A STRATEGIC APPROACH TO THE IMPLEMENTATION OF PRECISION AGRICULTURE PRINCIPLES IN CASH CROP FARMING

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ABSTRACT

Precision agriculture is one of the important agricultural technologies that can assist farmers and managers in promoting long-term success. Precision agriculture can help farm managers increase their management capacity, which is of utmost importance in the highly competitive modern agriculture. Increased yields and/or efficient input use can also be achieved with precision agriculture. Precision agriculture also involve a large capital outlay and requires skills in interpreting the masses of generated data. Modern farmers have to engage in pro-active thinking with regard to suitable agricultural systems that can enhance sustainable success of their farming businesses. Farm managers who are contemplating on getting involved in precision agriculture need to undergo a paradigm shift or a mind shift. This paper proposes a set of guidelines on how the process of implementing precision agriculture can be strategically approached in a holistic way.

Key words: Precision agriculture, Strategic approach, Farming, Farming success

INTRODUCTION

Precision agriculture is a technology that supplies farmers, managers and consultants with highly sophisticated and precise information to assist them in planning and strategic decision-making. Precision agriculture technology is one of the agricultural technologies that became available in the South African agriculture at a time when profit margins were becoming increasingly under pressure. In the free market economies such as South Africa, profit levels of crop farming operations are subjected to progressively more pressure every year due to the price: cost squeeze. Precision agriculture, a relatively new concept in South Africa, is one of the most important modern technologies that can assist farmers in their endeavour to achieve sustainable success of their farming operations.

There are different ways that can be followed in introducing precision agriculture technologies in farms, as well as in the identification of management zones (Zeilenga, 2004). These depend to a great extend on the methodology followed by the service provider advising the farming operation. Various methods have different time spans of implementation, and the cost structure involved also varies. The modern farmer needs to be informed about the pros and cons before venturing into precision agriculture. Farmers must not only be thoroughly versed with the precision agriculture technologies when considering adoption, but must also approach this decision in a holistic and strategic way. A strategic approach, developed by Nell and Napier (2005) is used in this paper to provide guidelines that farmers can follow in the process of becoming involved in precision agriculture technologies.

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Adopting precision agriculture technologies - A strategic approach

The plan of getting involved into precision agriculture should be approached in a holistic and futuristic way, thereby necessitating the strategic approach. Farmers considering to venture into the world of precision agriculture have to shift their management levels to a higher level of sophistication to be able to use the information available, and approach the technology strategically. This strategic approach entails a 11 step process that farmers or potential adopters have to engage in as an approach to analyse the suitable technology for a particular farming situation. This provides insight knowledge into the farming operation, in terms of physical, technical, economical and financial capabilities. Opportunities, threats, strengths and weaknesses of the business can thus be identified, and the intervention role of precision agriculture in reducing threats or exploiting opportunities can be determined.

The strategic approach as proposed by Nell and Ropier (2005) will involve the evaluation of the mission, vision, values and culture of the farming operation. Secondly, critical analysis of the external environment, the macro as well as the business will be conducted. This is followed by strategic analysis and identification of competitive advantage. Long-term goals will then be considered, as well as the main strategy that will ensure the realisation of the long-term goals. Short-term goals that are aligned to the long-term goals, and the corresponding functional tactics for their implementation will follow. Policies necessary for the implementation, the implementation process, and control of the implementation will conclude this strategic process.

Mission, vision, values and culture

Mission

The farm has to revisit its mission in order to determine how precision agriculture can aid in the realisation of this mission. If the mission is not already in place, it should be clearly defined for the same purpose. For instance, a farm with the following mission "A cash crop farm in the Northern Free State producing summer and winter cash crops with a holistic approach to utilise the natural resources in a sustainable way", has to find out where precision agriculture fits in. Can precision agriculture lead to an increase in yields of these cash crops and ensure sustainable use of resources with less environmental damage? If there is a positive response, precision agriculture can fit into this farming operation, but more strategic analysis is still essential.

Vision

With regard to the long-term plans of the farm, it has to be established how the implementation of precision agriculture technologies can lead to the realisation of the farm's vision. A vision of a farm can be: 'To improve the profitability of cash crop production to 15% return on investment (ROI)'. The present and future effects of the technology on the profitability of the farming operation have to be determined. Of the factors that contribute to profitability: the price of the output, the output, price of inputs and the inputs applied, which can be affected positively by precision agriculture? Precision agriculture has an effect of an increased output per management area and efficiency of input use (NRC, 1997; Lowenberg-DeBoer, 1997). It can therefore contribute to the achievement of the farm vision.

Culture

The culture of the farm has to be questioned. Is the culture of the farm to preserve the natural resources? Precision agriculture establishes the culture of environmental protection and sustainable use of resources. With precision agriculture, chemical inputs, the main environmen-

tal degraders are applied according to the requirements of the soil to ensure minimal surpluses that can damage the environment (Schilfgaarde,1999). If precision agriculture can contribute to keeping the culture of the farm, its adoption can have a positive impact on the operation.

External environment

In a turbulent external environment, good information is of utmost importance for the farm manager to make good decisions (Van Rooyen, 1998). A comprehensive investigation has to be made on all the aspects in the external environment that can have an effect on the progress of the farm. Opportunities and threats in the external environment have to be identified. New technology, particularly precision agriculture, can create both opportunities and threats for the farming business. Farmers that are abreast of the new technology have a competitive advantage and gain the benefits of first mover advantage (Bailey, 1997). Yields can be increased and/or inputs can be used more efficiently.

On the other hand, precision agriculture can pose threats. The increasing tempo of change in new technologies can result in obsolescence of equipment at its very early stage (Lowenberg-DeBoer, 1999). This uncertainty about the technological evolution, high purchase costs and the economic environment, can create uncertainty about the costs and benefits of the new technology amongst farmers. If benefits (positives) outweigh costs (negatives), precision agriculture can be a worthwhile investment. Both the macro and the business external environment have to be considered in the strategic evaluation of precision agriculture adoption.

Macro environment

Of the five macro environment facets namely; economy, politics and law, ecology and climate, social and cultures, and technology, only technology and climate will be attended to in this paper as the more relevant aspects. Precision agriculture is technology and the expected climatic outcomes have an effect on the functional application of precision agriculture.

Technology

Looking at the technological sector of the macro environment, precision agriculture is one of the important new technologies that can assist the farming operations in achieving sustainable success. The research done by Zeilenga (2004) indicates that there is a significant increase in average yield where precision agriculture was adopted. The results imply that precision agriculture has the potential to increase yields and enhance net returns. Precision agriculture has some risk reduction implications attached to it as it has the ability to reduce variability in growing conditions within the soil and yield of crops, and consequently net returns (Lowenberg-DeBoer and Swinton, 1997).

It was also found that the kilogram of nitrogen per ton maize produced increased in the first year of precision agriculture and showed a decline from year 2 onwards after the implementation of the variable rate technology (Zeiling, 2004). This indicates the efficient use of inputs as inputs are calibrated according to the management zones, with the likelihood of increased profits.

Climate

The short and long-term trends in the climatic conditions have to be taken into account in evaluating the adoption of precision agriculture. Different potential soils react differently to specific weather condition and have to be treated differently. If a La Nina year is expected, soils

that are characteristically wet and susceptible to drowning have be treated differently from other soils, or even put aside. If precision agriculture is not in place to do this, areas of possible problems may not be easily identifiable and treated accordingly. The same site-specific treatment can be awarded to areas highly sensitive to drought during El Nino years.

Business environment

Competitors, one of the aspects of the business environment have to be critically evaluated. More often, farmers venture into new technologies mainly to improve their competitiveness. Farmers have to determine whether the adoption of precision agriculture will increase their competitiveness relative to their competitors. In order to be successful and stay competitive, farmers have to know the yield potential of each hectare on their farms and aim to improve the productivity (Willemse, 2000). This information on yield potential can be provided by precision agriculture.

Internal environment

The internal environment is an important competitive leg as farmers can control it to some extent. Farmers have to have good knowledge of all the resources (workforce, management expertise, natural resources, production, mechanisation, information) on the farm thoroughly. Management must therefore identify strengths, weaknesses, successes and failures on the farm.

Farmers have to determine strong as well as weak points within their farming businesses in order to enhance or maintain their competitive advantage. Adoption of precision agriculture technologies can constitute a strong point to the business. Farmers that do not make use of new technologies cannot compete successfully with their counterparts who have the advantage of new technologies with their associated benefits. Agriculture is moving from commodity products to differentiated products, and precision agriculture can help farmers differentiate their products in various ways. An example is protein analysis available on a yield monitor that can assist farmers market high quality wheat at a premium. The information provided by precision agriculture can also facilitate documentation on how food was produced, thus differentiating the product from other non-documented products (Harris, 1997).

Sustainable success of the farming business depends on the precise knowledge of the different resources of the farm where soil is one of the most important resources to consider in analysing the strategies of implementing precision agriculture on a farm. Precision agriculture provides farmers with detailed information about their resources, particularly land potential. The farmer has to have good knowledge of the break even price and yield of all the enterprises within the farming business. With this information, it can be determined which particular fields or parts of the fields cannot be profitably tendered at a certain price and/or expected yield.

Strategic analysis and identification of competitive advantage

Having identified all the strengths, weaknesses, successes, and failures, the most important opportunities and strengths that can help create and strengthen a competitive advantage have to be identified. Methods that can be used to avoid threats and weaknesses that will have a negative effect on the strengthening of the competitive advantage of the farming business also have to be determined. The role that can be played by precision agriculture to fulfil this purpose has to be recognised. Opportunities created by the technology such as possibility of increasing yields, efficient use of inputs and differentiation can be exploited. The farmer can decide to follow the low-costs strategy or differentiation strategy from the advantages created by the

technology.

The information on the enterprise budgets can guide management in identifying ways to improve and strengthen the profit margins of the cash crop production. This information will assist management in deciding which areas to plant with each kind of crop and also whether specific lower potential areas must be planted at all.

Long-term goal(s)

The long-term goals have to be specified and the relationship between precision agriculture and the objectives have to be indicated. Will adoption of precision agriculture contribute to the achievement of the long-term goals? A long-term goal of increasing the return on investment (ROI) to 15% and return on equity (Re) to 18% in the next 3 years can be realised by improving yields through precision agriculture. Increased yields, efficient use of inputs and the likely consequent profit can aid management to pay off debt quickly, reducing the interest that has to be paid, thus increasing the return on own equity.

Main strategies (HOW)

The question HOW long-term goals will be achieved has to be answered by the main strategy. Referring to the long-term goal, the means of improving ROI and Re have to be sought. If it is decided that the principles of precision agriculture will be the major contributor to the long-term goal, it must also be decided HOW this technology will be implemented or phased into the business.

The following strategies are some of the ways currently used by farmers in South Africa when venturing into precision agriculture:

I. Using a yield monitor for three years, correcting obvious controllable soil characteristics, doing a full grid sampling over the whole field and starting to apply VRA technologies.

II. Using a yield monitor for three years, correcting obvious controllable soil characteristics, doing an intensive grid sampling in problem or specific high yield areas and then starting to apply VRA technologies.

III. Doing a full comprehensive grid sampling, correcting obvious controllable soil deficiencies and starting to apply VRA technologies as soon as the deficiencies are corrected.

IV. Firstly correcting pH in the first year by means of marking areas with the aid of a GPS, putting flags in the fields and as the tractor driver gets to the flags, the tractor is stopped, the VRA equipment settings changed manually and carrying on with the activity. In the second year, the farmer may adapt the current planter to vary inputs, and the following year or thereafter implement the whole VRA technology when the financial position of the farm permits (Zeilinga, 2004)

With the knowledge available to the farmers, a choice can be made whether to select only certain components of the technology such as variable rate fertilizer application or venture into a fully-fledged package of precision agriculture that encompasses VRA technologies (fertilizer, seed, pesticides, and herbicides), yield monitoring and mapping, and remote sensing.

Short term objectives and actions

Short-term objectives should be in-line with long-term objectives to contribute to the accomplishment thereof. At this stage, it must be decided WHAT will be done with regard to the implementation of precision agriculture, WHEN, and at which STANDARD, in order to ensure the achievement of the longer term goals. This is where the actions of implementation of precision agriculture have to be determined. A typical example of a short-term objective and actions necessary can be as follows:

WHAT - Grid sampling.

WHEN - July when the summer crops have been harvested.

STANDARD - One sample per four hectare.

Functional tactics

Production, marketing, financial, product development and research and human resources are the functional tactics that need to be attended to (Nell & Napier, 2005). The most important tactic is to determine whether the implementation of precision agriculture with variable rate technology (VRT) will have the desired financial results. Profitability of precision agriculture technology is the single most questioned aspect of the technology (Malzer, Mamo, Blee, Graff, Porter, Robert, Eash, Braum & Dikici, 1999), and it is important to determine the financial implications thereof. The following question are important to ascertain the financial implications of precision agriculture adoption:

V. Does the area under cultivation justify the investment in precision agriculture? Is there enough variability with the soil?

VI. Will the investment in precision agriculture improve ROI and Re?

VII. How will the investment be financed? Own funds or borrowed funds? Are the interest rates favourable?

VIII. Is further investigation or research necessary on the advantages (non-financial benefits) of precision agriculture to the farming business required?

Implementation policies

It is important to determine whether the farm policies allow the investment. There are rules, regulations and procedures within each implementation action, which need to be attended to before implementation can take place (Nell & Napier, 2005).

Human resources

It has to be established in time whether the workforce need further training on precision agriculture practices. According to Lowenberg Deboer and Erichson (2000), training costs for effectively implementing precision agriculture are often neglected by many farmers when planning to adopt this technology. Do the costs justify the investment? Are the training requirements in line with the labour policy of the farming operation? How will management deal with the results of labour saving due precision agriculture? Will there be a need to lay off some workers or will they be redistributed to other sectors of the farm? What are the policy implications?

Financial policies

Management has to determine whether there is enough capital available to purchase precision agriculture equipment, and how will it be financed. The financial policies of the farm such as the proportion of borrowed funds have to be considered in line with the required foreign capital to ensure that this policy is not violated.

Implementation

It is essential that at this stage everything should be set, so that decisions can be made about WHO is responsible for WHAT. If the decision is to start with yield monitoring, the farmer has start looking for the type of equipment needed for the harvesting process (combine harvester equipped with a yield monitor) and get specifications and prices of the equipment. The same should occur for VRT of input application by organising and getting hold of the necessary equipment. If it is decided that grid sampling will start, the service provider has to be approached to arrange the implementation of grid sampling.

Control

Control is essential to make sure activities are running smoothly and according to plan. Yield monitoring can serve as a control mechanism to determine the productivity of each area of land relative to the expected yield. The results obtained from monitoring the yield should be evaluated after harvesting. Management should also make use of simultaneous control, which means that the person in charge of the combining should carry-out control on a regular basis to determine whether the calibration of the yield monitor allow collection of the correct data.

Enterprise budgets for each management zone should be compared with the actual results realised. This can assist farmers to decide which areas can be cultivated under which crop at a profit.

CONCLUSION

Adoption and implementation of precision agriculture technologies requires an integrated and holistic evaluation to determine the effect of the technology on the farm performance, and to ascertain in time whether it will be profitable or not. Precision agriculture has advantages associated with it, which require some careful consideration in order to be exploited. If a holistic and strategic approach in planning the adoption of precision agriculture technologies is not followed, some potential benefits can be missed, or some major costs that can affect the farm might not recognised in time. Precision agriculture provides operators with highly sophisticated information and the management level of the farm manager must be on such a level that the information can be used to realise the vision and long-term goals of the farming business.

Used efficiently and correctly, precision agricultural techniques can optimise input applications, cut input costs, increase production, reduce production risks and promote greater profitability in the long-term. Coupled with this are environmental benefits.

REFERENCES

Barney, J. B. Gaining and sustaining competitive advantage. 1997. Addison-Wesley Publishing Company. Massachusetts.

Lowenberg-DeBoer, J. 1997. Taking a brief review of precision farming benefits. Modern Agriculture. Vol. 1, Issue. (32-33).

Lowenberg-DeBoer, J. & Swinton, S. M. 1997. Economics of Site-Specific Management in Agronomic Crops. In: Pieerce F. J. and Sadler E. J., Editors, 1997. "The state of Site-Specific Management for Agriculture." ASA-CSSA-SSSA, Winsconsin, USA. Chapter 16, p. 369-396.

Lowenberg-DeBoer, J. & Erickson. 2000. Precision Farming Profitability. Agricultural Research Programs. Purdue University. Indiana

Malzer, G. L., Mamo, M., Mulla, D., Bell, J., Graff, T., Strock, J., Porter, P., Robert, P., Eash, N., Braum, S., and Dikici, H. 1999. Economic Benefits and Risks Associated with Site-Specific Nutrient Management. In: Proceedings of the 5th site-specific farming workshop. Fargo, North Dakota.

National Research Council. 1997. Precision agriculture in the 21st century: Geospatial and information technologies in crop management. Washingto, D. C.: National Academy of Sciences

Nell, WT & Napier. 2005. The Journey to Farming Success. A Strategic Approach. Wim Nell Agricultural Management Consultants. Bloemfontein. South Africa.

Zeilenga, V. 2004. Evaluering van verskillende metodes om bestuursones in die sentrale akkerboustreek te identifiseer (Evaluation of various methods to identify management zones in the central agronomical area. M. Agric mini-thesis, University of the Free State, Bloemfontein.