CONCLUSION AND RECOMMENDATION

Precision farming is an attractive option to promote sustainable agricultural development. It is conceptualized by a system approach to re-organize the total system of agriculture towards a low-input, high-efficiency, sustainable agriculture (Shibusawa, 1998). It has created scope of transforming the traditional agriculture, through proper resource utilization and management, to an environmentally friendly sustainable agriculture. Thus the basic goal of PA is to optimize yield with minimum inputs and reduced environmental pollution which is highly required for developing countries to face the challenges of sustainability. The precision farming developments of today can provide the technology for the environment friendly agriculture of tomorrow (Auernhammer, 2001).

Precision farming is a comprehensive system designed to optimize production by using key elements of information, technology and management, so as to increase production efficiency, improve product quality, improve the efficiency of crop chemical use, conserve energy and protect environment. Application of the balanced soft and hard PA technologies based on the need of specific socio-economic condition of a country will make PA suitable not only for developed countries but also for developing countries and can work as a tool to reduce the gap between the developed world and the rest (Mondal, 2009).

The adoption of Precision farming techniques also depends on Farm characteristics for understanding a farmer’s decision to adopt (Prokopy et al., 2008). If a farmer perceives that the adoption of technology would be profitable prior to making decision, he will be likely to adopt precision agriculture (Napier et al., 2000; Roberts et al., 2004), product reliability, the support provided by manufacturers, government and the ability to show the benefits. Effective coordination among the public and private sectors and growers is, therefore, essential for implementing new strategies to achieve fruitful success.
Thus, precision agriculture is an appealing concept and its principles quite naturally lead to the expectation that farming inputs can be used more effectively, with subsequent improvements in profits and environmentally less burdensome production. Especially in the case of small farmers in developing countries, precision agriculture holds the promise of substantial yield improvement with minimal external input use. However, most of the researches on precision farming conducted in developing countries, and reveals that increased input efficiencies result in rather modest profitability increases (Kilian, 2000).

7.1 Summary and Conclusion

To meet the objectives of this study, a total of 114 farmers were selected in the sample survey and collected for them. Data consisting of 70 (61.4 percent) farmers who adopted precision farming techniques for water resource management and 44 (38.6 percent) non-adopters was analyzed for finding out factors influencing precision farming techniques for water resource management adoption drawn from two selected districts of Dharmapuri and Krishnagiri, Tamil Nadu. The dependent variables of our analysis have provided answer to different questions raised in this study.

All factors considered in this study have been grouped under two broad heads:

1. Socio-demographic factors, and
2. Farm characteristic factors.

On the basis of chi-square test, we find that there is a significant difference in socio-demographic profile of precision and non-precision farmers in majority of socio-demographic indicators. Therefore, we reject our null hypothesis that there is no difference in socio-demographic profile of precision and non-precision farmers. The results suggest that the two categories of farmers (adopters and non-adopters of precision farming techniques) exhibited statistically significant difference with respect to educational level, social category, occupation of spouse, income level and landholding size. Precision farmers are having comparatively higher education, belong to higher social category, higher income level and having large landholdings. Thus our study shows that educated and relatively large and rich farmers are adopting
precision farming techniques for water resource management, while less educated, small and poor farmers have not been able to adopt it.

Simple descriptive analysis has identified the motivational factors that affect the adoption of precision farming techniques. Results indicate that mean value of six indicators out of eleven indicators are more than 3, which implies that farmers agree that these six factors are motivating for adopting precision farming. These are:

1. Reduction in cost,
2. Increase in yield,
3. Increase in profits,
4. Reduction in chemical inputs use,
5. Reduction in farm labour usage and
6. Increase in value of farm land.

By applying ANOVA on the motivational factors, we find that precision farmers have stronger agreements on motivational factors of precision farming than the non-precision farming. Further applying factor analysis on motivational factors, these factors are reduced to three groups i.e. profit maximization and cost minimization (having a factor load of 42.215 percent of variance), knowledge enhancement (having a factor load of 26.380 percent of variance) and capacity building, and risk management (having a factor load of 16.398 percent of variance).

Thus our study clearly identifies the following three major factors as motivating factors in the adoption of precision farming technique for water resource management in India.

I. Profit maximization and cost minimization includes; increase yield, increase profit, reduce costs, reduce chemical inputs, increase my crop land value, allow efficient targeting of crop nutrients, and reduce farm labour.

II. Knowledge enhancement and capacity building includes; allow me to acquire and analyze field data, and allow me to create my own field experiment and provide environmental information and

III. Risk management includes; decrease financial risks.
Our analysis indicates that farmers have strong agreement (90 percent) on the barriers that affect the adoption of precision farming techniques for water resource management, and this is also proved by ANOVA technique. Further applying factor analysis on data barriers that affect adoption of precision farming technique for water resource management by farming community are reduced into three broad groups’ i.e. physical barriers (having a factor load of 36.79 percent of variance), skill barriers (having a factor load of 18.139 percent of variance), and knowledge barriers in adoption of precision farming (having a factor load of 15.733 percent of variance).

Thus our study clearly identifies three important barriers of precision farming techniques for water resource management in India, as follows:

1. **Physical barriers** includes; precision farming techniques are time consuming, are difficult to use, are difficult to integrate into traditional farming, require a large farm to be cost effective, high cost technology.

2. **Skill barriers** includes; requires me to get training in-order to use these tools, provide data that are difficult to interpret, and requires me to have skills that I do not have, and

3. **Knowledge barriers**; precision farming requires an understanding of agronomy and requires me find support sources for advice.

Findings of regression analysis clearly indicate that the adoption of precision farming techniques by the farmers are influenced by a number of socio-demographic and farm related variables. Socio-demographic factors are:

1. Age (-0.5)
2. Education (3.227)
3. Social category (2.241)
4. Monthly income (3.138)
5. Family size (-1.979)
6. Number of family members (3.639)

While farm characteristic factors includes:

1. Farm size (3.547)
2. Information and Communication Technique (2.205)

3. High yielding variety (0.826)

Hence, our analysis clearly identifies that the adoption of precision farming techniques for water resource management are significantly influenced by education level of the farmers, social status, household income, number of farm working members in the family, land landholding size and use of ICT by the farming community.

7.2 Policy implications

The regression model associated with the precision farming expands our knowledge of precision farming use by examining adoption pattern of farmers towards precision farming technology for water resource management. This research helps us to determine factors which influence adoption pattern, other than perceived economic benefits, that are important in making the decision to use precision farming technologies.

Basic drawback of our agricultural farming in India is that many of these technologies used are in an infant stage, and pricing of equipment and services is hard to pin down. Even though some farmers had started to use precision farming methods, majority of the farmers are still not aware about these technologies and also not all farms are suitable to implement precision farming tools. For instance, some growers are likely to adopt it partially; adopting certain elements but not others and thus limit its implications.

Results of our study show that, the adoption of precision farming technologies in India is a result of multi-dimensional considerations. Extrapolated from the discussion, the adoption of precision farming technologies is positively associated with:

1. Socio-demographic factors (farmers who have higher education level, social category, number of working members), and

2. Farm characteristics factors (farmer’s farm size, monthly household income).
Our findings clearly indicated that if both the above factors are promoted among farmers then it will help them to get well equipped with the precision farming technologies. Thus, for effective diffusion of precision farming technologies and their promotion, the above factors should be well targeted.

Hence, the attempt to answer the above two factors can be partly assisted by an Agricultural Census dataset, which is commonly available in individual countries. Apart of the dataset provides details on (1) socio-demographic factors (gender, age, household size, ethnic, marital status, educational attainment, employment status of farm holder), and (2) farm characteristic factors (size, land tenure, location, capital, sales/profit and main crop of farm). These variables are relatively ‘fixed’ over time. Thus, the dataset renders a valuable basis for making the decision to target on the basis which provided the greatest opportunity of success.

On the other hand, information on other factors such as:

1. Institutional factors,
2. Informational factors, and
3. Farmer perceptions have other important functions.

As these factors are modifiable, intervention is able to add more weight to the likelihood of precision farming technologies adoption. Firstly, public education on resource conservation will lead to consequential awareness. Increasing awareness will increase pressure on a farmer to use precision farming technologies in order to conform to the public demand for sustainability. However, this social pressure will not succeed if farmers are not exposed to the stimulant. Therefore, promotion of the issue should be targeted at mass societal groups. Secondly, carefully tailored information on precision farming technologies should be made available to farmers through effective channels at affordable prices (or even complimentarily). While extension officers are not hired to focus specifically on the promotion of precision farming technologies, they should be equipped with the necessary knowledge. If a third party’s service is preferred over extension services, state governments should provide public–private partnerships. Lastly, farm business is profit-orientated. Adoption is unlikely to happen if precision farming technologies are not perceived to be profitable or offer amenities and services valued by producers. Lehman et al.,
(1993) point out that a farmer still might adopt a new agricultural practice even though it might not result in a direct profit. This can be made possible through a number of financial initiatives, such as capital subsidies for the set-up and maintenance of precision farming technologies, tax reduction for adopters of precision farming technologies, cuts in interest rates, and complimentary precision farming technologies technical assistance to save costs and boost yields. One or more of these could indirectly reshape farmer’s perceived profitability and improve actual farm profitability.

To accelerate farmers’ adoption of precision farming technologies mass media and large-scale field demonstration is needed to convince farmers about the effectiveness of precision farming technologies. In addition, information dissemination and organized campaigns on the technology should be carried out continuously to make farmers understand its benefits and to encourage them to use it.

In successful Green Revolution areas of Punjab, Haryana and Western Uttar Pradesh where farmers are relatively rich and more educated the precision farming technique for water resource management can become easily popular if it’s perceived long-term benefits both economics and environmental are properly communicated. Government should encourage farmers to adopt precision farming technique for water resource management in these areas by providing necessary help like GIS services as well as some financial and tax concession.

7.3 Future Research

Although the findings of these results provide valuable insight into what factors are considered when farmers make the decision to use precision agriculture technologies, there are several areas where future research would be beneficial. One point of interest is that there was no significant relationship found between communication behaviours and self-efficacy and communications behaviours and compatibility. Secondly no major work has been done on the VRT; precision agriculture is dependent on the existence of variability in either or both product quantity and quality. If this variability does not exist then a uniform management system is both the cheapest and most effective management strategy and precision farming is redundant. Thus, in precision farming, “Variability of production and quality equals opportunity”. Having said this, the nature of the variation is also important in
determining the potential for PA in a system. 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). Thirdly no scientific work has been done on the Precision Irrigation, on soil quality testing, water quality. Finally, GIS, GPS and Soil sensors are not fully implicated.

Precision Farming is an advanced technology in farming sector. In India after Green Revolution, farmers and scientists realized the fact that the soil is contaminated by excessive use of fertilizers and pesticides and thus the scope of precision agriculture extends from planting to harvesting. For instance, intelligent seeding systems prevent errors by making adjustments during planting and keeping precise records of which seeds are planted in which rows.

Though precision farming is very much talked about in developed countries, it is still at a very nascent stage in developing countries, including India, and therefore, future research in this field is beneficial.