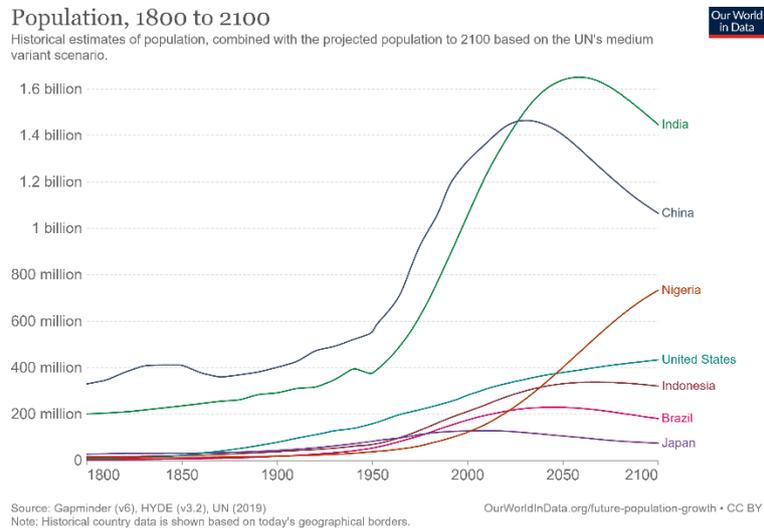
FIGURES

Figure 1 – Population Growth

Population, 1800 to 2100
Historical estimates of population, combined with the projected population to 2100 based on the UN's medium variant scenario.

Source: Gapminder (v6), HYDE (v3.2), UN (2019)
Note: Historical country data is shown based on today's geographical borders.
OurWorldInData.org/future-population-growth • CC BY

Figure 2 - Urbanization trend

Urban and rural population projected to 2050, World, 1500 to 2050
Total urban and rural population, given as estimates to 2016, and UN projections to 2050. Projections are based on the UN World Urbanization Prospects and its median fertility scenario.

Source: OWID based on UN World Urbanization Prospects 2018 and historical sources (see Sources)
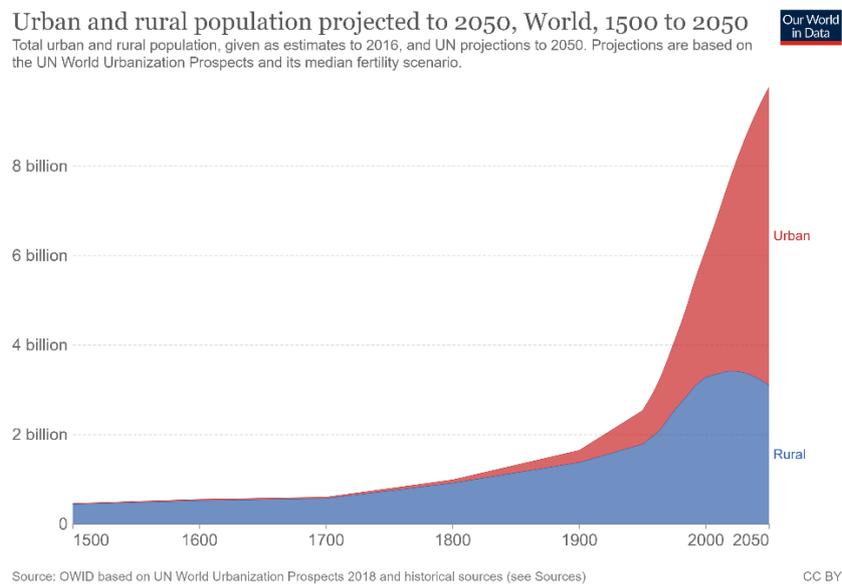CC BY

Figure 3 - Artificial Intelligence as core for Precision AG/Automation/Autonomy