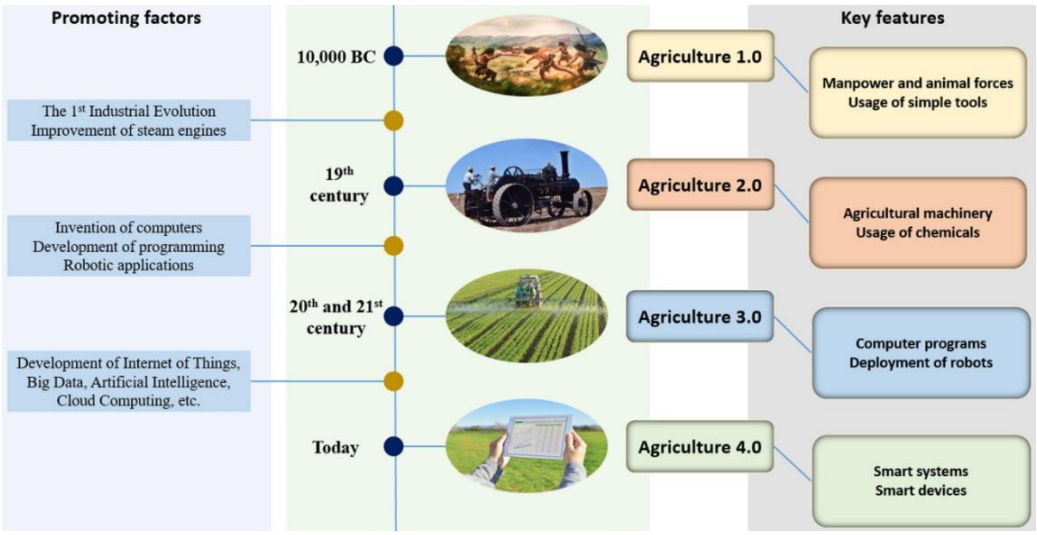
B1.9 Decision making made on Internet of Things data

Human beings have cultivated lands and bred animals to obtain food for their survival since ancient times. This practice – agriculture – has evolved following a long-term progressive process from Agriculture 1.0 to *Agriculture 4.0*.



(https://www.sciencedirect.com/science/article/pii/S0168169919316497)

Agriculture 1.0: traditional agriculture relied on manpower and animal forces, the use of simple tools like sickles and shovels, and while humans could not get rid of heavy manual labour, the productivity remained at a low level.

Until the 19th century, steam engines were widely used to provide new powers in agriculture. It came to the era of Agriculture 2.0 when various agricultural machines were manually operated by farmers and plenty of chemicals were used. Agriculture 2.0 significantly increased the efficiency and productivity of farm works.

In the 20th century, Agriculture 3.0 emerged from the rapid development of computing and electronics. Computer programs and robotic techniques allowed agricultural machines to perform operations efficiently and intelligently.

Nowadays, the evolution of agriculture steps into *Agriculture 4.0*, thanks to the employment of technologies like the *Internet of Things*, *Big Data*, *Artificial Intelligence*, *Cloud Computing*, and *Remote Sensing*. The application of these technologies can improve the efficiency of agricultural activities significantly.

Internet of Things and developed low-cost sensors aim at optimising the production efficiency, increasing quality, minimising environmental impacts, and reducing the use of resources such as energy and water.

Decision Support System

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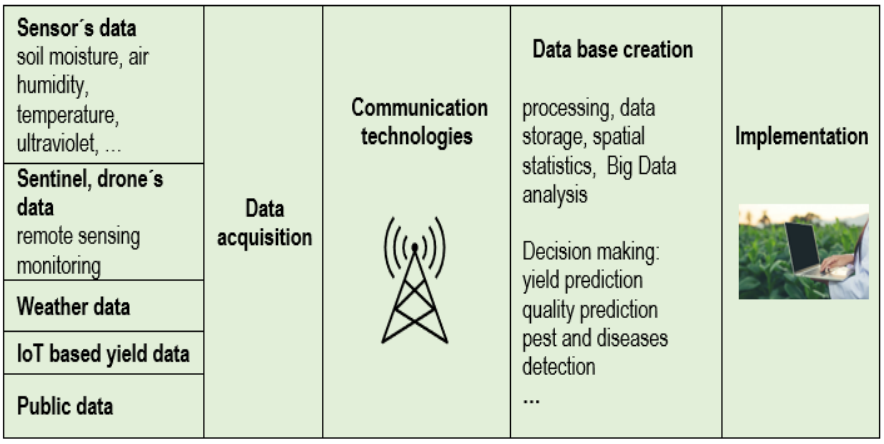
Decision Support System (DSS) is a computer architecture based on processing of Big Data able to assist the user by providing him with valid support. The decision maker provides guidance on:

- the availability of all information necessary for understanding the problem,
- the possibility of exploring data from different points of view and according to the user's needs,
- the possibility of assessing the scenarios resulting from the choices made.

The close relations between the system and its user makes it necessary to have strong customization regarding the various types of decisions and data coming from different sources.



The figure illustrates data flows from sources to the database and final data

DSS provides collecting and processing of spatial data, data in time, machine-generated data, process generated data and human sourced data.

- Agricultural yield is closely related to geographic location termed as *spatial data* and it is stored as coordinates to locate an area. The various stages of crop growth, such as seeding, fertilising, pest management, weeding, water supply, harvesting represent *data in time*.
- *Machine generated* data includes data from sensors, unmanned aerial vehicles, GPS. These data from new technologies may vary from sounds to images.
- *Process generated* data includes data collected from farms such as information on planting, monitoring, and recording of the farming process such as seeding fertiliser application.
- *Human-sourced* is previously sourced recorded human experiences which were previously stored as books are digitised and stored to provide accessibility.

DSS can be applied in agriculture with the support of *experienced agricultural experts.*

What are the advantages of DSS in precision agriculture?

- It supports the farmers in maintaining control over all variables necessary to assess decisions.
- It helps by providing numerical forecasts, even in the very short term.
- It can be managed remotely.
- It stores all information by creating a historical database.

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DSS automatically collects, organises, interprets and integrates information. Useful data can be drawn from suggesting the most appropriate actions to respond to different farm needs, whether they are long-term strategic or tactical decisions to be taken in the short term.

DSS offers farmers an important negotiation tool. So far, only a small percentage of agricultural enterprises use it, on average around 7% in Europe, and around 11% in the USA. And mostly they are only partial applications, the full deployment of DSS is still awaited.

What is the future of the application of DSS in agriculture?

There are 10.3 million agricultural holdings in the EU, and 66% of them have an area of less than 5 hectares. In total, 171 million hectares of land is used for agricultural production – which is about 40% of the total area of the EU. However, it is a fact that only 3% of agricultural enterprises in the EU farm on 100 hectares or more of agricultural land – which makes up approximately half of the EU's used agricultural area.

65% of farms in the Union have an area of less than 5 ha, but only 7% of farms have an area of more than 50 ha. Among the Member States, this difference is most striking in Romania, where 92% of farms (i.e 3.1 million farms) are smaller than 5 ha, but only 0.5% of the total number of farms farm on 50 ha. or more (they farm 51% of the country's agricultural land). Larger farms (at least 50 hectares and more) are in Luxembourg (52%), France (41%), Great Britain (39%) and Denmark (35%).

The technologies that use DSS are also constantly developing. Moore's Law[1] is still valid, scientific knowledge will not stop and will offer more new applications.

From the given data, it is clear that small and medium-sized agricultural business entities are the basis of agriculture throughout the EU. This is why the subsidy policy of the European Commission after 2020 is aimed precisely at *supporting these farmers*, and that is why the mandatory capping and degressive nature of direct payments is envisaged. The goal is for the subsidies to be aimed at the development of real small and medium-sized farmers, and not giant agrarian holdings.

The future use of state-of-the-art technologies in agriculture will not be possible without subsidies from the EU and national states. It is expected that by 2030 the number of DSS applications will at least double, by 2050 the use of DSS for farm management should be widespread.

Being a key part of sustainable agriculture, DSS will become more and more robust. The increased connectivity of technologies and the multiplication of smart devices on the field will stimulate the accumulation and storage of data. Actors from the sector will have the ambition to make DSS more ergonomic and user-friendly. Companies already offer mobile interfaces on smartphones and tablets that are easy to handle and can be used in real time, directly on the field. Such developments allow more farmers to use DSS, since, at the end of the day, they are the final recipients and users of new technologies which will revolutionise agriculture.

[1] **Moore's Law***: Moore's Law is the principle that the speed and capability of computers can be expected to double every two years, as a result of increases in the number of transistors a microchip can contain. Over time, the details of Moore's Law were amended to reflect the true growth of transistor density. First, the doubling interval was increased to two years and then decreased to around 18 months. The exponential nature of Moore's Law continued and created decades of opportunity for the semiconductor industry and the electronics that use them. So, Moore's Law has been able to continue to really push computing to the outer edge.

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Summary

Decision Support System (DSS) is a computer architecture based on processing of Big Data and IoT able to assist the user by providing him with valid support. DSS provides collecting and processing of spatial data, data in time, machine-generated data, process generated data and human sourced data. Advantages of DSS in precision agriculture include: a) supporting the farmers in maintaining control to assess decisions; b) helping the farmer by providing numerical forecasts, even in the very short-term; c) storing all information in a historical database. DSS automatically collects, organises, interprets and integrates information. Useful data can be drawn suggesting the most appropriate actions to respond to different farm needs, whether they are long-term strategic or tactical decisions to be taken in the short term. The future use of state-of-the-art technologies in agriculture will not be possible without subsidies from the EU and national states. It is expected that by 2030 the number of DSS applications will at least double, by 2050 the use of DSS for farm management should be widespread.

Links to relevant topics

Zhaoyu Zhai José, Fernán Martínez 2020 *"Decision support systems for agriculture 4.0, Survey and challenges"*, Computers and Electronics in Agriculture, Vol. 170, DOI:

DOI: 10.1016/j.compag.2020.105256

Javaregowda, M., Indiramma, M. 2019 "Role of Big Data in Agriculture", International Journal of Innovative Technology and Exploring Engineering 9(2), pp 3811-3821 DOI: 10.35940/ijitee.A5346.129219

https://en.wikipedia.org/wiki/Decision_support_system

Key words

Agriculture 4.0.

Internet of Things

Big Data

artificial intelligence

cloud computing

remote sensing

spatial data

data in time

machine generated

process generated

human-sourced

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