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”Precision agriculture and how to sell products in the world markets”
Big data and analytics are transforming the world of agriculture as we know it

In the quest for bigger yields and greater environmental protection in agriculture, arguably the most important transformation these days is the increasing use of digital technologies in “smart farming” or “Farming 4.0”.

After mechanisation, the introduction of mineral fertiliser, and the industrialisation of production processes, connectivity and data management are now creating the fourth revolution in the history of farming. And smart digital farming has been recognised as the highest-ranking technology opportunity in terms of its expected positive impact on society.

While precision agriculture (the use of satellite navigation, remote sensing and other tools to farm each square metre as efficiently and sustainably as possible) has been an evolving reality for some time, IT has now reached a point where it is not only possible to collect vast quantities of data, but also to use quite inexpensive, small processors to make use of this information to control different pieces of equipment or monitor individual animals.

A growing number of farmers in Asia and in Vietnam are starting to adopt digital technology and data-driven innovations. Thanks to digital connectivity, intelligent agricultural machines can connect in a working process by consulting, for instance, weather data, ordering spare parts or accessing field-specific information from a central, cloud-based farm management software.

However, many Vietnamese farmers are still operating today in the Third Industrial Revolution utilising a basic personal computer, the internet, and simple ICT, and others are still in the Second Industrial Revolution with reliance on the telephone, light bulb, and the internal combustion engine. They are a long way from understanding or utilising the benefits of the Fourth Industrial Revolution.

Big data can deliver bigger yields and greater environmental protection. Farms in Germany using advanced digital technology have reported higher yields per hectare while reducing nitrogen levels significantly, as well as cutting herbicide and diesel use by 10% and 20% respectively.

Moreover, Farming 4.0 is a highly dynamic and rapidly evolving concept and will offer great improvements in a short space of time. Even if Farming 4.0 already is a reality in certain regions of the world, there is still a lot of untapped potential in terms of automated data processing, completely integrated production processes, and building up smart digital ecosystems (SDEs) in agriculture.

Yet, while the development potential is high, digital progress in agriculture has been slow. So far, overall adoption and penetration rates of agricultural software solutions worldwide are slow and much lower than predicted, and digital system’s capabilities are often underutilised on the farm.

For Farming 4.0 to become a reality, we need a dedicated joint effort between the public sector, industry players and the farming community. Above all, decision-makers and the national government needs to ensure that the fundamental digital infrastructure for rapidly growing data flows, in terms of network coverage and transmission rates in rural areas, is put in place.

Secondly, we need supportive government policies that help to address the investment gap in agriculture, particularly in times of low commodity prices. We need a policy that includes new and more dedicated measures and mechanisms to boost farmers' ability to invest in those innovative digital technologies and equipment that have proven benefits to both the society and the environment.

In parallel, industry players must strive to create a competitive and innovation-friendly landscape that enables the flow of data streams, and encourages fair competition at all levels. Here, we need communication and interface standards that facilitate vertical and horizontal communications i.e. permit data exchange between machines, business partners, as well as different data portals and platforms.

Finally, farmers need to get ready to embrace the upcoming digital change. What is important is to ensure that the necessary digital skills are developed and that there is an openness about potential new business opportunities and models that may be available with the digital transformation.

For instance, with retailers and consumers increasingly interested in the traceability of the food they supply and eat, the ability to collect data on exactly how a crop was grown or an animal reared could become an invaluable asset, particularly if Vietnam wants to be competitive on the world stage and in the global supply chain. This can help growers to deliver high-quality specialised produce, fully traceable to the field, and could allow supermarkets to offer a better choice to their customers. At the same time, digital documentation could alleviate the administrative burden of farmers to demonstrate compliance with legislation.

Most importantly, farmers need to be given reassurances about the security, ownership, and control of their data. The principle that data generated on a farm is the property of the farmer needs to be adequately reflected in contract law. In practice, more and more farm-data will be pooled in cloud-based data platforms to facilitate data processing, analysis, and flow of information. Yet the farmer needs to be able to decide on the allocation of access rights and on which partners receive which kind of data, and in this way retain ownership of the data.

Thanks to digital technology, people everywhere have got used to having a powerful computer in their pocket, being in constant contact with friends, colleagues and having a world of information and entertainment in front of them. Farmers now have that same power available to them, adapted to meet their particular needs. With Farming 4.0, they are able to run their farms on entirely new levels of automation, sustainability, and productivity, while retaining full control.

Precision Agriculture (PA)

Precision agriculture is a key component of the modern agricultural revolution. From 1900 to 1930 internationally, each farmer produced enough food to feed about 26 people. The 1990s prompted the Green Revolution with new methods of genetic modification, which led to each farmer feeding about 155 people.

And it is expected that by 2050, the global population will reach about 9.6 billion, and food production must effectively double from current levels in order to feed every mouth. With new technological advancements in the agricultural revolution of precision farming, each farmer will be able to feed 265 people on the same acreage.

The first wave of precision agriculture has come in the forms of satellite and aerial imagery, weather prediction, variable rate fertilizer application, and crop health indicators. The second wave aggregates the machine data for even more precise planting, topographical mapping, and soil data.

Precision agriculture aims to optimize field-level management with regard to:

- crop science
- environmental protection; and
- economics

Precision agriculture also provides farmers with a wealth of information to build up a record of their farm, to improve decision-making, to foster greater traceability enhance marketing of farm products; and to enhance the inherent quality of farm products.

Prescriptive planting is a type of farming system that delivers data-driven planting advice that can determine variable planting rates to accommodate varying conditions across a single field, in order to maximize yield. It has been described as "Big Data on the farm." Monsanto, DuPont and others launched this technology in the US.

Data collection: Geo-locating a field enables the farmer to overlay information gathered from analysis of soils and residual nitrogen, and information on previous crops and soil resistivity. Geo-location is done in two ways:
- The field is delineated using an in-vehicle GPS receiver as the farmer drives a tractor around the field.
- The field is delineated on a base-map derived from aerial or satellite imagery. The base images must have the right level of resolution and geometric quality to ensure that geo-location is sufficiently accurate.

Using soil maps, farmers can pursue two strategies to adjust field inputs:
- Predictive approach: based on analysis of static indicators (soil, resistivity, field history, etc.) during the crop cycle.
- Control approach: information from static indicators is regularly updated during the crop cycle.

Decisions may be based on decision-support models (crop simulation models and recommendation models), but in the final analysis it is up to the farmer to decide in terms of business value and impacts on the environment.

It is important to realize why PA technology is or is not adopted, for PA technology adoption to occur, the farmer has to perceive the technology as useful and easy to use. It might be insufficient to have positive outside data on the economic benefits of PA technology as perceptions of farmers have to reflect these economic considerations.

Precision agriculture uses technology on agricultural equipment (e.g. tractors, sprayers, harvesters, etc.):
- positioning system (e.g. GPS receivers that use satellite signals to precisely determine a position on the globe);

- geographic information systems (GIS), i.e., software that makes sense of all the available data;
- variable-rate farming equipment (seeder, spreader).

The concept of precision agriculture first emerged in the United States in the early 1980s. It was also at this time that the practice of grid sampling appeared (applying a fixed grid of one sample per hectare). Towards the end of the 1980s, this technique was used to derive the first input recommendation maps for fertilizers and pH corrections. The use of yield sensors developed from new technologies, combined with the advent of GPS receivers, has been gaining ground ever since. Today, such systems cover several million hectares.

Around the world, precision agriculture has developed at a varying pace.
One third of the global population still relies on agriculture for a living. Although more advanced precision farming technologies require large upfront investments, farmers in developing countries like Vietnam are benefitting from mobile technology. This service assists farmers with mobile payments and receipts to improve efficiencies.

Precision agriculture means application of precise and correct amount of inputs like water, fertilizer, pesticides etc. at the correct time to the crop for increasing its productivity and maximizing its yields.

Precision agriculture management practices can significantly reduce the amount of nutrient and other crop inputs used while boosting yields. Farmers thus obtain a return on their investment by saving on water, pesticides and fertiliser costs.

The second, larger-scale benefit of targeting inputs concerns environmental impacts. Applying the right amount of chemicals in the right place and at the right time benefits crops, soils and groundwater, and thus the entire crop cycle.

Consequently, precision agriculture has become a cornerstone of sustainable agriculture, since it respects crops, soils and farmers. Sustainable agriculture assures a continued supply of food within the ecological, economic and social limits required to sustain production in the long term.
Tools and technology Self-steering tractors have existed for some time now. The tractor does most of the work, with the farmer stepping in for emergencies. Technology is advancing towards driverless machinery programmed by GPS to spread fertilizer or plough land. Other innovations include a solar powered machine that identifies weeds and precisely kills them with a dose of herbicide or lasers. Agricultural robots, also known as AgBots, already exist, but advanced harvesting robots are being developed to identify ripe fruits, adjust to their shape and size, and carefully pluck them from branches.

Advances **in drone and satellite technology** benefits precision farming because drones take high quality images, while satellites capture the bigger picture. Light aircraft pilots can combine aerial photography with data from satellite records to predict future yields based on the current level of field biomass. Aggregated images can create contour maps to track where water flows, determine variable-rate seeding, and create yield maps of areas that were more or less productive.

The Internet of things is the network of physical objects outfitted with electronics that enable data collection and aggregation. IoT comes into play with the development of sensors and farm-management software. For example, farmers can spectroscopically measure nitrogen, phosphorus, and potassium in liquid manure, which is often inconsistent. They can then scan the ground to see where cows have already urinated and apply fertilizer to only the spots that need it. This cuts fertilizer use by up to 30%.

Moisture sensors in the soil determine the best times to remotely water plants. The irrigation systems can be programmed to switch which side of tree trunk they water based on the plant's need and rainfall.

Innovations are not just limited to plants **-** they can be used for the welfare of animals. Cattle can be outfitted with internal sensors to keep track of stomach acidity and digestive problems. External sensors track movement patterns to determine the cow's health and fitness, sense physical injuries, and identify the optimal times for breeding. All this data from sensors can be aggregated and analyzed to detect trends and patterns.

Precision Livestock Farming (PLF)

PLF is one of the most powerful developments to revolutionise livestock farming. If properly implemented, PLF or Smart Farming could:

- improve or at least objectively document animal welfare on farms;
- reduce greenhouse gas (GHG) emission and improve environmental performance of farms;
- facilitate product segmentation and better marketing of livestock products;
- reduce illegal trading of livestock products; and
- improve the economic stability of rural areas

However, there are only a few examples of successful commercialisation of PLF technologies introduced by a small number of commercial companies which are actively involved in the PLF commercialisation process.

Efficient information management is very much part of profitable livestock production. The main purpose of Precision Livestock Farming (PLF) is to improve the efficiency of production, while increasing animal and human welfare, via applying advanced information and communication technologies (ICT), targeted resource use and precise control of the production process.

Through the adoption of electronic data collection, processing and application, precision farming has the potential to improve production efficiency and reduce costs, as well as increase animal and human welfare. There is currently an abundance of information available to livestock managers, but it is not generally structured in a way that can be applied readily. Furthermore, many producers perceive that adopting high productive management systems involves increased risk. The perceived risks include financial failure because of unforeseen environment or market circumstances, damage to the farm infrastructure such as soils and pasture, compromises to animal health and welfare, and increased stress on farmers from managing an intensified system. These risks are real. Thus, it is important to develop a management system that ensures only the most essential procedures are carried out, they are all carried out correctly and consistently, and in a way that controls risk. Such a system, based on the Hazard Analysis Critical Control Point (HACCP) method, has been developed for grazing beef enterprises in Australia and forms a model that can be applied to any other animal industry in any country.

Traceability within livestock management has largely been limited to movement and disease control applications such as the European passport system for cattle, the Pig Pass for pigs in Australia and the movement permit across state/provincial borders in Malaysia and Vietnam.

However, virtually no attempt has been made to unlock the economic benefit that traceability can have for livestock enterprises.

Feed and feed input providers can greatly improve the composition of their products if they have access to slaughterhouse statistics resulting from the feeding profiles applied on the farm. Farms can use such a system for the selection of the right feed (or right feed provider). They can also optimise their feed use/intake from the statistics of other farms on the network. Abattoirs can use the system as a basis for cooperation with farms to produce and source more animals on weight and conformation specification. And Industry statistics are a very important tool for both governments and the industry itself to steer the sector. Reliable statistics can be used for political decision making, benchmarking, lobbying and business decision making.

Examples and principles of commercialising PLF technologies: Examples of commercial adoption of PLF techniques include the use of robotics in dairying, measurement of water usage, egg counting, bird weighing, better control of environment in poultry houses, computerised feed systems, climate control, automated disease detection, growth measurement and real-time production site data capture in piggeries.

Although farmers usually invest part of their gains in technology, it is typically machinery that they would buy (as opposed to software or sensors). The food industry in general is a very conservative industry. Although it is one of the largest industries world-wide, its margins are very small and its products are usually very delicate. Agriculture is in addition a fragile industry, because it depends directly or indirectly on climatic factors and seasonal demand/supply circles. In addition, even for the more adventurous farmer it is very difficult to judge the applicability of a particular technology and guess its benefits. There is an absence of clear cost benefit data on PLF that takes into consideration the complexity of farmers' purchase decisions. Demonstrating and verifying the economical, welfare and environmental benefits of these technologies are essential in the commercialisation process. The other key limiting factor of adoption rate of PLF technologies on farms is the lack of co-ordination between researchers, developers and technology suppliers. Achieving better co-ordination between the developers and suppliers of PLF tools is very difficult, but would result in the development of better integrated systems.

PLF as a facilitator of progress: In the next 10 years, it is very unlikely that PLF will revolutionise livestock industries, particularly in Vietnam. However, in the next 5-10 years, sensors will be deployed routinely around animals that might allow farmers to effectively monitor a range of useful parameters for all livestock species. This will enable a range of new services to be developed and implemented on farms, such as individual feeding, heat detection, health monitoring and animal localisation. Mobile robots will emerge for milking and other tasks both in the shed as well as in the open. Virtual fencing will contribute to better herd and paddock management and improve financial returns for grazing enterprises. Most farms in Europe will be computerised in 10 years and use software tools for their management. Greenhouse gas (GHG) emissions are going to be very important in the future and PLF can contribute to the reduction of such emissions by measuring emissions and potentially adjusting feeding, temperature and other parameters that influence the emission of gases. Farm enterprises in the supply chain are making a concentrated effort to keep animals under optimal conditions, to keep emissions down and to provide the best livestock product at the lowest possible price. PLF can assist in transporting this information to other parties within the supply chain, and ultimately to the consumer. It can facilitate more informed choices by consumers and can be the base for other business models, such as selling meat by protein content, emitted GHG gases, or other concepts. The exchange of information on the feed-animal-food chain has a great potential for optimising livestock production. Feed producers could reap very important information from carcass composition data. Farmers could improve their feeding regime and choose the feed provider with the "best" feed for their animals. Traceability and PLF are the basis for such an information exchange. PLF will have its role in feeding strategies; perhaps will link to gas and waste production. PLF can also contribute to the avoidance of illegal trading of livestock and livestock products. Smuggling animals across borders is a major problem (health and financial) in countries like Vietnam.

Precision livestock farming (**PLF**) is the use of advanced technologies to optimize the contribution of each animal. Through this "per animal" approach, the farmer aims to deliver better results in livestock farming. Those results can be quantitative, qualitative and/or addressing sustainability.

Precision livestock farming (PLF) is made possible by monitoring each individual animal. Although this sounds like 21st century technology, precision farming is not new. It is not so long ago that most farmers knew each of the animals by name. Moreover, a farmer could typically point out who the parents were and sum up other important characteristics. Each animal was approached as an individual.

In recent times, farms have multiplied in scale, with highly automated processes for feeding and other tasks. Not surprisingly, farmers currently work with average values per group. Using modern information technology, farmers now can record numerous attributes of each animal, such as pedigree, age, reproduction, growth, health, feed conversion, carcass weight as percentage of its live weight, and meat quality. When this information is available, huge benefits can be derived. Culling, currently typically done on the basis of age, can now be done on the basis of reproduction value. The result is significantly higher reproduction outcomes, with each new born also contributing to a higher meat value. In addition to these economic goals, precision livestock farming supports societal goals: food of high quality and general safety, animal farming that is efficient but also sustainable, healthy animals and well-being of animals and a low footprint of livestock production to the environment.

The key to unlock the potential of precision farming is consistently collecting information of each animal.

Electronic Identification (EID): Each animal gets a unique number (typically by means of an ear tag), which can be read by a handheld "reader". For example, at birth, the farmer selects "Birth" from the menu on the reader, after which the interactive screen requests the user to read the tag of the mother. Next, tags are inserted in the ears of new-borns and read. With this simple action, important information is recorded, such as:

- who is the mother
- how many siblings did she deliver
- what is the gender of each sibling
- what is the date of birth

The second piece of technology users need is software. By using readers which are wirelessly connected to the internet, data is processed immediately on servers, and the results are instantly available. In the past, people have used plain readers. Sometimes, users forgot to sync these devices with their PC for many weeks. The result is that the precision farming data becomes outdated, and thus useless. Moreover, connected readers can download important information wherever the farmer is. For example, if he wants to check the passport of certain animal, he simply reads the tag and all relevant information is immediately visible on his handheld device, over the mobile internet. Due to high computational requirements, precision livestock farming requires computer-supported tools.

Precision livestock farming is all about recognizing the individual properties of each animal. That brings huge benefits to a farmer. Abattoirs, for example, can do exactly the same. More and more slaughterhouses deploy Slaughter Registration Systems. Such systems read each tag at the moment of slaughtering, after which the carcasses are traced through the abattoir. When the ready-to-sell carcass is moved into storage, the tag number and other slaughter data (such as weight, quality, fat and customer) are added to the carcass. The pertinent slaughter data (carcass weight, quality, fat) are fed back to the farmer, who can use this data to improve his farming.
For more than 10,000 years people have cultivated crops using trial and error, received wisdom and how the soil feels when they rub it between their fingers. Only recently in history, mechanisation revolutionised the countryside with machinery and replaced horses with tractors.

Nowadays, we're witnessing a new farming revolution triggered by the adoption of staggering new technologies**:** satellites, high precision positioning systems, smart sensors and a range of IT applications combined with high-tech engineering.

Farming 4.0 is here.