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CEMA
European Agricultural Machinery Association

Smart Agriculture for All Farms

What needs to be done to help small farms access Precision Agriculture? How can the next CAP help?

by Gilles Dryancour, Chairman of CEMA's Public Policy Group

Executive Summary

This paper focuses on the question of how to improve access by small farm holdings in Europe to Smart & Precision Agriculture (PA) technologies[1].

It provides concrete answers to 3 critical questions raised by EU Agriculture Commissioner Phil Hogan in the context of the upcoming CAP reform:

- **What measures could make Smart & Precision Agriculture technologies accessible to the average European farmer (farming between 50-100 ha)?**
- **How can Smart & Precision technologies boost sustainability & environmental protection?**
- **What kind of Smart & Precision Agriculture technologies should be promoted by the CAP?**

1) This is CEMA's 3rd Position Paper on the future of the CAP and supplements the two previous Papers issued in February 2015 and March 2017. Both Papers are available at: www.cema-agri.org

CEMA aisbl - European Agricultural Machinery Industry Association
Boulevard Auguste Reyers 80, 1030 - Brussels, Belgium
Email: secretariat@cema-agri.org Tel: +32 (2) 706 81 73

Smallholder Agriculture, the Scale Factor & Access to Smart Agriculture Technologies

Smallholder agriculture still dominates the European rural economy, with 86% of EU farms holding an area below 20ha. Advanced agricultural machinery solutions can help farm holdings – regardless of their size – to operate in a profitable, competitive and sustainable manner. In particular, Precision Agriculture (PA) technologies holds great potential for farmers in this regard. However, available economic evidence shows that there is a strong link between the size of a farm holding and its income, with larger farms tending to have higher income and investment capacity.

The importance of this 'scale factor' has also been evident in the uptake of PA technologies: at the beginning, only larger farms were able to buy, for instance, guidance devices and amortize them in a profitable manner. By today, these PA technologies have started to spread across the 100ha farm holdings segment.

Meanwhile, there still is a clear bottleneck for the farm segment below 100ha with an income below EUR 25,000. For these farms, it is still difficult to access certain PA technologies in a profitable way, unless they operate in a niche production. As a result, still, less than 25% of EU farmers have access to Precision Agriculture technologies.

Support from the EU's CAP after 2020 to stimulate the wider dissemination of PA technologies will be fundamental to reduce the negative impact of the scale factor. If no such supportive action to improve the uptake of PA technologies for farms below 100ha (97% of EU farms) were to be taken, it could become increasingly difficult for these farms to compete with farms in the USA, Canada and New-Zealand or even with larger EU farms, all of which massively invest in PA technologies. Not only could smaller EU farms thus lose their competitiveness. They might struggle to comply with greening targets and EU environmental policy goals.

Precision Agriculture Technologies to Be Promoted by the CAP

PA technologies are one of the most efficient tools to improve sustainability and productivity in farming. PA. technologies offer solutions to produce more with less and enhance food security and safety. Practically, PA technologies provide farmers with extra sensors which give them more information on how to manage natural variations like weather conditions, pests, insect and fungal infestation.

Some of the most prominent environmental benefits of PA technologies are:

- Preventing ground water pollution by optimizing manure and chemical spraying
- Reducing fresh water withdrawals with precision irrigation
- Limiting crop damages by responding rapidly and effectively to pest and fungal infestation
- Allowing new types of polyculture (critical to stimulate biodiversity, noticeably for pollinators)

Some PA diagnostic technologies are already highly affordable and thus available to smaller farms thanks to smart phones or tablets and their applications. Such applications can directly signal a problem on the field or connect to an online service for further probing.

Other fundamental PA technologies are less available to smaller farms and should therefore be promoted by the CAP. These technologies can be divided in three categories:

1. Guidance Systems
2. Variable Rate Applications (VRT) & Nutrient Sensing
3. Precision Livestock Farming (PLF) Technologies

Each of these technologies offers distinct advantages in terms of sustainability and profitability for farmers.

CAP Reform: Support to Access Smart & Precision Agriculture Technologies Tailored to Farm Size

The CAP after 2020 should help improve access to Smart & Precision Agriculture Technologies through a Sustainable Productivity Bonus which would be adapted to the farm size and differ for different sizes of farms, namely:

- **Farms < 50ha**
  As most of these farms do not have adequate access to PA technologies, they should be eligible for a dedicated subsidy to invest in basic PA technologies or a voucher for using contractual services. In addition, CEMA proposes for this size of farm to create a special voucher for buying small-scale communication technologies with agricultural applications, like smart phones, tablets, computers. This special annual voucher for lower-scale technologies could be in the range of EUR 500-750.

Farms 50-100ha

CEMA proposes a two-tier system for this category of farms: they could either go for the Sustainable Productivity Bonus or apply for a dedicated Smart Technologies subsidy or voucher. CEMA estimates that a dedicated subsidy ranging between EUR 6,500-7,000 would be suitable to cover the basic PA needs farmers of this size category. The dedicated Smart Technologies subsidy could be used either for investing in advanced technologies or renting the services of a certified contractor/ cooperative equipped with these technologies. In case of a direct investment, the subsidy could be allocated based on the normal depreciation period of the purchased technology, i.e. EUR 7,000 / 5 years = EUR 1,400 per year. If the farmer would be using a cooperative's or contractors' services, it is proposed to issue a smart technologies voucher to the farmer to be released by the contractor.

Farms >100 ha

A majority of these farms have at least access to one the fundamental PA technologies identified in this paper. For these farms, the Sustainable Productivity Bonus put forward would still apply and would practically work this way: "Farmers investing a given percentage of their revenue in certified sustainable technologies will automatically be eligible to the Greening direct CAP payments. Optionally, EU farmers who would not reach this percentage could still use the traditional Greening CAP scheme". Other certified smart technologies could potentially be eligible to the Sustainable Productivity Bonus, like: Big Data, the Internet of things, smart devices smart-phones, tablets, software, applications, embarked computers, unmanned systems, drones, robots, and autonomous machinery.
In order to avoid unnecessary administrative costs and extra burdens for EU farmers, the manufacturers and producers should be able to self-certify the sustainable technologies they offer to EU farmers according to criteria clearly pre-defined in the CAP.

1. Smallholder Agriculture Still Dominates the European Rural Economy

1.1. Scale Factor & Smart Agriculture Technologies

In 2017, there are about 10 million farm holdings in the EU (28), occupying roughly 170 million hectares. The average EU farm size is about 17 ha, although this average covers wide unevenness in the size and the distribution of farm holdings between the Member States. The EU average farm size is 10 times smaller than the US average size (175 ha) and 47 times smaller than in Australia, which has the largest average farm business size in the world (800 ha).

It should also be noticed that the average farm sizes of global competitors such as Argentina, Canada and New Zealand are growing at a much faster rate than EU farms. The Member States with the largest number of farms are Romania (3.6 million), Poland (1.4 million), Italy (1.0 million), Spain (0.9 million) and Greece (0.7 million). Together, these five account for over 70% of all EU farms.

The largest average area can be found in the Czech Republic (133 ha) followed by the United Kingdom (94 ha), Slovakia (81 ha), Denmark (67 ha) and Luxembourg (63 ha). As such, the Member States with the largest average areas remain well below the area of other global competitors like the US, New-Zealand (252 ha) or certain regions of Brazil like ''Centro-Oeste" with 897 ha. In Brazil, 1% of farms are larger than 1,000 hectares, occupying 45.1% of all land used in agriculture.

Figure 1: Distribution of EU Agricultural Holdings by Area (2013)

Area of holding	Number of holdings	% of total holdings	Utilised Agricultural Area (ha)	% of Utilised Agricultural Area
< 2 ha	4 706 370	44.1%	3 578 030	2.0%
2 - 4.9 ha	2 307 300	21.6%	7 313 240	4.2%
5 - 9.9 ha	1 277 230	12.0%	8 940 870	5.1%
10 - 19.9 ha	888 540	8.3%	12 442 190	7.1%
Sub-total <20 ha	9 179 440	86%	32 274 330	18%
20 - 29.9 ha	374 870	3.5%	9 134 540	5.2%
30 - 49.9 ha	387 730	3.6%	14 974 730	8.6%
50 - 99.9 ha	388 680	3.6%	27 264 410	15.6%
>100 ha	336 740	3.2%	90 965 810	52.1%
Sub-total =>20 ha	1 488 020	14%	142 339 490	82%
Total	10 667 460	100.0%	174 613 820	100.0%

Source: Eurostat

2) Estimations based on the 2013 census figures.

A comparable figure could be found in the EU for the agricultural holding above 100 ha. However, as the table above shows, 86% of the EU farm holdings have an area below 20 ha. So the overwhelming reality is that smallholder agriculture still dominates the European rural economy.

It is a given fact that the agricultural equipment industry takes well into account and for which it has no prejudice against. Contrary to the assumption of some academic writers, our industry doesn't *"push"* for farm consolidation with the goal to sell more and more powerful machinery.

As we demonstrated in 2016:

"The continuous structural decline of the agricultural machinery's customer base and market in Europe has been fueled by the rural exodus. If tractors became more powerful this was essentially due to the fact that farm consolidation did not leave any other option. In other words, bigger farms needed more powerful tractors. Otherwise, they could not be operated efficiently. This trend has thus been clearly triggered by the demand-side and not by the structure of the production. Also, the assumption that the growth in horse power would have compensated for the overall decline in sales numbers cannot be verified by the statistics. In fact, if we take the German market as a reference and check how many kilowatts were sold in total from 1970 to 2001 (all tractor power categories taken together), we can find that this figure also declined: in 1970, 65,000 tractors were sold in Germany representing a total amount of 2.2 million kilowatts. In 2001, 24,000 tractors were sold representing a total amount of 1.8 million kilowatts.[3]"

In 1950s there was a time when tractors sales reached 1 million units in the EU 28 (against an average 160,000-170,000 these last 5 years) and the industry was much more prosperous, with many more farmers and numerous manufacturers which gradually disappeared over these last decades[4].

It should be also said that despite the rural exodus our industry remained remarkably diversified. The CEMA 4,500 manufacturers serve all type and size of farms and supply them with 450 different types of highly-specialised machines ranging from tractors and combine harvesters to plant protection equipment and precision seed drills. By tradition, CEMA members consider that there's a market for any size of farm and there is a great potential for all farmers to access precision agriculture technologies. However, economic evidence shows that there is a strong link between the size of the farm holding and its income: see table on page 7.

3) Gilles Dryancour, The agricultural Machinery Market & Industry in Europe, An analysis of the most important structural trends & why EU regulation of the sector needs to change, CEMA, Brussels, October 2016. 4) i.e. Lanz, FAR, Ford, Citroën, Röhr, BMB, Steel hoof, Merlin, Latil, SFV, Energique, to name just a few.

Figure 2: EU Distribution of Holdings & Utilized Area by Size Class in EUR, 2005 & 2010 (Source: Eurostat)

Size classes in EUR	Number of holdings			Utilised agricultural area		
	EU-27		EU-28	EU-27		EU-28
	2005	2010	2010	2005	2010	2010
Total (thousands ha)	14 482	12 015	12 248	171 996	174 499	175 815
0	2%	2%	2%	0.2%	0.6%	0.6%
> 0 to < 2000	44%	42.7%	42.6%	4.9%	4%	4.1%
2000 to < 4000	17.1%	15.7%	15.8%	4.8%	3.6%	3.6%
4000 to < 8000	13%	12.4%	12.5%	6.7%	5.3%	5.4%
8000 to < 15000	7.5%	8%	8%	7.1%	6.4%	6.5%
15000 to < 25000	4.4%	4.9%	4.9%	7%	6.4%	6.4%
25000 to < 50000	4.4%	5.1%	5.1%	11.7%	11.1%	11.2%
50000 to < 100000	3.3%	3.9%	3.8%	15.4%	14.7%	14.7%
100000 to < 250000	2.8%	3.4%	3.4%	20.5%	21.4%	21.3%
250000 to < 500000	0.9%	1.2%	1.2%	9.9%	11.7%	11.6%
500000 or more	0.4%	0.7%	0.7%	11.8%	14.6%	14.6%

This table underscores the scale factor in the uptake of Precision Agriculture technologies. At the beginning, only larger farms were able to buy guidance devices and amortize them in a profitable manner. By today, these PA technologies start to spread across the 100 ha farm holdings segment. Meanwhile, there is a clear bottleneck for the farm segment below 100 ha with an income below 25,000 EUR. For these farms it is still difficult to access P.A. technologies in a profitable way, unless they are on a niche production. Consequently, less than 25% of the EU farmers have access to Precision Agriculture technologies.

Any support from the EU CAP for supporting the dissemination of these technologies would significantly help to reduce the scale factor. The scale factor is critical and was recently addressed in the debate, which followed the presentation to the AGRI Committee of a STOA study on Precision Agriculture and the future of farming in Europe on August 30th [5]. On this occasion:

"MEP Maria Noichl (S&D, DE) argued that small scale farmers cannot keep up with these technological challenges. How do they invest in this, she asked. She pointed out that larger farms can probably manage. In terms of Professor De Baerdemaeker's statement of producing more with less, she stated that this is only partially possible. Pretending that because one uses less energy is something that does not add up. She asked about the broader cost expenses and equipment. She asked whether they really think this is feasible for small scale farmers"[6].

5) A study supported by CEMA's experts who contributed to the STOA workshops linked to the study. 6) Dods Monitoring Alerts for 31/08/2017.

Professor Josse De Baerdemaeker of the University of Leuven, rapporteur of the STOA study answered: *"Small farmers have been a major concern. What would happen if one just sits back and let things go? How will agriculture look like in 15-20 years?"*[7].

It is obvious that if no appropriate action would be undertaken to improve the uptake of PA technologies for the farms below 100 ha (97% of the EU farms) it will be extremely difficult for them to compete with US, Canada and New-Zealand and even EU larger farms, which massively invest in P.A. technologies. Not only smaller EU farms will lose competitiveness, but they will also be unable to cope with the Greening targets of the CAP and EU environmental policies.

In CEMA's views, P.A. technologies are one of the most efficient tools to improve sustainability and productivity.

1.2. Precision Agriculture & Sustainability

According to the most recent Sustainability Journal study, funded by the European Commission Joint Research Centre (JRC)[8], agriculture is a major source of GHGs liable for climate change:

"The major GHGs produced in the agricultural sector are methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2). CH_4 is mainly produced from the anaerobic decomposition of organic matter during enteric fermentation and manure management, but also from paddy rice cultivation; N_2O arise from the microbial transformation of N in soils and manures (during the application of manure and synthetic fertiliser to land) and via urine and dung deposited by grazing animals; and CO_2 arising from: (i) energy use pre-farm, on-farm and post-farm; and (ii) from changes in above and below ground carbon stocks induced by land use and land use change. The agricultural sector contributes to the production of 25% of CO_2, 50% of CH4, and 70% of N_2O emissions in a global basis summing up to nearly 13.5% of the total global anthropogenic GHG. The application of precision agriculture (PA) practices, using the large reservoir of Precision Agriculture Technologies (PATs) in agricultural field operations could positively contribute to GHG emission reduction due to: (i) the enhancement of the ability of soils to operate as carbon stock reserve by less tillage and reduced nitrogen fertilization; (ii) the reduction of fuel consumption through less in-field operations with the tractor (direct GHG decrease); and (iii) the reduction of inputs for the agricultural field operations (indirect GHG decrease)"[9].

7) Ibid. 8) Sustainability Journal, MDPI Study, Precision Agriculture Technologies Positively Contributing to GHG Emissions Mitigation, Farm Productivity and Economics. 9) Ibid.

As we understand, GHG production is not predominantly related to the size of the farm holdings and, as shown in figure 2, EU farms with an area smaller than 100 ha represent almost the half of the total utilised agricultural area (48%). With this figure in mind, it is difficult to imagine that half of the EU agricultural area would be constantly improving its environmental performances while the other half would become less and less sustainable.

Producing less GHG with a maintained crop production or even an increased level, if we take into account the food security challenge, cannot be achieved with conventional practices. New P.A. technologies for all agricultural practices (ploughing, planting, fertilizing, spraying, harvesting) will be needed to ensure GHG mitigation in line with the EU 2030 climate and energy binding targets adopted in October 2014:

- At least 40% cuts in greenhouse gas emissions (from 1990 levels),
- At least 27% share for renewable energy,
- At least 27% improvement in energy efficiency

Beyond the GHG binding targets, society wants more sustainability to justify the CAP payments. P.A. technologies offer solutions to produce more with less and enhance food security and safety. Practically, PA technologies provide farmers with extra sensors which give them more information on how to manage natural variations like weather conditions, pests, insect and fungal infestation.

The most visible environmental benefits of PA technologies are:

- Preventing ground water pollution by optimizing manure and chemical spraying,
- Reducing fresh water withdrawals with precision irrigation,
- Limiting crop damages by responding rapidly and effectively to pest and fungal infestation,
- Allowing new type of polyculture.

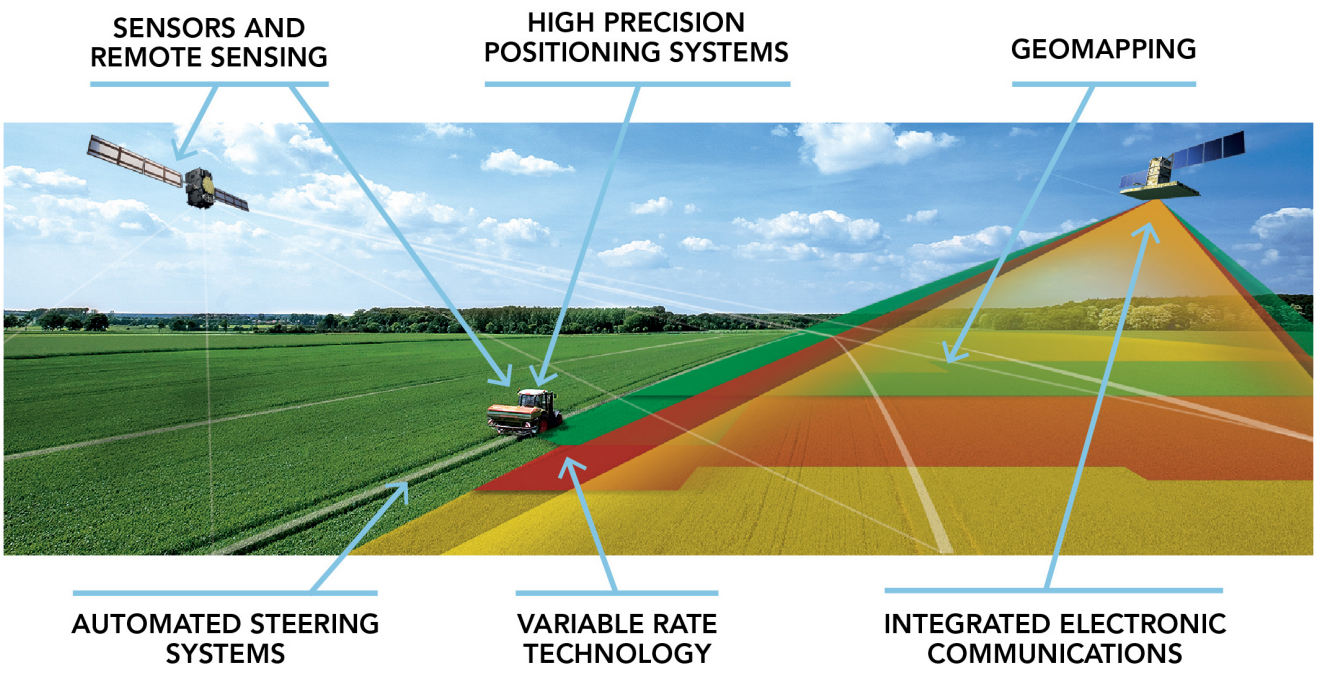
The latter is critical to stimulate biodiversity, noticeably for pollinators.

Some of these PA diagnostic technologies are already available to smaller farms thanks to smart phones or tablets and their applications. The application could directly signal a problem on the field or connect to an online service for further probing.

Pest-control is in, a certain way, even more critical for small-sized farms than for larger farms. Due to the way pests disseminate – from a spot to the entire field -, small farms have a shorter time to react and they face the risk to lose their entire crops, while bigger farms have somewhat more time to react and are also better equipped to limit the damages to a certain percentage of their crops.

Since Precision Agriculture has a proven positive impact on sustainability and profitability CEMA calls for the most fundamental PA technologies to be actively promoted by the next Common Agriculture Policy (CAP).

Figure 3: Key Precision Farming Technologies (Source: CEMA)

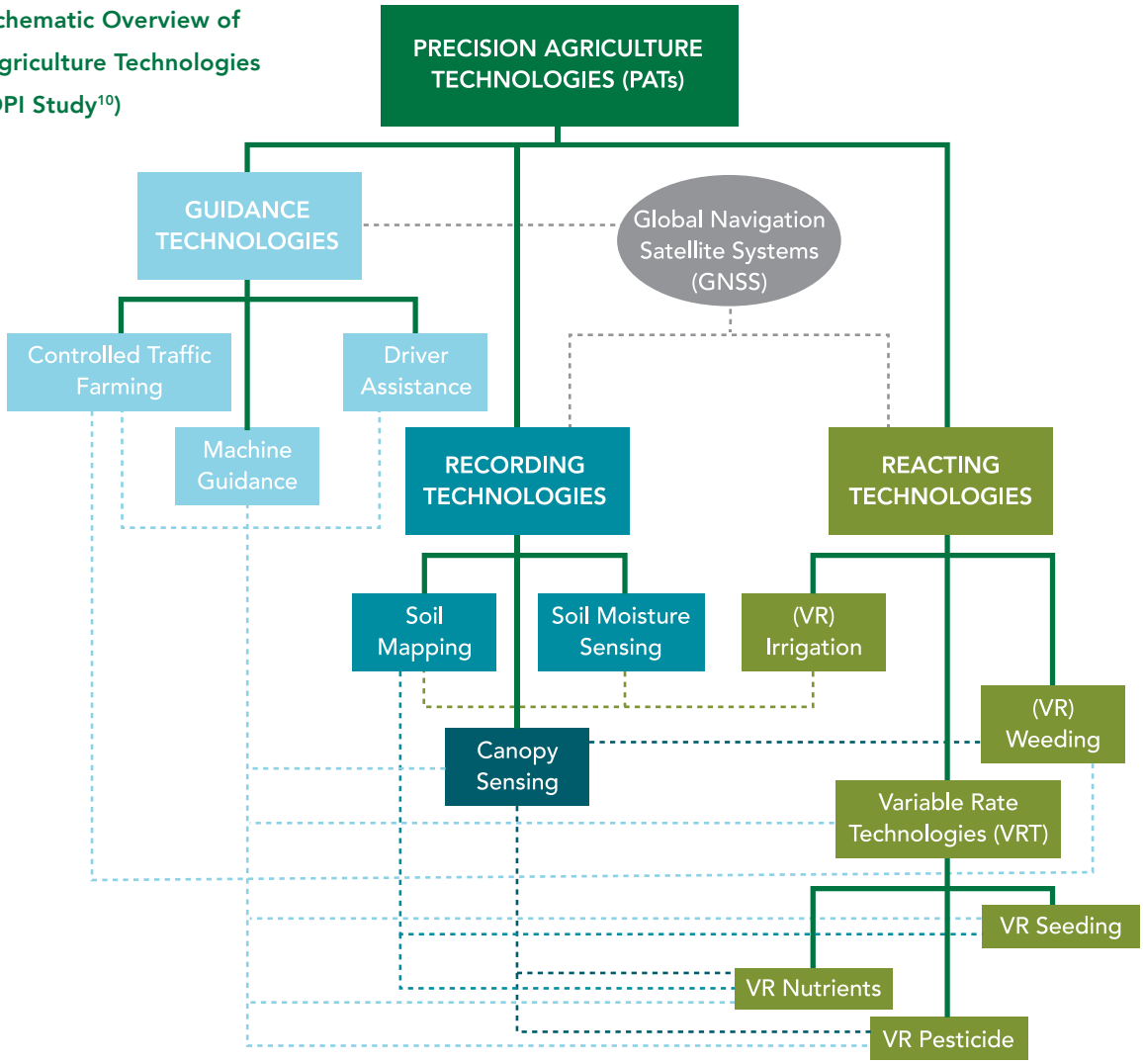


2. Precision Agriculture Technologies to Be Promoted by the CAP

2.1. Overview of Precision Agriculture Technologies

In its efforts to categorize PA technologies, the MDPI/JRC study comes to this graph:

Figure 4: Schematic Overview of Precision Agriculture Technologies (Source MDPI Study[10])



This graph is almost identical to CEMA's perception of what the generic and most fundamental P.A. technologies to be promoted by the CAP are. In CEMA's opinion these technologies could be divided in three categories:

1. Guidance Systems
2. Variable Rate Applications & Nutrient Sensing
3. Precision Livestock Farming (PLF) technologies

10) Op. cit., p. 6.

Each technology offers distinct advantages in terms of sustainability and profitability for all farmers.

2.2. Precision Agriculture Technologies to Be Promoted

2.2.1. Guidance Systems

Guidance systems form the generic backbone technology for Precision Agriculture. They can be used by all kinds of equipment (e.g. tractors, combine-harvesters, sprayers, planters…) and as part of a broad range of different agricultural applications. Guidance systems focus on precise positioning and movement of the machine with the support of a Global Navigation Satellite System (GNSS).

Figure 5: Functional Benefits of Guidance Systems

Guidance Systems enable:

- Automatic steering
- Precise machine movement between plant rows
- Precision drilling and sowing
- Precision spraying
- Mechanical weeding
- Field digitalisation

Field-mapping allows the creation of a very refined imagery of soil conditions. PA technologies have reached such a granular level that it is now possible to seed different plants simultaneously. For example, it is technically feasible to seed wheat and honey plants on the same ground so that each plant will grow at its own pace and will not impede each other's growth.

Figure 6: Digitalised Field & Precision Planting

Guidance technology maximise the machinery drive and substantially reduce overlapping during soil preparation.

Figure 7: Soil Preparation & Precision Headland-Turns

GPS technologies also enable Precision Harvesting.

Figure 8: Precision Harvesting Supported by Guidance Systems

An American study[11] showed that guidance systems with an accuracy of less than 2.5cm are needed for larger farms while GPS systems with less than 10cm inaccuracy are a viable alternative for smaller farms.

11) Bergtold, J.S.; Raper, R.L.; Schwab, E.B. The Economic Benefit of Improving the Proximity of Tillage and Planting Operations in Cotton Production with Automatic Steering. Appl. Eng. Agric. 2009.

The most tangible benefits of Guidance technologies are:

- Minimising overlapping by increasing pass-to-pass efficiency leading to lower fuel consumption (up to 10% less fuel consumption)
- Reduction of all agricultural inputs (seeds, herbicides, pesticides, fertilizers…)

Auto-steered systems have also a positive impact on farmers work and fatigue. A paper study from Jordan M. Shockley, Carl R. Dillon, and Timothy S. Stombaugh (2011) show that the potential benefits of auto-steer not only include reduction in overlap but also an increase in field speed and length of operator's work day:

"For the sprayer, it was assumed field speeds increased 20% for preplanting applications and 10% for post-planting applications. An increase in speeds were assumed because of the abilityto drive faster during headland turns and the ability to quickly determine which row to enter to continue operating. Speed increases of 5% for planting and 10% for both fertilizer application and stalk shredding were also assumed (Stombaugh, 2009). With the above benefits of both auto-steer systems quantified, a percent multiplier was computed and implemented to calculate the new field capacities for the appropriate machines and the reduction in the impacted input costs. Only the reduction in overlap and inward drift was considered for calculating the multiplier for reduced input costs. In addition, suitable field days were altered to represent the adoption of auto-steer by increasing the operator's workday from 13 hours to 15 hours. This was attributed to the ability of the operator to work further into the night with less fatigue"[12].

Figure 9: Auto-Guidance Helps Farmers to Avoid Overlaps Caused by Human Error or Fatigue

12) Jordan M. Shockley, Carl R. Dillon, and Timothy S. Stombaugh, A Whole Farm Analysis of the Influence of Auto-Steer Navigation on Net Returns, Risk, and Production Practices, Journal of Agricultural and Applied Economics, 43,1(February 2011):57–75

According to other studies, auto-steering devices can benefit farmers by reducing working hours by 6% for all main crops[13].

In line with the above, it is evident that guidance systems have a positive impact on:

- Reducing farm-related GHG emissions and other pollutants,
- Boosting the profitability and productivity of farm holdings, as less inputs and less work is needed for maintaining, or even increasing, yields levels.

Arguably the only disadvantage farmers associate with guidance systems are their up-front costs. Machine guidance implies significant costs depending on the level of accuracy, the type of equipment and the options associated with it. According to Balafoutis Beck Fountas, Vangeyte & al. (2017) the cost for guidance systems starts from 1,300 € and can reach up to 40,000 € if equipped with a fully automatic steering and recording device.

2.2.2. Variable Rate & Nutrient Sensing Technologies

A) Variable Rate Technologies (VRT)

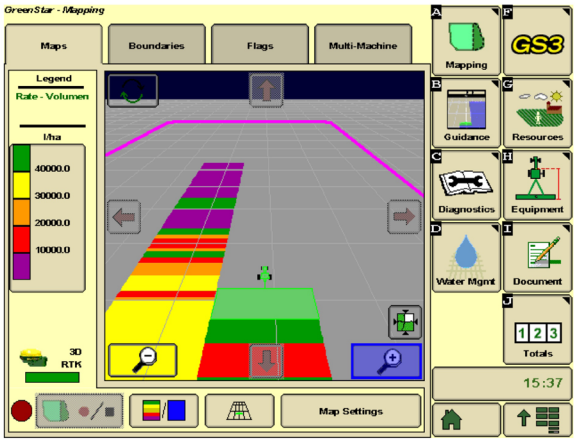
Variable rate technologies (VRT) or variable rate applications (VRA) have features that allow to vary the rate of the application to the specific needs of the plants, which depends for instance from the yield variability, within the same field, as shown on the map below.

Figure 10: Winter Wheat Yield Map Example, Netherlands, 2014 (Source: courtesy of CEMA member)

13) MDPI Study, op. cit.

Once the field is Geo-referenced, prescription can be used for variable rate application:

Figure 11: Geo-Referenced Fields (Source: courtesy of CEMA member)

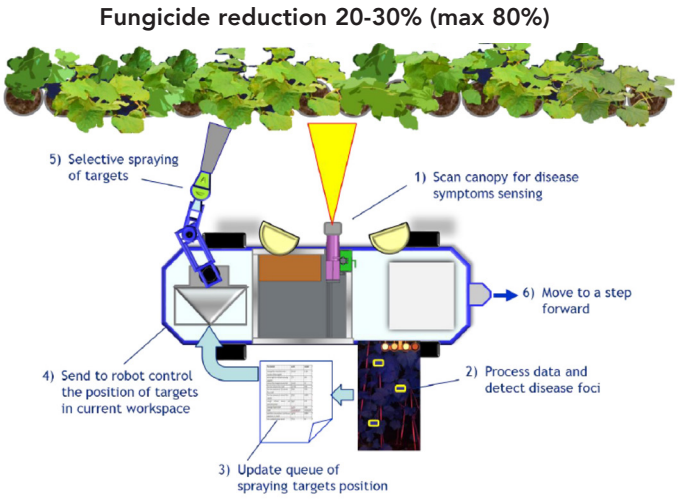


VRA technologies are mostly used for spraying:

- Water
- Pesticides
- Herbicides
- Fungicides
- Inorganic and manure fertilisers

Selective spraying is possible if a disease sensor and a controller are available with the VRA system, as shown in the graph below:

Figure 12: Selective Spraying for disease control



Source: Professor Josse De Baerdemaeker, STOA study, Precision agriculture and the future of farming, presentation made at the European Parliament, August 30th, 2017

The technology presented above allows from 20% up to 80% fungicide reduction. It is a major characteristics for all variable rate technologies:

- For herbicides savings could be in the range of 20-30 % (Kempenaar et al., 2014),
- For inorganic fertilizers savings could reach 40% (MDPI 2017) with a major impact on GHG emissions:

"Technology advancement has decreased total GHG emissions from 7.9 tCO2-eq/t AN-N to a level below 3 tCO2-eq/t AN-N, which can be achieved by adopting de-N2O catalyst systems that reduce N2O emissions from nitric acid production using catalytic systems that break down N2O under high temperature into harmless nitrogen (N2) and oxygen (O2). These systems are being fitted to many nitric acid plants and virtually all operating plants in Europe had abatement systems since the mid-2010s. An example of the effect of de-N2O catalyst systems is the respective GHG emissions from wheat production at the economic optimum N fertilizer application rate that is significantly reduced by about 40%, from 2.55 tCO2-eq/ha to 1.6 tCO2-eq/ha"[14].

B) Nutrient Sensing Technologies

Among the member states and EU regulator, there is an increasing concern about the use of fertilizers. Their primary concern is water quality. Phosphorus surpluses has a proven negative impact on freshwater resources such as rivers, streams and lakes. Regular additions of phosphorus to surface freshwater resources increases algal growth damaging the marine life and rises the cost of water treatment. Excess nitrogen in drinking water can put children's and young livestock's health at risk. Excess nitrogen in rivers clearly contribute to the degradation of marine life in various coastal areas like Bretagne (France), Belgium, Netherlands, Denmark and the UK.

Figure 13 shows the estimated nitrogen surplus for the year 2005 across Europe. Surplus nitrogen in the soil is a result of excessive application rates and/or low plant uptake.

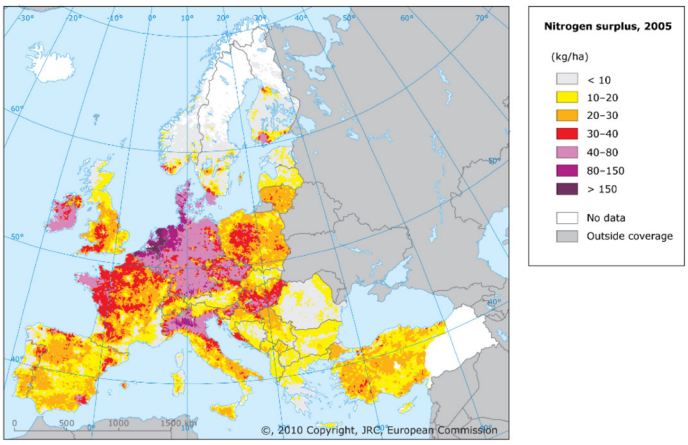


Figure 13: Nitrogen Surplus across Europe, 2005 (Source: JRC, Bouraoui et al., 2009)

14) MDPI, op. cit.

In this table we can also see that nitrogen surplus is not distributed equally in Europe. Obviously there is room for implementing better nutrient management schemes and using manure as an alternative fertilizer to mineral fertilisation. Until now, the technical challenge was to transform manure from waste to valuable organic fertiliser. One the reasons being the variance of nutrients in manure:

"Successfully using manure as a fertilizer requires assessing the available nutrients in manure, calculating the appropriate rate to provide the needed nutrients to the crop and applying the manure uniformly across the field at the target rate. Efficient use of manure as a fertilizer is complicated by the imbalance of nutrients in manure, variability in many sources of manure"[15].

In a near past, success of manure fertilisation was up to chance. No manure sensing technology, to precisely apply the slurry with a nutrient target and limit rate in kg/ha was available. When tested the liquid manure ingredients show high levels of variance between different manure types, between different types of storages and even in the same tank load. The following table shows and example of the level of nutrient variability that is occurring based on more than 4000 measurements per second of hog manure in one tank load.

Figure 14: Manure Variability

Ingredient	Average (kg/ton)	Standard deviation	High value	Low value	Range
Dry matter	8.79	2.33	15.4	1	2 - 9.6%
Ntotal	6.83	1.44	10.36	1.77	3 - 5.9%
NH4N	3.69	0.76	6.71	1.13	1.8 - 4.5%
P2O5	4.47	1.13	7.8	0.3	1.3 - 3.5%
K2O	4.95	1.7	8.5	1.4	2 - 7.3%

Source: PDK, Netherlands, 2014

15) Using manure as a fertilizer for crop production, John A. Lory and Ray Massey, Associate Professors of Extension, University of Missouri; Brad Joern, Professor, Purdue University, published by EPA, 2006.

Nowadays, nutrient sensing technologies automatically control the desired nutrient application rates on the go as accurately as never before. These technologies combined with VRT and nutrient management definitively contribute to a more sustainable and profitable agriculture with the following benefits:

- More precise application of both organic and mineral fertilizer
- Optimization of nutrient balance (by field and within fields) during complete growing season
- Real time information on supplied-, received- and applied nutrients
- Manure applied based on actual NPK values (kg/ha) i/o volume (m3/ha)
- Variability of manure nutrient ingredient contents fully compensated
- Easier & better agronomic decision support & documentation
- Maximize crop yield potential with environmental protection
- More sustainable crop production & soil fertility management

Total cost savings linked to manure sensing technologies are in the range of 0.50 €-1.66€/m³ including labour time, machine cost, mineral fertilizer input, manure documentation and analysis in laboratory[16].

Figure 15: Precision Manure Sprayer Equipped with Nutrient Sensing Technology

Source: courtesy of CEMA member

Variable Rate and nutrient sensing technologies can substantially contribute to the environmental policies implemented in the European Union to decrease nitrogen emissions from agriculture, noticeably the Nitrates Directive of December 1991 which aims to reduce nitrate leaching from agriculture and focusing on groundwater containing more than 50 mg/l of nitrates.

16) Source: http://www.agrarmarkt-nrw.de/duengermarkt.shtm, 19.09.2013. 17)The nitrates directive, European Commission, http://ec.europa.eu/environment/water/water-nitrates/index_en.html/

This directive also sets limits for fertilizer application (mineral and organic): *"Taking into account crop needs, all nitrogen inputs and soil nitrogen supply, maximum amount of livestock manure to be applied, (corresponding to 170 kg nitrogen /hectare/year)"*[17].

For all the motives analysed above, CEMA's is of opinion that guidance systems, variable rate and nutrient sensing technologies are the most critical technologies to be promoted by the next CAP, so that they can be accessible to all farms.

2.2.3. Precision Livestock Farming (PLF) Technologies

PLF technologies include a wide variety of machines, farm management systems and other devices used for livestock farming. They range from advanced feeding systems to cleaning and milking robots. Technologies like these are available and beneficial for all types and sizes of farms. In the last years these technologies have progressed rapidly and now have proven benefits for the environment, animal welfare and farmers' competitiveness.

3. CAP Reform & Improving Access to Smart & Precision Agriculture Technologies

In its second contribution to the debate on the CAP's future, CEMA proposed new concepts for supporting sustainability through a sustainable productivity bonus[18]. This approach remains broadly valid but needs to be adjusted to the farm size.

3.1. Adjusting the Sustainable Productivity Bonus to the farm Size

3.1.1. Farms < 50 ha

These farms represent about 30% of the EU utilised agricultural area and 93% of the total EU farm holdings. Most of them don't have any access to precision agriculture. For this size of farm proposes to make them eligible to the measures mentioned above: a dedicated subsidy for investing in basic PA technologies or a voucher for using contractors services.

18) Gilles Dryancour, Towards a New Strategic Agenda for the Common Agricultural Policy (CAP) after 2020 CEMA's contribution to the debate on the CAP's future: new concepts for supporting sustainable productivity, CEMA, Brussels, March 2017.

In addition, CEMA proposes for this size of farm to create a special voucher for buying small-scale communication technologies with agricultural applications, like smart phones, tablets, computers able to i) take pictures of plants and interpret crop health (through the application or the cloud), ii) access market data (commodity price, futures), iii) online training, iv) expert management systems, v telematics. This special and annual voucher for lower-scale technologies could be in the range of 500-750€.

3.1.2. Farms 50 – 100 ha

These farms represent about 15% of the EU utilised agricultural area and a little bit less of 4% of the total EU farm holdings. From CEMA's perspective, they are in a grey area as for the access to P.A. technologies. The most profitable farms in the upper segment of this category might have access to some basic P.A. technologies (most probably guidance systems) but certainly not to all of them.

For this reason, CEMA proposes a two-tier system for this category of farms. They could either go for the Sustainable Productivity Bonus as described above or apply for a Smart Technologies dedicated subsidy or voucher.

CEMA estimates that a dedicated subsidy ranging between 6,500 and 7,000 € should be suitable to cover the basic PA needs of the EU farmers of this size category. In order to keep the market properly functioning, it is recommended that the dedicated Smart technologies subsidy could be used either for investing in advanced technologies or renting the services of a certified contractor/cooperative equipped with these technologies.

In case of a direct investment, it is suggested to allocate an annual subsidy based on the normal depreciation period of the purchased technology, i.e. 7,000 € / 5 years = 1,400 per year. This will help farmers and their credit partners to secure the financing of these technologies.

If the farmer would be using a cooperative's or contractors' services it is proposed to issue a smart technologies voucher to the farmer to be released by the contractor. The amount of the annual voucher would be calculated on a given percentage of the total cost of the service representing the P.A. part of it. This second option is essential to guarantee the dissemination of smart technologies by cooperatives and contractors. Both play a critical role in modern farming, remarkably regarding shared farming.

Logically the use of the dedicated subsidy or the voucher will not automatically grant the eligibility to the direct greening payments.

3.1.3. Farms >100 ha

In 2017, these farms represent about 53% of the total EU utilised agricultural area and 3.5% of the EU total farm holdings. A majority of these farms have at least access to one the fundamental P.A. technologies identified in this paper (Guidance Systems, Variable Rate or Nutrient Sensing Technologies). For these farms the sustainable productivity bonus put forward would still apply and would practically work this way:

"Farmers investing a given percentage of their revenue in certified sustainable technologies will automatically be eligible to the Greening direct CAP Payments. Optionally, EU farmers who would not reach this percentage could still use the traditional greening CAP scheme"[19].

As pointed out in the CEMA March position paper, other certified smart technologies could potentially be eligible to the sustainable productivity bonus, like: Big Data, the Internet of things, smart devices smart-phones, tablets, software, applications, embarked computers, unmanned systems, drones, robots, autonomous machinery and so forth…

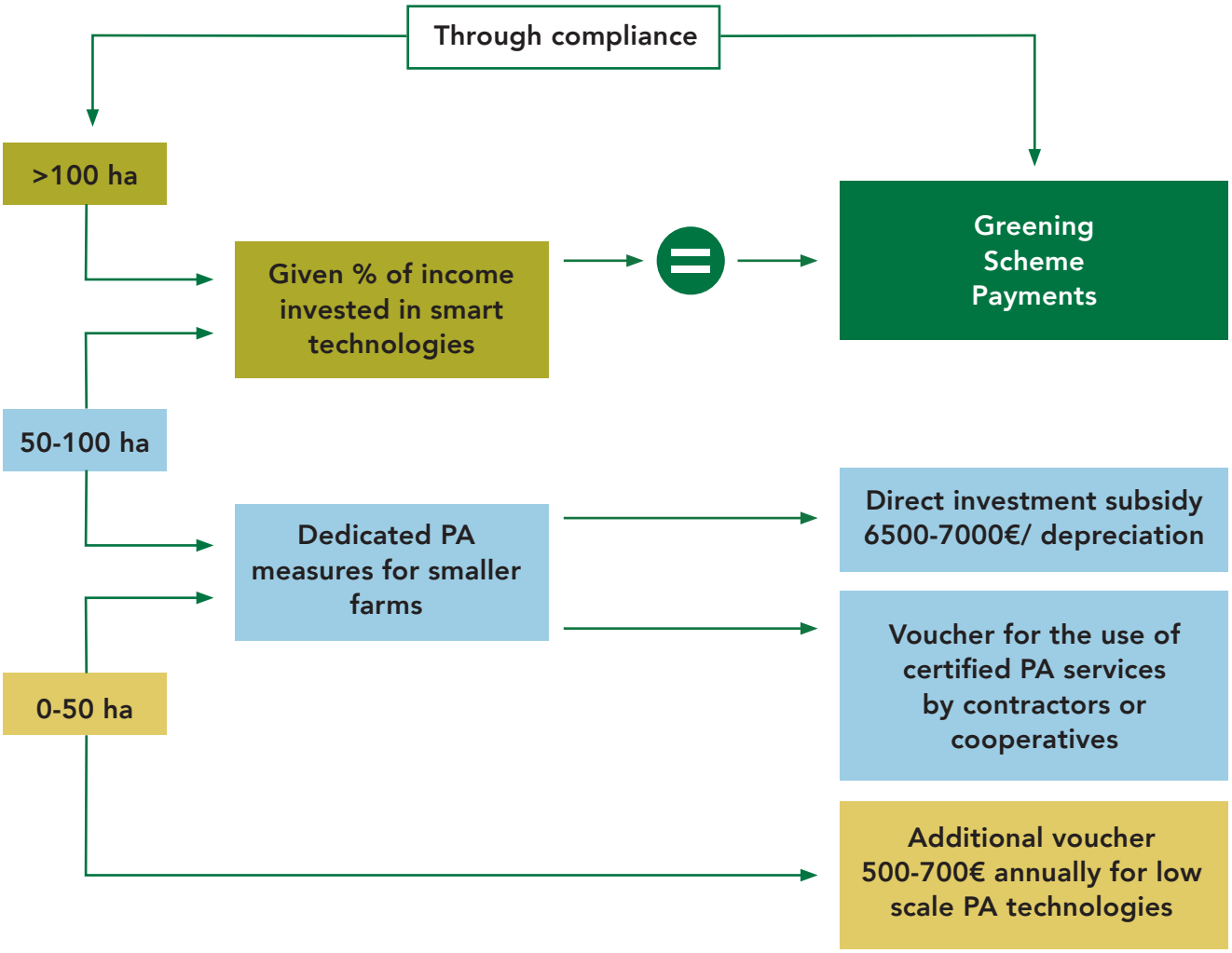
As CEMA also suggested, in order to avoid unnecessary administrative costs and extra burdens for the EU farmers, the manufacturers and producers should be able to self-certifying the sustainable technologies they offer to EU farmers.

3.2 Towards a 3rd CAP Pillar focused on Sustainability & Smart Technologies

All the measures above plead for the setting-up of a 3rd CAP Pillar for which the Greening Direct Payments will be the corner stone. This 3rd Environmental Pillar would function as described in the figure on the next page.

19) Ibid.

Figure 16: Proposals for a new 3rd Pillar in the CAP



About the author

Gilles Dryancour is honorary President of CEMA having served as President of the Association from 2009 until 2014. He is also Chairman of CEMA's Public Policy Group (PPG).

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