#7773 THE STATUS OF PRECISION AGRICULTURE AND ITS ADOPTION IN MOROCCO

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ABSTRACT

In Morocco, agriculture represents a major economic sector and has known important changes in the last two decades. Nevertheless, despite the many efforts to improve the agricultural environment and boost productivity, precision agriculture (PA) practices are still in their embryonic stage. Factors affecting PA onset and adoption are multiple, among which (i) the dominance of smallholder farming and the structure of the farms, (ii) the level of farmer's education, perception and ability to use new technologies, (iii) the affordability of relevant information and specific equipment required, (iv) the lack of training and extension regarding PA, (v) the limited number of PA service providers and their high service cost, (vi) government restrictions on the use of drones for PA purposes, (vii) limited support in previous government strategies for hard PA technologies. PA in Morocco did not reach yet to the level of "adoption", but still at the level of "presence". Most farmers are not well informed about PA and its benefits. Few tentatives of soft PA have been initiated in the past but did not attain satisfactory momentum. Soil testing, as a basic classical example for soil fertility assessment and nutrient management, was promoted and subsidised for a long time, but is remain limitedly adopted by farmers on a large scale. Precision irrigation, a vertical approach in precision farming, is an exception that has known particular expansion in Morocco as a result of the efforts by the government for promoting drip irrigation with regard to water scarcity, yet meriting innovative and adapted technologies, especially for small farmers. Sensing-based assessment of soil properties and crop monitoring (drone carried sensors, soil scanners) were recently introduced, but are still in a trial process and their cost is very discouraging, even for large commercial farms. Free online platforms providing vegetation indices are just being discovered and explored by few curious farmers and used to experiment making adjusted nutrient rates (even without adapted equipment). The implementation of digital technologies by the sugar industry for affiliated farmers for sowing, input use, yield monitoring and traceability is a recent success story that merits to be extrapolated to other industrial crops. The present paper raises questions about the factors that delayed the presence and adoption of PA in Morocco and provides insights of its future development.

Keywords: precision agriculture, adoption, developing countries, Morocco

INTRODUCTION

PA, as an integrated crop management system that uses various tools and technologies for assessing and monitoring soil and crop spatial variability and for implementing site-specific applications, is considered nowadays in many developed countries a common practice rather than an innovation. On the contrary, in most developing countries, agriculture is still struggling with the basics of farming, and is constrained by many factors, such as land tenure and farm structure, low inputs use, limited farmer's knowledge, weak extension service and undeveloped markets.

Agriculture, like other industries, is evolving towards a knowledge-based direction. Its development and competitiveness will be highly driven by new technologies. In most developing countries, increasing productivity on small-scale farms is of priority concern and is critical for food security. However, the delay in the introduction, promotion and adoption of new technologies will enlarge the time gap and leave these countries way behind. PA has known a good emergence and a rapid spreading in the USA since late 80s, and has also known in recent years a good take-off in several other countries in Europe, Latin America, China and Australia (Tey and Briandal; 2012; Silva et al, 2015; Kendal et al. 2017, Lowenberg-DeBoer and Erickson, 2019). However, in Morocco, as in similar developing countries, PA is still poorly known, if not unknown at all, among farmers and even among a large community of professionals and decision makers.

PA in Morocco

Morocco is a country of which the economy is tightly related to agriculture. Although small holder farms are dominant (about 65%), medium and large size farms play an important role in driving the changes in farming systems and in adopting new technologies. Past government agricultural strategies focused on various segments such as crop diversification, improved input use, adoption of machinery, water management (large infrastructures and in-farm systems), access to financing, etc. Conversion to drip irrigation was among the main targets, especially with regard to water scarcity. Although the 'Green Morocco Plan' included multiple actions to boost Moroccan agriculture, the promotion of new technologies, such as PA, was timid. The new 'Green Generation Strategy 2020-2030' explicitly addressed such a dimension and is intended to give particular attention in the future to PA and other digital technologies.

To some extent, small farmers have been practicing insentiently various forms of soft PA techniques for a long time. Varying seed and fertilizer rates on slope lands, adjusting manure applications to poor field areas, adapting irrigation water to soil texture, etc. are examples of such use. However, these practices are not to the level of technology and advancement to catch-up with the rapid development expected for a modern agriculture.

Soil testing can help implement appropriate site-specific fertilizer applications if soil sampling takes into consideration within-field zoning and among-field differences. Soil testing has been subsidized (50%) and promoted since early 90s. However, its adoption by farmers remained very limited, until recent years. Despite the overlooking of infield spatial variability required for PA, soil testing remains a good tool for optimizing fertilizer use and increasing productivity.

PA is applied to some extent in high-value crops such as orchards and vignards. Farms with several fields are managing fertilizers and irrigation according soil heterogeneity, varieties, age, expected yield, etc. Within field variability is sometimes taken into consideration and site-specific applications are implemented with available means. Examples include field patches with high pH and high lime causing micronutrient deficiencies, for which site-specific soil application or foliar sprays are used. Segmenting fields for drip irrigation allows variable rate (VR) irrigation (and fertigation) according to crop requirement at various growth stages. This is often automated as the cost of irrigation packages are becoming affordable with government incentives. A smartphone application (IrriSmartOne) was developed recently by a team from the National School of Agriculture to help farmers better manage irrigation water and engage widely in the practice of precision irrigation.

At a large-scale mapping, soil fertility assessment was recently implemented over 7 million ha of arable land by a joint public-private partnership. This project enabled developing a country-wide reference soil fertility database, generating spatial variability maps of selected soil parameters, and developing an online DSS platform (fertimap.ma) to help farmers and

extensionists make sound fertilizer recommendations for specific crops. Although this project is considered a valuable tool, the coarse resolution of the data does not reflect in-field spatial variability which is the foundation for PA.

In Morocco, PA application in its technological concept is still at an embryonic stage. It is not yet to the level of "adoption", but still to the level of "presence". Most farmers are not well informed about it and about its benefits. Few tentatives of soft PA have been initiated in the past but did not reach satisfactory momentum.

The main manufacturer of white sugar in Morocco (Cosumar) engaged in a farmer aggregation process to provide technical and financial support and guaranty the absorption of production. Since 2019, they digitally registered about 80000 farmers to undergo real time monitoring of agricultural practices (sowing, input use, irrigation, etc.), crop growth and yield, as well as the planning of harvest and flow to sugar factories. Soil testing is performed for all farmers and adapted fertilizer recommendations are provided. PA in this example is considering variability among clusters of farmers rather variability within-field.

Sensing based proximal tools using different technologies (contact resistivity, infrared reflectance, passive gamma-ray spectroscopy, etc.) were recently introduced by a couple PA service providers and are in the phase of trials and demonstration in few large commercial farms. These sensors (if well calibrated using soil testing data) have the advantage of providing rapid, direct or indirect, assessment of some soil properties and delivering spatial variability maps for quick PA use. However, their adoption has been delayed by several factors, mainly, their high cost, the required knowledge for information handling, and the unavailability of variable-rate-equipment to implement site-specific nutrient management. Al-Moutmir program of the OCP group recently introduced the SoilOptix tool and is conducting multiple trials in small farm to demonstrate the use of such technology for fertilizer management.

Remote sensing information from satellites or drone-carried sensors, are getting popular among farmers. Free online platforms providing vegetation indices (VI) are being explored by few curious farmers to experiment crop monitoring and make adjusted nutrient rates. The example of the 'Onesoil' platform offers reasonable spatial (10m) and temporal (5 days) resolutions NDVIs and generates map files that can be used for VR applications. However, to our knowledge, only two farms in Morocco have GPS guided tractors and VR equipment, and therefore, the use of such platforms remains limited to an overall crop monitoring. Drone flying is subject to very strict licensing in Morocco and therefore remains of limited use.

Although yield mapping using yield monitors have been increasingly used in several developing countries (South Africa, Turkey and Mexico), this practice is still absent in Morocco from both machinery and farmers perspectives.

Factors Affecting PA Onset and Adoption in Morocco

The attitude of farmers towards any new technology is strongly driven by the benefits that this technology can provide, mainly increasing profitability with reasonable investments (financial, technical, time & efforts). The net return of any PA technique should offset the costs of dedicated/necessary equipment and software, information and data processing, knowledge upgrade, trained personnel, related services, etc. The question often postulated: '*Is it worth the hassle*'. The logic in this process will differ among farmers, depending on various factors especially linked to their socio-economic and cultural context.

A rapid and unstructured survey with a short list of farmers and professionals revealed that the main factors behind the limited onset and adoption of PA, in its technological concept, are the following:

- Lack of awareness and information: at the level of the farmers, professionals and extensionists

- Perception: PA has been perceived as a practice that requires highly advanced knowhow, hard technologies and heavy investments
- Farm structure: small size and fragmentation of farms (fields) are not in favour of in-field variability-based PA
- Level of education: PA requires a minimum level of training and ability to use computers, process and manage data, understand and manipulate RS information, use smart-apps, etc
- Cost of equipment: packages required for PA (data, equipment, software, etc) are still expensive even for commercial farms. Soft tools are still not available on the market with reasonable prices
- Cost of PA services: only a few service providers are present and their services are expensive and not economically justified
- Constraints on the use of flying objects (drones): the use of drones is subject to severe restriction for use by farmers and service providers
- Lack of trained personnel: limited number of PA specialists
- Limited government support: PA has not received much attention in previous Ag-strategies

The Future of PA in Morocco

Various soft PATs have been used by small farmers in many developing countries and showed good promise even in traditional cropping systems (Cook et al., 2003, Mondal et Basu, 2009; Lowenberg-DeBoer and Erickson, 2019). The costs and benefits of using PATs are very complex (Thompson et al. 2018) and would require time to be demonstrated.

PA in Morocco can be promoted and implemented at various scales (spatial, temporal, equipment, etc.) by targeting key agricultural practices, low-cost tools, adapted decision support systems (DSS), extension, data availability, incentives (subsidies) for equipment acquisition, etc.

Future development of PA and its adoption in Morocco needs to take into consideration the local context, mainly farm size and fragmentation, level of education, limited financial means to invest in equipment and other related tools. Farms of less than 20 ha represent about 65% of arable land (20-100 ha: 25% and >100 ha: 10% only). In some regions with a high agricultural potential, PATs would be much easily perceived, implemented and more likely adopted.

PA actions need to be adapted to the various categories of farm holders (Table 1). The spontaneous initiatives need to be capitalized and used to bring new followers. Simple tools (leaf colour charts, handheld sensors, etc.) adopted in countries such as India and South Africa can be tested to help grasp the concept of in-field variability and the practice of site-specific interventions.

Table 1. Adapted PA technologies to different farmer categories

Small farms (soft PA)	• Simple soil and crop tests, free available remote sensing information, in situ observations field mapping-, low-cost tools and low cost adapted equipment for GNSS and VR applications; • Easy-to-use smartphone apps and DSS; • Farmer clustering (aggregation, cooperatives, etc.); • Incentives (subsidies) for equipment and related software
Medium and large commercial farms (soft and hard PA)	• Soil fertility mapping (intensive soil testing, proximal soil scanners, etc) • Remote sensing (free or via service provider) • Yield monitoring system, • GNSS and VRA equipment, • Advanced smartphone apps and DSS

Field demonstrations and pilot projects (by the extension services or business companies) can play a major accompanying role to show the usefulness and the added-value of PA, train leading farmers as early adopters, and expose other potential followers. To train specialists in PA and related information technologies, academic institutions need to update and tailor their curricula to offer adapted PA programs. Continuing education programs need to be developed for professionals willing to invest in PA tools and services. Relevant information on PATs should be made available to farmers and professionals through appropriate and operative channels (extension programs, social media, agri-fairs, media, etc). The international agricultural Fair of Meknes, visited annually by thousands of farmers and professionals, can serve as a platform for promoting PATs with the effective presence of the industry operating in this segment.

Despite the actual constraints, the future developments of PA technologies and equipment and their affordability, the availability of open-source relevant information, the competitivity among service providers, and the fostering of digital technologies are all factors in favour of better prospects for PA in Morocco. Internet development and the wide use of smartphones by farmers and extension agents would greatly help raising the awareness towards PA. The degree of future adoption will depend on several factors:

- Government support (including subsidies) and promotion of PA (concrete actions of the 'Green Generation' strategy)
- Change of perceptions for PA
- Availability and/or design of adapted strategies
- Market availability and affordability of technologies and services
- Increased presence of specialized service providers
- Farmer's organisation
- Training, extension and advisory for PA use
- Creation of business opportunities for PA technologies and services.
- Supporting research and development to develop adapted PATs and assess their feasibility and benefits.

The curve of PA adoption can be timely compressed to reduce the gap of PA development and engage in a rapid adoption with context-fitted solutions.

REFERENCES

Cook SE, O'Brien R, Corner RJ, et al. 2003. Is precision agriculture relevant to developing countries. Proceedings of the 4th European conference on precision agriculture, vol. 115–119. The Netherlands: Wageningen Academic Publishers.

Kendall H, Naughton P, Clark B, Taylor J, Li Z, Zhao C, Yang G, et al. 2017. Precision agriculture in China: Exploring awareness, understanding, attitudes and perceptions of agricultural experts and end-users in China. Adv. Anim. Biosci. 8(2): 703–707.

Lowenberg-DeBoer J, Erickson B. 2019. Setting the Record Straight on Precision Agriculture Adoption. Agronomy Journal 111(4): 1552-1569.

Mondal P, Basu, M. 2009. Adoption of precision agriculture technologies in India and in some developing countries: Scope, present status and strategies. Progress in Natural Science 19: 659–666.

Silva Antolini L, Scare RF, Dias A. 2015. Adoption of precision agriculture technologies by farmers: A systematic literature review and proposition of an integrated conceptual framework. International Food and Agribusiness Management Association Conference. St. Paul, MN, 14–17 June 2015 https://www.ifama.org/resources/files/2015-Conference/1259_paper_Antonlini_precision.pdf (Accessed November 2020).

Tey YS, Brindal M. 2012. Factors influencing the adoption of precision agricultural technologies: A review for policy implications. Prec. Agric. 13: 713–730.

Thompson N, Bir C, Widmar D, Mintert J. 2018. Farmer perceptions of precision agriculture benefits. J. Agric. Appl. Econ. 51: 142–163. doi:10.1017/aae.2018.27