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PRECISION AGRICULTURE IN THE WORLD AND ITS PROSPECT IN BANGLADESH

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Precision Farming merges the new technologies borne of the information age with a mature agricultural industry. It is an integrated crop management system that attempts to match the kind & amount of inputs with the actual crop needs for small areas within a farm fields. This study is basically based on the secondary data and it is a review paper. As it is a review paper so, there was less opportunity to follow any specific method in preparing this paper. Valuable information has been collected through internet browsing, journals etc. In this paper, we examine that, GPS, GIS, VRT, profitability, yield mapping etc. are most common precision agriculture techniques where, GIS can help in site-specific applications of fertilizers and soil amendments and help effectively detect and map black fly infestations, making it possible to achieve precision in pest control. Remote sensing combined with GIS and GPS can help in site-specific weed management. From the review we observed that, the global adoption of yield monitors has been predominated in North-America and Europe. The precision technologies have been used on a wider variety of crops in Denmark and UK than in the US. In Bangladesh, precision agriculture has great prospect as our country is highly natural calamity sensitive and through it we can easily take measure to prevent our agricultural products from damage caused by natural calamities. Though, precision agriculture is very costly but the benefit from it is more than its cost for most of the developing countries. So, the precision agriculture has great prospect in Bangladesh as well as in the world and it is the utmost time to adopt this technology in our traditional agriculture.

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INTRODUCTION

Agricultural production system is an outcome of a complex interaction of seed, soil, water & agro-chemicals (including fertilizer). The time has now arrived to exploit all the modern tools available by bringing information technology & agricultural science together for improved economic & environmentally sustainable crop production. Precision agriculture merges the new technologies borne of the information age with a mature agricultural industry. As we have known, precision agriculture (PA) was first expounded in 1980's in American based on the demands to solve the agricultural environment such as fertilizer and pesticide pollutions. According to Srinivasan (2001) said that, the scope for funding new hardware, software and consulting industries related to precision agriculture is gradually widening. In Japan, the market in the next 5 years is estimated at about US $ 100 billion for GIS and about US $ 50 billion for GPS and RS. It targets inputs and management practices to variable field conditions such as soil/landscape characteristics, pest presence and microclimate. A more holistic agricultural approach, PA uses information technology to bring data from multiple sources to bear on decisions associated with agricultural production, logistics, marketing, finance, and personnel. Precision agriculture is an information-based approach to farming that is enabled by a collection of rapidly changing technologies. Although adoption of these technologies has been reasonably rapid, it is not clearly understood how to exploit the full power of precision agriculture. Additional research related to precision agriculture should be needs based. Once these key needs are understood, we can develop appropriate research projects to meet these needs. Considering the above facts, the present study was undertaken to know about the precision farming, to be acquainted with the opportunities & need of precision farming and to know the present scenario of precision farming around the world and its prospect in Bangladesh.

MATERIALS AND METHODS

Scientific approach requires a close understanding of the subject matter. This paper mainly depends on the secondary data. Different published reports of different journals mainly supported in providing data in this paper. This paper is completely a review paper. Therefore no specific method has been followed in preparing this paper. It has been prepared by Internet search, comprehensive studies of various articles published in different journals, books and proceedings available in the libraries of SAU, BARI, BRRI and BARC. Valuable information has been collected through personal contact with respective resource personnel to enrich the paper. It compiled the all related information to prepare this paper.

RESULT AND DISCUSSION

Basic concept of precision agriculture

The precision agriculture is a agricultural technique where the crop, soil and climate related data are monitored then mapping the attribute and then taking decision and finally take action. It is fully information based approach.

The Basic Tools of Precision Farming

Precision farming basically depends on measurement and understanding of variability, the main components of precision farming system must address the variability. Precision farming technology enabled, information based and decision focused, the components include, Remote Sensing (RS), Geographical Information System (GIS), Global Positioning System (GPS), Soil Testing, Yield Monitors and Variable Rate Technology.

The Global Positioning System (GPS) is the heart of precision agriculture. A GPS receiver is a location device that calculates its position on earth from radio signals broadcast by satellites orbiting the earth. The U.S. government has 24 satellites that are constantly orbiting the earth. These satellites contain precise atomic clocks, and the exact time is encoded into the signals broadcast from each satellite. A GPS receiver uses this time information to measure the distance to each satellite from which a signal is being received. With at least four satellite signals, the receiver can use triangulation to calculate its position on the ground.

The base station receives the satellite signals and compares its calculated position with its exact position. GPS receivers can be used in a wide range of situations to provide the latitude and longitude of a machine operating in a field, or of a field scout who is making observations and taking samples. Field images, or maps, can be made by recording parameters such as yield or fertilizer application along with position in the field.
Mapping software is used to handle, display and analyze data stored as a value and a position. Mapping software is available with a wide range of capabilities. Low-end packages are used primarily for creating maps or graphical images, and have little capability to process or analyze data. High-end products are known as Geographic Information Systems or GIS, and have many data processing capabilities. Because precision farming requires a relatively high level of data processing, software used for this purpose has become known generically as GIS software.

Variable Rate Technologies (VRT) describes machines that can automatically change their application rates in response to their position. VRT systems are available for applying a variety of substances including granular and liquid fertilizers, pesticides, seed and irrigation water.

Yield mapping is another important technique in precision farming. Yield maps show the variability in yield within a field. A yield mapping system measures and records the amount of grain being harvested at any point in the field, along with the position of the harvester. To produce a yield map, the harvester must be equipped with a GPS receiver and a yield monitor. A yield monitor can be a flow meter or a scale.

The profitability of precision farming is as variable as field conditions. Producers who use site-specific management must recognize that information becomes another input to the system, and that it has a cost. With soil, weed, fertility and yield maps for a particular field, the producer can know more about the field's yield potential and determine which areas of a field are creating the largest profit, as well as which areas are not capable of producing as well as others.

Remote sensing is the acquisition of information about an object from a distance, with precision, without coming into contact with the same. Although the use of RS is a decade old, its relevance to agriculture in spatial variability management is relatively new. RS measures visible and invisible properties of a field or a group of fields and converts point measurements into spatial information, to monitor temporally dynamic plant and soil conditions.

Basic Steps in Precision Farming

- The basic steps in precision farming are,
- Assessing variability
- Managing variability and
- Evaluation

I) Assessing variability

Assessing variability is the critical first step in precision farming. Factors and the processes that regulate or control the crop performance in terms of yield vary in space and time. Quantifying the variability of these factors and processes and determining when and where different combinations are responsible for the spatial and temporal variation in crop yield is the challenge for precision agriculture.

ii) Managing variability

Once variation is adequately assessed, farmers must match agronomic inputs to known conditions employing management recommendations. Those are site specific and use accurate applications control equipment. In site-specific variability management, we can use GPS instrument, so that the site specificity is pronounced and management will be easy and economical. For successful implementation, the concept of precision soil fertility management requires that within-field variability exists and is accurately identified and reliably interpreted, that variability influences crop yield, crop quality and for the environment.

iii) Evaluation

There are three important issues regarding precision agriculture evaluation.

- Economics
- Environment and
- Technology transfer

Potential improvements in environmental quality are often cited as a reason for using precision agriculture. Reduced agrochemical use, higher nutrient use efficiencies, increased efficiency of managed inputs and increased production of soils from degradation are frequently cited as potential benefits to the environment. Enabling technologies can make precision agriculture feasible, agronomic principles and decision rules can make it applicable and enhanced production efficiency or other forms of value can make it profitable.The term technology transfer could imply that precision agriculture occurs when individuals or firms simply acquire and use the enabling technologies.

Technology Transition

In precision farming, “Variability of production and quality equals opportunity”. For example the magnitude of the variability may be too small to be economically feasible to manage. Alternatively the variability may be highly randomized across the production system making it impossible to manage with current technology. Finally the variability may due to a constraint that is not manageable. Thus the implementation of precision farming is limited by the ability of current variable rate technology (VRT machinery/ technology that allows for differential management of a production system) to cope with the highly variable sites and the economic inability to produce returns from sites with low variability using precision farming (VRT).

Opportunities

Business opportunities for precision farming technologies including GIS, GPS, RS and yield monitor systems are immense in many developing countries. The scope for funding new hardware, software and consulting industries related to precision agriculture is gradually widening. In Japan, the market in the next 5 years is estimated at about US $ 100 billion for GIS and about US $ 50 billion for GPS and RS (Srinivasan, 2001). Punjab and Haryana states in India, where farm mechanization is more common than in others, may be the first to adopt precision farming on a large scale.

Recently, the governments of certain Asian countries initiated special efforts to promote precision farming. In Japan, the Ministry of Agriculture has allocated special funds for research on remote sensing applications of precision farming. A quasi-governmental institute “Bio-oriented Technology Research Advancement Institute (BRAIN)” is also funding research on precision farming. In Malaysia, the Malaysian Agricultural Research and Development Institute (MARDI) is promoting research on precision farming of upland rice.

Precision farming is useful in many situations in developing countries. Rice, wheat, sugar beet, onion, potato and cotton among the field crops and apple, grape, tea, coffee and oil palm among horticultural crops are perhaps the most relevant.

In Sri Lanka, researchers at the Tea Research Institute are examining precision management of soil organic carbon.Nutrient stress management is another area where precision farming can help sub- continent farmers. Most cultivated soils here vary in pH. Detecting nutrient stresses using remote sensing and combining data in a GIS can help in site-specific applications of fertilizers and soil amendments such as lime, manure, compost, gypsum and sulphur. Pests and diseases cause huge losses to many crops. If remote sensing can help in detecting small problem areas caused by pathogens, timing of applications of fungicides can be optimized. Recent studies in Japan show that pre-visual crop stress or incipient crop damage can be detected using radio-controlled aircraft and near-infrared narrow-band sensors. Likewise, GIS have been shown to effectively detect and map black fly infestations in citrus orchards, making it possible to achieve precision in pest control.

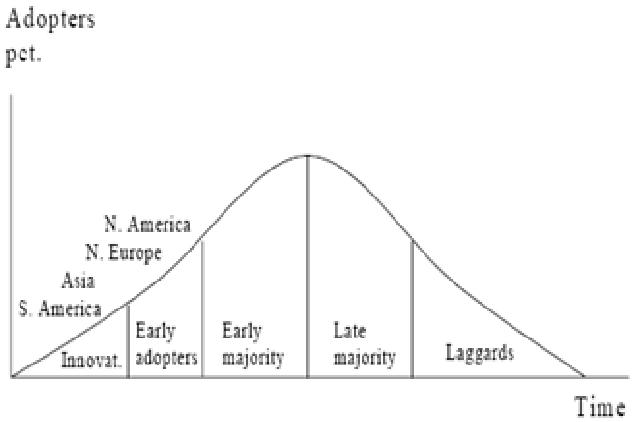
The Need for Precision Farming

Green revolution of course contributed a lot in world agriculture. However, even with the spectacular growth in the agriculture, the productivity levels of many major crops are far below than expectation. In many countries of the world the production of their high yielding varieties have not reach in their potential level.Precision farming techniques can improve the economic and environmental sustainability of crop production. Some of the primary impacts are cost reduction and more efficient use of production inputs, use of information technology to increase the size and scope of farming operations without increasing labor requirements, improved site selection and control of production processes that help in the production of higher value or specialty products, improved recordkeeping and production tracking for food safety, and environmental benefits (Lowenberg-DeBoer and Boehlje 1996). When used to precisely control where equipment travels in a field, precision agriculture can also reduce soil compaction and erosion.

At a basic level, precision agriculture can include simple practices such as field scouting and the spot application of pesticides. However, precision agriculture usually brings to mind complex, intensely managed production systems using global positioning system (GPS) technology to spatially reference soil, water, yield, and other data for the variable rate application of agricultural inputs within a field. Precision agriculture methods help farmers recognize areas that have productivity and environmental problems and to select the best solution for each one. At the extreme, precision agriculture may help a producer identify land that should be taken out of the current production system because of economic and environmental considerations.

Present scenario of precision farming around the world

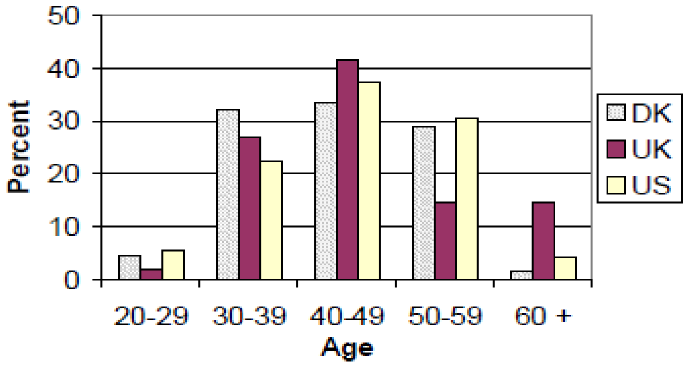
Yield monitors connected to a GPS-receiver was by most farmers the first real attempt to conduct site-specific management on their fields. The global adoption of yield monitors has been predominated in North-America, Europe and Australia but countries like Argentina, Brasilia and some East Asian countries have also adopted some practices. To date, we are in a stationary state between the early adopters and the early majority, mainly since yield increases aren't well enough documented to cover the cost of equipment. According to S. Blackmore (2001), the adoption of precision farming technologies is likely to follow a normal distribution with the innovators and early adopters as the first to adopt the technology and then later on will the majority of farmers follow up. The adoption of precision farming is currently in a stationary phase between the early adopters and the majority. Figure 10 shows a likely adoption pattern for precision farming.



Source: Blackmore, 2008

Figure 1. Global adoption of precision farming practices

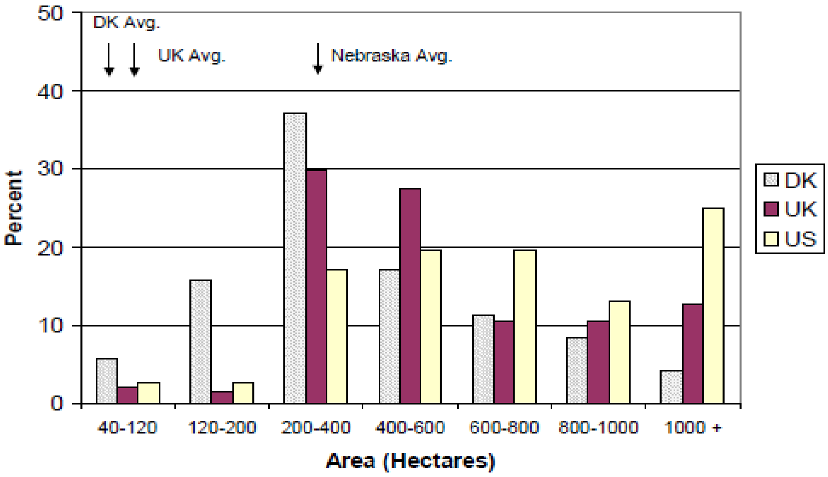
The age distribution of farmers of Denmark, USA & UK adopting precision agricultural practices tends to be similar among the three countries (Figure 2). In general, younger farmers may be interested in precision agriculture but have less economic flexibility to invest in equipment, while older farmers may be reluctant to invest in the time necessary to learn new technologies.



Source: Pedersen *et al.,* 2009

Figure 2. Age distribution of producers using precision agriculture

Farms in the US tend to be larger, followed by the UK, then Denmark (Figure 3). The land area farmed by producers using precision technologies in all three countries tends to be larger than the average in each country.



Source: Pedersen *et al*., 2009

Figure 3. Area farmed by producers using precision agriculture

Precision farming practices have been applied on a large variety of crops, although the most common application is to grain crops that can be harvested by a combine harvester (Table 1). This finding was anticipated given that the UK and Denmark survey participants were customers of companies producing yield-mapping combines. Precision technologies have been used on a wider variety of crops in Denmark and UK. In Denmark and the UK, 91% and 95% respectively use precision practices on wheat, as well as on barley, oilseed rape, grass seed, peas and tubers (beets and potatoes). It should be stressed that table 1 only includes crops where some type of precision practice has been used. It does not address the extent of current farm practices within each country on each crop.

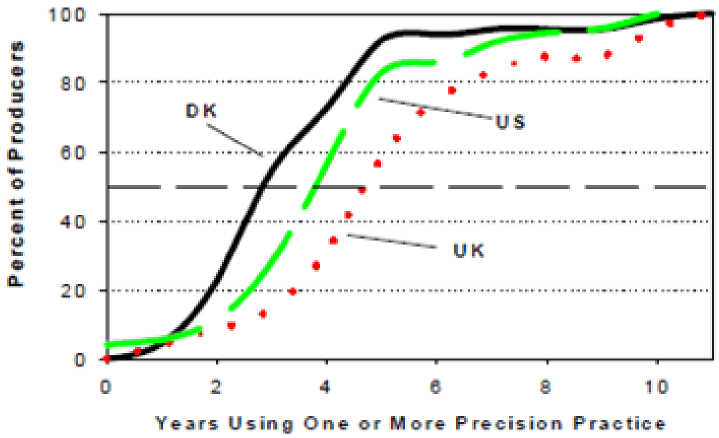
Table 1. Percentage of respondents who have used a precision practice for the given crop

Crop	DK	UK	US
	-----------------------	%	-----------------------
Wheat	91	95	13
Barley	82	72	0
Rye	16	5	0
Oat	7	9	1
Triticale	11	0	0
Oilseed Rape	36	67	0
Corn (maize)	4	0	100
Grass seed	45	0	0
Flax	7	0	0
Beets	5	2	0
Potatoes	9	7	0
Peas	13	21	0
Linseed	0	14	0
Beans	0	28	0
Soybean	0	2	87
Grain sorghum	0	0	10
Other[1)]	10	2	9

[1)] Crops where 5 percent or less precision practices are used in the three countries include: Seed corn, grass, herbage seed, edible beans and alfalfa.

Source: Pedersen *et al.,* 2009

There are differences among countries in how long farmers have used precision practices, with farmers in the UK tending to have used them longer than farmers in the US or Denmark (figure 4). The majority of Danish and US respondents have used one or more precision practice between two and four years, while the majority of UK respondents have used a precision practice between five and seven years.



Source: Pedersen et al., 2009

Figure 4. Length of time producers have used a precision practice (cumulative distribution)

Yield mapping with GPS is the most common practice used in all three countries. Yield monitoring without GPS is used significantly only in the US. Directed soil sampling, according to yield maps or other spatial information, is a practice of increasing popularity in the US and UK, given the high investment required for grid sampling. A larger percentage of producers have tried aerial photography or remote sensing in the US relative to the UK and Denmark. More producers in the UK and Denmark have mapped soil conductivity on their farms than in the US. A significant number of producers in the UK indicated they had used conventional soil surveys on their farm (this question was not asked of producers in the US or Denmark). In the US, a significant percentage of producers had had their fields mapped for topography, primarily in relation to leveling for irrigation.

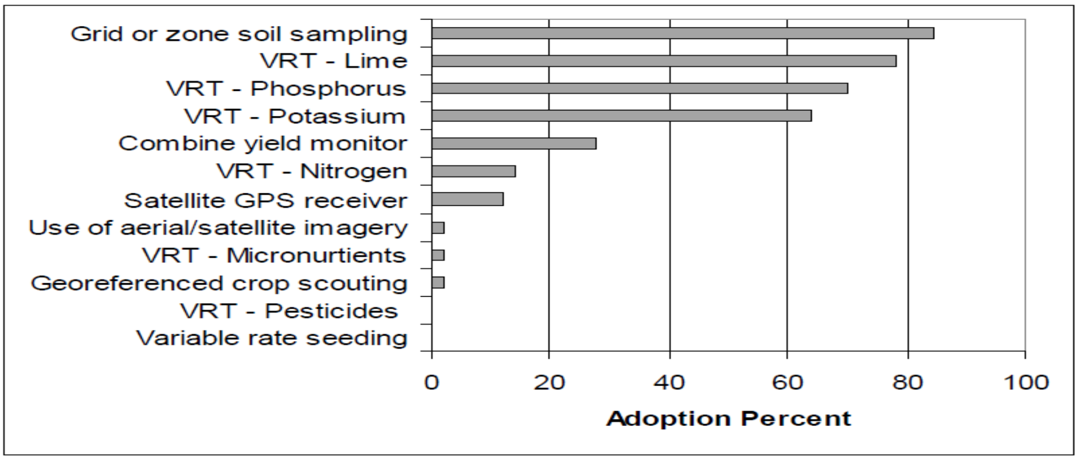
Table 2. Use of precision practices among countries (Percent of respondents in each country who indicate they have used the practice)

Practice	DK	UK	US
		%	
Information Gathering			
Grid soil sampling	49	56	50
Directed soil sampling	14	27	39
Yield monitoring (no GPS)	7	17	29
Yield mapping (GPS)	80	100	76
Aerial photography	3	27	40
Remote sensing	3	17	19
GPS-pest monitoring	1	2	3
Soil conductivity mapping	14	19	6
Soil topography mapping	1	4	22
Conventional soil mapping		17	
Mean	19	29	32
Taking Action			
VRT fertilization	26	58	47
VRT lime	37	33	26
VRT pesticide	10	10	3
Mean	24	34	25
Other	3	6	14

Source: Pedersen et al., 2009

Table 2 shows that, on average, US and UK producers are highest in adoption of evaluative, or information gathering, practices (32% and 29% average adoption, respectively, compared to an average adoption of 19% in Denmark). Producers in the UK are more likely than Danish or US producers to take action on the information they have gathered, with 34%, on average, adoption of prescriptive practices, compared to 24% and 25% in Denmark and the US.

Figure 5 summarizes precision farming adoption by individual components in Central Ohio, Japan. The number of responses for each of the seven components was about 50. The highest adoption percentage, 84.6%, occurred with georeferenced grid soil sampling, followed by 78% adoption of georeferenced variable rate application of lime, 70% VRT phosphorus, and 64% VRT potassium.



Source: Arnholt et al., 2007

Figure 5. Adoption percentages for various precision farming component technologies and practices in Central Ohio, Japan

When farmers are asked to list the top three practices they felt would have the most potential economically for their farm, producer responses varied somewhat by country (table 3). The most commonly listed practice among all three countries was variable rate fertilization. The second most commonly listed practice in the UK and US was yield mapping, while in Denmark the second most commonly listed practice was variable rate lime application. The third most commonly listed practice in the US and UK was grid soil sampling, while the third most commonly listed practice in Denmark was variable rate pesticide application.Two-thirds of Danish farmers believe either variable rate fertilization, liming, or pesticide application will be economically beneficial, compared to 34% in the UK and 25% in the US. This is likely related to restrictions on N rates below the economic optimum in Denmark, as well as substantial taxation on the use of pesticides (Langkilde, 1999).

In case of variable rate application producers in different countries sometimes had different opinions regarding the impact of adopting precision agriculture practices on the total amounts of inputs, such as fertilizer and seed, for crop production (table 4). Table 4 Impact of adoption of precision practices on total inputs (↑ indicates an increase, ↓ indicates a decrease, and → indicates no change in the overall total of each input; where two arrows are shown, there were significant numbers of farmers who held each opinion – the first arrow shown is the predominate opinion)

Table 3. Precision farming practices that farmers believe to have the greatest potential economic impact on their farm

Practice	DK	UK	US
	----------	%	----------
Information Gathering			
Grid soil sampling	16	28	33
Directed soil sampling	2	13	14
Yield monitoring (no GPS)	5	0	20
Yield mapping (GPS)	28	58	46
Aerial photography	0	5	3
Remote sensing	3	10	10
GPS-pest monitoring	10	5	0
Soil conductivity mapping	3	5	3
Soil topography mapping	2	5	1
Conventional soil mapping		3	
Mean	8	13	14
Taking Action			
VRT fertilization	81	60	54
VRT lime	66	18	20
VRT pesticide	53	25	1
Mean	67	34	25
Other	9	38	39

Note: The respondents were asked to mention up to three practices they believed would be beneficial on their farm.

Source: Pedersen et al., 2009

Table 4. Impact of adoption of precision practices on total inputs

Input	DK	UK	US
Nitrogen	→	→	→
Phosphorous	→↓	→↓	→↑
Potassium	→↓	→↓	→
Other Fertilisers	→	→	→
Lime	↓	→	→↑
Herbicides	↓	→	→
Insecticides	→↓	→	→
Fungicides	↓→	→	→
Seed	→↓	↓→	→
Growth regulators	↓→	→	→

Source: Pedersen *et al*., 2009

Only nitrogen and other fertilizers showed no difference in opinion among countries, with all farmers feeling there would be no change in these total inputs. Farmers in Denmark and the UK felt precision practices would leave unchanged or decrease their total use of phosphorous fertilizers, while farmers in the US felt if anything it would increase total P use. Farmers in Denmark and the UK felt potassium use would remain the same or decrease, while farmers in the US believe it would remain unchanged.

Producers in Denmark felt lime use would decrease, while US farmers felt it would increase. Danish farmers also felt herbicide, insecticide, and fungicide use would decrease or remain unchanged, while producers in the other two countries felt they would be unchanged. US farmers felt that total seed and growth regulator use would remain unchanged, while farmers in Denmark and the UK felt they would remain the same or decrease. In Denmark and the UK, where agriculture is often more intensive than in Nebraska, soil phosphorus levels are generally higher. Soil potassium levels generally are higher in Nebraska than in the UK or Denmark due to relatively younger, less weathered soils. Also, the use of fungicides and growth regulators is more common in Denmark and the UK for intensively grown cereals. The expectation that precision practices will decrease overall herbicide use in Denmark may be related to more stringent regulations on the use of herbicides in Denmark, compared to the UK or US.

An interesting observation is that respondents in Denmark and the UK felt precision practices would leave unchanged or reduce total inputs.The relative benefits and costs associated with the use of each PF component is evaluated in Table 5. Farmers were asked to respond to the statement, “On my farm the benefits of (named component) clearly exceed its costs”. The scale used was 1 (strongly disagree) to 5 (strongly agree). The combine yield monitor ranked the highest (4.2), suggesting that this is the most profitable single PF component. No producer disagreed that benefits of the yield monitor exceeded its costs. Similarly, all adopters of Satellite GPS receivers agreed that benefits of this component clearly exceeded its costs. Nearly 77 percent agreed or strongly agreed that the benefits of VRT of fertilizers or lime exceeded their costs, and 59 percent felt that grid soil sampling had positive net benefits.

Table 5. Farmer evaluation of relative benefits and costs for precision farming technology

		Percent [a]					
Precision Farming Component [b]	Adoption Percent	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Average Score
Georeferenced grid or zone soil sampling	84.6	0.0	4.9	36.6	43.9	14.6	3.7
Combine yield monitor	27.5	0.0	0.0	15.4	46.2	38.5	4.2
Satellite GPS receiver	12.0	0.0	0.0	0.0	100.0	0.0	4.0
VRT of Fertilizers or Lime	73.3	0.0	2.6	20.5	64.1	12.8	3.9

Source: Arnholt*et al*., 2007

a: this is based on a scale of 1 to 5, with 1 meaning strongly disagree, 2 meaning disagree, 3 meaning neutral, 4 meaning agree, and 5 meaning strongly agree; b: farmers were asked "On my farm, the benefits of (precision farming component) clearly exceed its costs"

Table 6. Farmer evaluations of the costs associated with precision farming adoption and use

	Cost Level [a]						
Costs	Not a cost	Very Low Cost	Low Cost	Medium Cost	High Cost	Very High Cost	Average Score
Service charges for Variable Rate Application of fertilizer/lime	0.00	0.00	13.64	45.45	31.82	9.09	3.36
Soil testing fees	2.27	15.91	20.45	36.36	22.73	2.27	2.68
Soil sample collection costs	8.89	15.56	20.00	31.11	20.00	4.44	2.51
Manger time required (including your time)	30.23	23.26	27.91	11.63	4.65	2.33	1.44
Consulting fees paid	39.53	20.93	16.28	16.28	4.65	2.33	1.33
GPS equipment and differential correction subscription	66.67	4.76	0.00	9.52	14.29	4.76	1.14
Input application equipment (spreaders/sprayers/planters)	76.19	2.38	0.00	7.14	4.76	9.52	0.90
GIS and mapping software costs	71.43	4.76	2.38	11.9	7.14	2.38	0.86
Computer hardware	76.19	2.38	4.76	9.52	2.38	4.76	0.74
Service charges for Variable Rate Application of herbicides, insecticides, and fungicides	80.49	0.00	2.44	9.76	2.44	4.88	0.68
Service charges for Variable Rate Planting	87.80	4.88	0.00	2.44	2.44	2.44	0.34
Remote sensing data fees	88.10	4.76	0.00	2.38	2.38	2.38	0.33

a - this scale is rated 0 to 5, where 0 means NOT a cost, 1 means very low cost, and 5 means very high cost.

Source: Arnholtet al., 2007

The various costs associated with the adoption and use of precision farming is identified in table 6. Farmers were asked to evaluate these cost sources using a scale of 0 to 5, where 0 is not a cost, 1 is a low level of cost and 5 is a very high cost. It is clear that these farmers perceive the highest cost associated with the adoption and use of PF to be the service charges for variable application of fertilizers and lime (3.36). The next two highest costs are soil testing fees (2.68) and soil sample collection costs (2.51). Nearly all of the mean cost scores (9 of 12) are below 1.50. This suggests that nine of the cost descriptions listed is considered low to very low cost factors associated with the adoption of PF according to the sample surveyed. The lowest cost scores are associated with remote sensing data fees (not a cost for 88% of the farmers)), service fees for variable rate planting (also not a cost for 88% of the farmers) and service fees for VRT application of herbicides, and pesticides (not a cost for 80% of the farmers).

A benefits gained over the cost associated with adoption of precision farming is listed in Table 7. The same 0 to 5 scale was used to score each possible benefit a farmer may have gained by using PF. The highest rated benefit is precise knowledge of soil pH levels in grids and or management zones (4.07) followed by precise knowledge of soil nutrient levels in grids and or management zones (3.76) and reduction in lime usage (3.25). The lowest ranked benefits include reduction in insecticide or fungicide usage (0.25), reduction in herbicide usage (0.43), and precise knowledge of weed problem areas (0.89). Most of the farmers surveyed (84.6%) have adopted grid or management zone soil sampling.

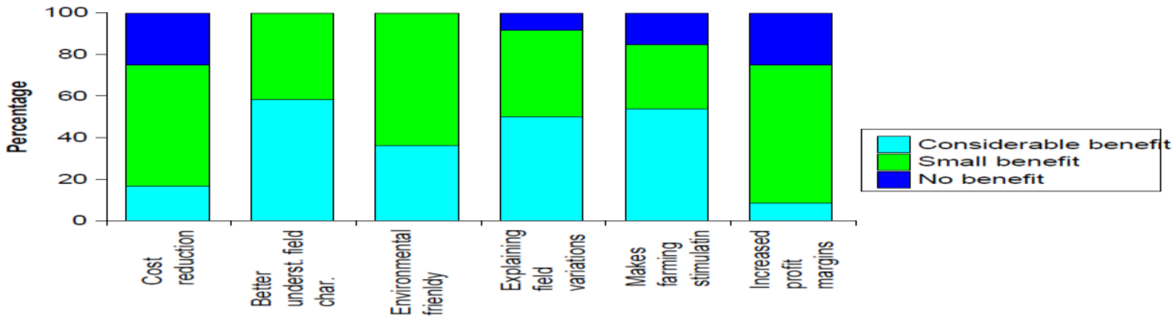
Table 7. Farmer evaluations of the benefits gained over the cost from precision farming adoption and use

	Benefit Level [a]						
Benefits	Not a Benefit	Very Low Benefit	Low Benefit	Medium Benefit	High Benefit	Very High Benefit	Average Score
Precise knowledge of soil pH levels in grids/management zones	2.33	0.00	0.00	13.95	53.49	30.23	4.07
Precise knowledge of soil nutrient levels in grids/management zones	4.44	0.00	4.44	22.22	44.44	24.44	3.76
Reduction in lime usage	9.09	6.82	11.36	15.91	36.36	20.45	3.25
Increased farm average yield	9.09	6.82	4.55	31.82	31.82	15.91	3.18
Reduction in fertilizer usage	11.11	8.89	6.67	28.89	31.11	13.33	3.00
Decreased variability (risk) in yields	25.00	6.82	13.64	15.91	31.82	6.82	2.43
Better knowledge for future selection of hybrids and varieties	32.56	9.30	11.63	11.63	23.26	11.63	2.19
Quantified and precise knowledge of areas of high/low yields	46.51	6.98	4.65	11.63	20.93	9.30	1.81
Better environmental records	41.86	6.98	11.63	18.60	18.60	2.33	1.72
Improved information for crop rotation management	44.19	6.98	25.58	13.95	6.98	2.33	1.40
Identification of drainage problems	57.78	8.89	0.00	17.78	11.11	4.44	1.29
Increased ability to compete/negotiate for leased land	55.81	6.98	6.98	18.60	9.30	2.33	1.26
Reduction in soil compaction	54.76	7.14	11.9	14.29	11.90	0.00	1.21
Better information for crop insurance claims	65.12	6.98	6.98	4.65	9.30	6.98	1.07
Knowledge of where equipment failure may have occurred	65.12	4.65	11.63	11.63	4.65	2.33	0.93
Precise knowledge of weed problem areas	68.18	4.55	4.55	18.18	2.27	2.27	0.89
Reduction in herbicide usage	77.5	12.50	0.00	10.00	0.00	0.00	0.43
Reduction in insecticide or fungicide usage	86.36	6.82	2.27	4.55	0.00	0.00	0.25

a - this scale is rated 0 to 5, where 0 means NOT a value/benefit, 1 means very low value/benefit, and 5 means very high value/benefit.

Source: Arnholt *et al*., 2007

From the quantitative data, it can be seen in the figure 6 below, that the major benefits were the improved understanding of field characteristics, explaining field variations and making farming more interesting and simulating.



Source: Fountas, 2008

Figure 6. Major benefits of using precision farming

Efficient use of land through precision agriculture

Precision agriculture helps to use the lands in efficient manner through:

I. GPS helps to select appropriate the lands for appropriate crops.
II. GIS helps to analyse the data.
III. VART helps to provide the appropriate amount of pesticide in the crops whichhelps to keep the soil fertile.

Prospect of precision agriculture in Bangladesh

- Bangladesh is a over populated country and by precision agriculture we can produce more by using available resources to feed these population not only in quantity but also can provide them nutritious food.
- In Bangladesh, we can use precision agriculture by using the data (rainfall, temperature, humidity, sunshine, wind speed etc.) available in different institutions.
- Precision agriculture helps to produce and improve crops at minimum cost which is very essential for Bangladesh as it is a developing country where money or investment is a very big problem.
- In Bangladesh, precision agriculture has great prospect as our country is highly natural calamity sensitive country and through it we can easily take measure to prevent our agricultural products from damage caused by natural calamities.
- Though, precision agriculture is very costly but the benefit from it is more than its cost for most of the developing country.

Disadvantages of Precision Farming

The most common disadvantage listed in all three countries was the cost of using the technology, and the apparent lack of economic return (table 8). (An interesting concern given the generally optimistic outlook producers have for the eventual positive economic impact of adopting precision agriculture). The second most commonly listed disadvantage was the time required – for making equipment work and analyzing and summarizing data.

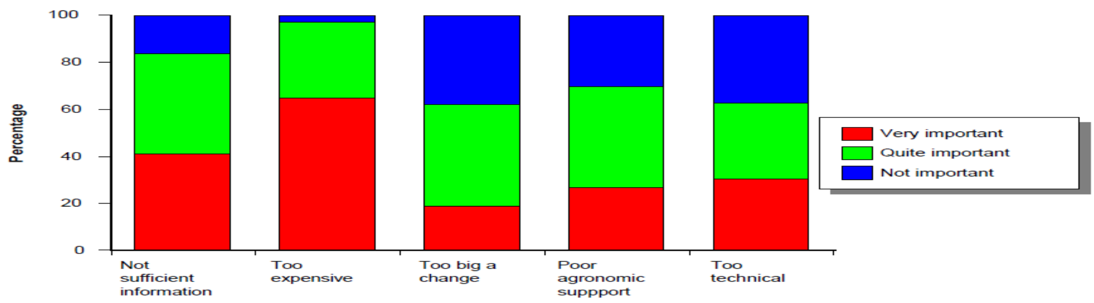
Table 8. Proportion of disadvantages listed among all producers (%)

Cost vs. Return	Equipment Problems	Potential Government Regulation	Lack of Research and Advice	Time Spent on Precision Agriculture
58	5	4	12	21

Source: Blackmore, 2008

Reasons for not using any Precision Farming techniques

The main important reasons are 'too expensive' 65% and 'not sufficient information' 41%. Less importance the farmers consider that precision farming is 'too big a change' 38% and 'too technical' 37%.

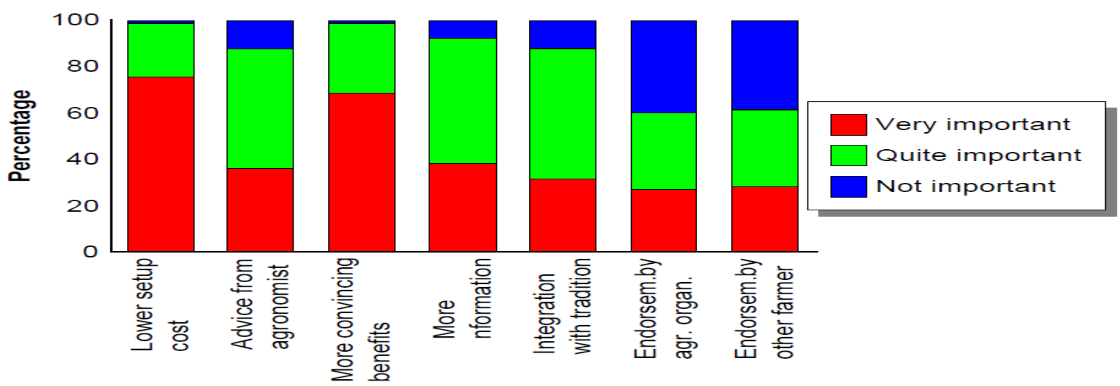


Source: Fountas, 2008

Figure 7. Reasons for not using precision farming techniques

Ways of encouraging the adoption Precision Farming technology

Key reasons are 'lower set-up cost' 75%, and 'more convincing benefits' 69%. Not important are 'endorsement by agricultural organizations' 40% and 'endorsement by other farmer' 38%. Quite important are 'advice from agronomist' 51%, 'A more developed integration with current systems' 56% and 'more information' 54%.



Source: Fountas, 2008

Figure 8. Ways of encouraging the adoption of precision farming

Obstacles

There are many obstacles to adoption of precision farming in developing countries in general. Some are as follows.

- Culture and perceptions of the users
- Small farm size
- High cost
- Lack of success stories
- Heterogeneity of cropping systems and market imperfections
- Land ownership, infrastructure and institutional constraints
- Lack of local technical expertise

CONCLUSION

Precision agriculture gives farmers the ability to use crop inputs more effectively including fertilizers, pesticides, tillage and irrigation water. More effective use of inputs means greater crop yield and/or quality, without polluting the environment. However, it has proven difficult to determine the cost benefits of precision agriculture management. At present, many of the technologies used are in their infancy, and pricing of equipment and services is hard to pin down. This can make our current economic statements about a particular technology dated.

REFERENCES

1. Arnholt M, MT Batte and S Prochaska, 2007. Adoption and Use of Precision Farming Technologies: A Survey of Central Ohio Precision Farmers, OSU AED Economics (AEDE-RP-OO11-O1), December 5.
2. Blackmore BS, 2008. Interview, Centre for Precision Farming, KVL, Taastrup.
3. Lowenberg –DeBoer J and M Boehlje, 1996. Revolution, evolution or dead-end: economic perspectives on precision agriculture. InProceedings of the Third International Conference on Precision Agriculture. P.C. Robert RH Rustand W.E. Larson, eds. American Society of Agronomy, Crops Science Society of America, Soil Science Society of America. Madison, WI.
4. Pedersen SM RB Ferguson and M Lark, 2009. A Comparison of Producer Adoption of Precision Agricultural Practices in Denmark, the United Kingdom and the United States, SJFI – Working Paper no. 2.
5. Stephen WS, 2009. Precision Farming: A New Approach to Crop Management, Texas Agricultural Extension Service.
6. Srinivasan, 2001. Precision farming in Asia: Progress and prospects, Geospatial Analysis Center, Regional Science Institute, Hokkaido, Japan.