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Typology of farm management decision-making research

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ABSTRACT

A review of 183 papers published between 1990 and 2006 led to development of a typology of farm management decision-making (FMDM) research. An existing model which categorises decision research according to purpose as being either *Analytical* (descriptive), *Normative*, or *Prescriptive* was blended with a second form of categorisation based on six emergent decision domains: (1) *factors*; (2) *processes*; (3) *events*; (4) *evaluation*; (5) *patterns*; and (6) *aids*. The result was a typology of seven main discernible types of FMDM research with four being Analytical in purpose (Factors, Processes, Events and Patterns), two being Normative (Event and Evaluation), and the last being Prescriptive Aid. Each of these types is outlined and examples of representative publications listed. Finally, some trends in publication patterns, in accord with this typology, are presented. This work is presented in the hope it helps readers to navigate more easily though a large and complex literature.

KEYWORDS: Farm management; research; typology; decision-making

1. Introduction

Understanding how farmers make decisions is of great interest to many stakeholders including researchers, extension workers, policy makers, input suppliers, product marketers and supply chain managers. The field of farm management decision-making (FMDM) research has a long history, and now is represented in a vast and multi-faceted literature which can be seemingly impenetrable to the casual reader and even to the experienced researcher. This paper attempts to address the maze of FMDM research literature by providing a guide or 'road map' based on the type and purpose of research. It was developed as part of doctoral research into decision making by farmers of the Republic of South Korea. Our aim is to share with others what we believe is a useful typology of decision theories and research methods used in FMDM research. We also report on several trends apparent in recent FMDM literature.

2. Materials and methods

The review of FMDM research was conducted in two steps with an initial broad overall review being followed by an in-depth review. The overall review was focused on establishing a general profile of FMDM from the research publications to allow categorisation, and the in-depth review was conducted to deal with the more detailed characteristics of FMDM, such as the research methodology employed.

FMDM research was reviewed through the following procedures:

- (1) For ease of electronic access, it was decided that the review would include all articles published since 1990 and listed on two powerful databases: 'CAB abstracts®' and 'Science Direct'. 'CAB abstracts®' was selected because at the time this study commenced, it had been reported to be the most comprehensive of all available applied life sciences bibliographic databases emphasising agricultural literature (Kawasaki 2004). 'Science Direct' is another comprehensive database with a strong agricultural coverage that was available through University of Queensland (UQ) Library resources at the time. This review yielded a total of 183 journal articles. Although much useful FMDM research had also been published prior to 1990, it was considered impossible to review all of these articles within the time constraints of this research. Furthermore, it was also difficult to gain electronic access to the full text of these earlier articles. The key words for searching the databases were 'farm*' and 'decision*' which captured any articles including the words 'farm' (e.g. farmer or farm management) and 'decision' (e.g. decision-making, decision process or decision support) within their title.
- (2) Full length text articles available in English were obtained and reviewed in full, whereas for those published in other languages the review depended on their abstracted text.
- (3) The initial broad review focused on comparing the aims and area of each study, and resulted in the identification of two main categories and nine subcategories. The second, in-depth review resulted in the consolidation of these into seven types of FMDM research.

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3. Categorisation of FMDM research

During the 15 year period of publication under review, it was found that much research dealing with farmers' decision-making had been conducted in various farm management research areas (e.g. production, marketing, financial, resources, environmental management and so on) and for various purposes. As a result, these different areas of FMDM research were broken into two main categories according to: (1) research aim or purpose (Purpose Category); and (2) the domain of FMDM research (e.g. decision factors, decision processes) on which the research was focused (Domain Category). By establishing these two main categories, seven types of FMDM research were consolidated.

Purpose Category research

For Purpose Category, three subcategories relating to research purpose were adopted and included descriptive (D), normative (N) and prescriptive decision research (P), in accordance with the analysis provided by Bell, Raiffa and Tversky (1988) and Rapoport (1989). The Purpose Category and its three subcategories are illustrated in Table 1. For greater consistency with standard economics terminology, the Descriptive subcategory was renamed Analytical in this study.

Analytical decision research (subcategory A), which is typically studied in psychology (especially social psychology) and the other behavioural sciences, deals with questions pertaining to how people really *do* make decisions. Analytical decision research begins with observations of how decision makers (e.g. farmers selected to be observed) make choices in given situations (e.g. financial issues that need to be tackled) and attempts to describe systematically (inductively) the decision processes or social phenomena resulting from their decisions (e.g. causes and effects of observed events described in terms of psychological states (motivations, preferences, satisfaction, disappointment etc)). The purpose of analytical decision research is to identify the rules determining the decisions of certain classes of decision makers and to predict decisions or their consequences.

In contrast, normative decision research (subcategory N), which is usually studied in the context of economics, statistics and mathematics, is aimed at addressing the question of how people *ought to (should)* make decisions in given decision situations. Normative decision research relies upon the use of mathematical language in which the precise definitions of terms, deductive analysis and assumptions of idealised conditions (rationality) are essential. This is the reason why normative studies are considered both formal and optimal (Bell *et al.*, 1988; Einhorn and Hogarth, 1988). Thus, the main objective of normative decision research is to reveal the logical

essence of an idealised decision problem (Rapoport, 1989).

Prescriptive decision research (subcategory P) is focused on *how* to help people to make good decisions or *how* to train people to make better decisions. Thus, prescriptive research, which is usually studied in the disciplinary area of operational research or management science, uses elements of both logical consequences (normative study) and empirical findings (descriptive study), but also draws on a level of prescriptive analysis which differentiates it from normative and descriptive (analytical) approaches (Bell *et al.*, 1988). One good example of a prescriptive study is the development of decision support systems (DSS).

Category II research

Category II (the domain of decision research) is made up of six subcategories. These were the main subcategories that emerged in this review and were identified as: (1) the decision factors affecting farmers' decision-making; (2) decision processes; (3) decision events; (4) decision outcomes evaluation; (5) decision patterns; and (6) decision aids (see Table 2).

Identifying these six subcategories was difficult and somewhat arbitrary because the majority of the previous studies addressed more than one subcategory, and also because the subcategories themselves cannot be neatly separated by explicit definition. This is a weakness in categorising FMDM research and it was found that some of the previous studies could be included, at least to some extent, in every subcategory. However, in spite of the difficulties and weaknesses associated with classification, the decision research area was ultimately classified by considering elements of the FMDM research that had been emphasised by previous researchers because the purpose of classifying the previous studies was not to define them by rigorous criteria.

Subcategory 1, the decision factors, includes studies that deal mainly with the factors influencing farmers' farm management decision-making such as economic, environmental and social factors (external factors) and farmers' goals, motivations, attitudes, personality, and biography (internal factors). Studies that deal with farmers' full decision-making process from detecting problems through to implementing decisions are categorised into subcategory 2, the decision process. Studies focusing on farmers' decisions about a specific event in a decision situation, such as uncertain or risky situations, are grouped into subcategory 3, the decision event. Studies attempting to evaluate decision outcomes or identify the relationship between farmers' decision-making and their performance are classified into subcategory 4, the decision outcome. Subcategory 5, the decision pattern, includes studies with a focus on the identity and roles within the farm household of the main

Table 1: Classification of farm management decision research by purpose

Categories	Subcategories	Main focus
Category I: The aim of FMDM research	Analytical (descriptive) study Normative study Prescriptive study	Understanding how farmers actually make decisions Providing solutions for how farmers should (ought to) make decisions Developing decision support systems to help farmers make better decisions

Table 2: Classification of farm management decision research by domain

Categories	Subcategories	Concepts
Category II: FMDM research domain	Decision factors (1) Decision processes (2) Decision events (3) Decision evaluation (4) Decision patterns (5) Decision aids (6)	Factors affecting farmers decision-making Farmers' decision-making process from detecting problems to implementing decisions Farmers' decision on the specific event under the special situation (uncertainty, risk, or multi objectives) Evaluation of decision outcome or relationship between D-M and performance Major roles of main decision-maker within family members Decision support system (DSS) or other helpful means to improve farmers' decision-making

decision makers. Finally, subcategory 6, the decision aid, is strongly related to studies developing decision support systems (DSS) or extension services for the purpose of assisting farmers' decision-making.

Consolidated typology of FMDM research

The review of these two forms of categorisation allowed for their consolidation into a single scheme to identify seven main types of FMDM research (see Table 3). This was achieved by combining the purpose of FMDM research (Category I) and the FMDM research domain (Category II) as illustrated in Figure 1. This figure shows that with three types of research purpose (analytical, normative and prescriptive) and six research domains (factors, processes, events, evaluation, patterns and aids) an 18 cell (6X3) matrix may be created. However, only seven of these cells have been populated by the categorisation of research reported. Each of these seven types of FMDM is briefly described in Table 4 with some examples of key references relating to each type. Explanatory notes and discriminating features for each type of FMDM research are set out below.

Analytical Factors (AF): Studies that describe and analyse the factors influencing farmers' decision-making

Analytical factors decision research is focused on identifying and analysing the factors that affect farmers' decision-making in either day-to-day management decisions or in given decision situations. Many studies similarly conclude that the factors influencing farmers' decision behaviour tend to differ among farmers due to differences in their goals, resources, level of knowledge,

environment and their approaches to confronting uncertainty. Therefore, researchers agree that given these variations it can be quite difficult to identify the key determinants affecting farmers' decision behaviour. However, these types of studies tend to be carried out with the purpose of identifying the diverse variables that are needed to build farmers' decision models or to identify the implications related to the provision of extension services or policy making.

Various factors influencing farmers' decision-making have been studied. With respect to internal aspects, farmers' attitudes and objectives, which are generally believed to depend on their beliefs, values or personalities, are thought to strongly affect farmers' behaviour (Tassell and Keller, 1991; Farinos Dasi, 1994; McGregor *et al.*, 1996; Willock, J. *et al.*, 1999). Many decision studies have found that farmer characteristics such as age, education, farm size or farm income level have very close relationships with decision behaviour (Featherstone and Goodwin, 1993; Fox *et al.*, 1994; Stirm and St-Pierre, 2003; Bragg and Dalton, 2004; Chianu and Tsujii, 2004; Selvaraju *et al.*, 2005; Iqbal *et al.*, 2006). Solano *et al.* (2006) analysed the impact of farmers' biographical variables and decision-making profiles on farm management and performance and concluded that among the biographical characteristics, education level and age most strongly affected the majority of management practices (decision-making). However, it was found that education level affected these practices positively, while age affected them negatively.

With regard to the external factors associated with farmers' decision behaviour, environmental and economic factors (Kolodinsky and Pelch, 1997; Illukpitiya

Table 3: Categorisation of FMDM research published between 1990 and 2006

Farm Management Decision-making Research Domain	FMDM Research Purpose		
	Analytical (n=95)	Normative (n=26)	Prescriptive (n=62)
DM Factors	Analytical Factors (n=28)		
DM Process	Analytical Process (n=14)		
DM Event	Analytical Event (n=29)	Normative Event (n=21)	
DM Evaluation		Normative Evaluation (n=5)	
DM Pattern	Analytical Pattern (n=24)		
DM Aid			Prescriptive Aid (n=62)

(n=number of papers categorised)

Table 4: Typology of farm management decision research

Types	Description	Examples
Analytical Factors (AF)	Studies on the understanding or analysis of factors influencing farmers' decision-making	(Featherstone and Goodwin, 1993; Kolodinsky and Pelch, 1997; Willock, Joyce <i>et al.</i> , 1999; Solano <i>et al.</i> , 2003; Stirm and St-Pierre, 2003; Bragg and Dalton, 2004; Iqbal <i>et al.</i> , 2006)
Analytical Process (APr)	Studies on the understanding of the farmers' decision processes	(Gonzales-Intal and Valera, 1990; Murray-Prior, 1998; Ohlmer <i>et al.</i> , 1998; Murray-Prior and Wright, 2001; Dounias <i>et al.</i> , 2002)
Analytical Event (AE)	Studies on certain farm management decision issues by the way of descriptive approach	(Mistry, 1998; Bandong <i>et al.</i> , 2002; Vaarst <i>et al.</i> , 2003; Matshe and Young, 2004; Blackett <i>et al.</i> , 2006)
Analytical Pattern (APa)	Studies dealing with decision patterns or decision makers' decision styles	(Timsina <i>et al.</i> , 1992; Rogers and Vandeman, 1993; Kalinda <i>et al.</i> , 2000; Ozkan <i>et al.</i> , 2000)
Normative Event (NE)	Studies dealing with rational decision models on specific issues especially under uncertainty or risk	(Piech and Rehman, 1993; Juan <i>et al.</i> , 1996; Backus <i>et al.</i> , 1997; Strasser and Prato, 2002; Humphrey and Verschoor, 2004; Pritchett, 2004)
Normative Evaluation (NEval)	Studies on evaluation of the outcomes of decision behaviour	(Varela-Ortega <i>et al.</i> , 1998; Buysse <i>et al.</i> , 2005; Qiu, 2005)
Prescriptive Aid (PA)	Studies aimed at developing decision support systems or useful means to help farmers make better decisions	(Gauthier and Neel, 1996; Attonaty <i>et al.</i> , 1999; Morag <i>et al.</i> , 2001; Pomar and Pomar, 2005); (Dorward, 1991; McCown, 2001; Swinton <i>et al.</i> , 2002; Coleno <i>et al.</i> , 2005)

and Gopalakrishnan, 2004; Lindgren and Elmquist, 2005) and government policies (Hollick, 1990) have significant impact on farmers' decision-making. It is also clear that farmers' preferred information sources (Solano *et al.*, 2003), the role of information or knowledge (Casey *et al.*, 2002), and information systems (Streeter, 1992; Verstegen *et al.*, 1998) have played a very important role in farmers' decision-making.

Analytical Process (APr): Studies focusing on farmers' decision processes

Analytical Processes and *Analytical Factors* types of decision research are usually predicated on the belief that the main reason for the failure of policies or programs that are launched with the purpose of improving farm management is a lack of understanding of farmers' decision behaviour or decision processes (Ohlmer *et al.*, 1998; Murray-Prior and Wright, 2001; Bekele and Drake, 2003; Illukpitiya and Gopalakrishnan, 2004). Therefore, both types of decision research share a similar research purpose.

The decision research included in type *APr* attempts to describe and predict farmers' decision-making behaviour through developing an understanding of the process of decision-making. The work of Ohlmer *et al.* (1998) is a good example of this type of decision research. They initially used the traditional model of the decision-making process (i.e. values and goals, problem detection, problem definition, observation, analysis, development of intention, implementation and responsibility bearing) in order to describe the farmers' full decision-making process. They subsequently used this approach to revise a conceptual model of the decision-making process.

In another example of type *APr*, a hierarchical decision model (Gladwin, 1980; Gladwin, 1989) employs a two stage decision process, which can be represented as a decision tree, to describe and predict farmers' decisions. Such a model is based on an ethnographic approach for

building the decision models. Gladwin (1980) has claimed that hierarchical decision models studied in many cultures have a high level of predictability with these models predicting around 85 to 95% of actual decisions. In the first stage, decision makers are assumed to quickly narrow down the possible alternatives to a small set by eliminating all those that fail to pass a set of criteria or aspects. This is a form of 'elimination by aspects' theory (Tversky, 1972). This first step, called 'a pre-attentive process' (Murray-Prior, 1998), is used to simplify the problem rapidly and often unconsciously. Once two or three alternatives remain, decision makers take the conscious or 'hard core' step of entering the decision process, which can be further divided into six steps for more comprehensive analysis. Thus, this stage, called 'a conscious stage' (Murray-Prior, 1998), is 'essentially an algebraic version of maximization subject to constraints and may be represented by an algorithm, decision tree or table, or set of decision rules' (Gladwin, 1980).

Similarly, Gonzales-Intal *et al.* (1990) employ a three stage crop decision model that is a modified version of Gladwin's (1980) hierarchical decision model. In the first stage, the family's rice consumption requirement is considered before an elimination process of alternatives is undertaken in the second stage. Gonzales-Intal *et al.* (1990) postulate that after the first stage of the decision process, farmers will choose to plant the diversified crop by moving into the same process as described in Gladwin's hierarchical decision model.

In addition to the hierarchical decision model, many studies (Kirchner *et al.*, 2004; Le Quang and Mensvoort, 2004; Pritchett, 2004) both in the descriptive and normative traditions, have employed decision tree techniques to build up the decision model and to test its effectiveness by visualising complex decision processes and their relationships.

However, most *APr* decision research concludes that the process of farmers' decision-making is very complex

and does not follow a linear process. Thus, in order to understand farmers' decision processes, they need to be considered within a broad context.

Analytical Event (AE): Studies focusing on decision issues with descriptive approaches

Type *AE* decision research is focused on the alternatives that farmers tend to choose rather than the decision-making factors (type *AF*) or the full decision-making process (type *APr*). This study type attempts to describe or analyse which alternatives are chosen by farmers in response to certain decision issues so that researchers can develop a better understanding of farmers' decision-making with regard to specific issues related to farm management, for example, allocation of land use, pest management, water management, and so on.

However, *AE* research typically has a broader research boundary than types *AF* and *APr*. This is because some *AE* research considers both decision factors and decision processes in order to achieve research objectives (Mistry, 1998; Bekele and Drake, 2003; Blackett *et al.*, 2006). Some *AE* research also employs decision tree models to depict the process of choosing between the alternatives or to describe farmers' decision behaviour (Gonzales-Intal and Valera, 1990; Bhuiyan *et al.*, 1995; Le Quang and Mensvoort, 2004).

Analytic Pattern (APa): Studies dealing with decision patterns or decision styles

Most *APa* research deals with the roles of farm family members, especially women, in decision-making about both on and off-farm activities. This is due to the increasing recognition of the importance of women's participation in farming, especially in developing countries, such as India, where women are increasingly becoming involved in almost all stages of farming. Thus, this type of decision research attempts to seek answers to the following research question: To what extent and in what kinds of farm management decision-making do women participate?

Many studies concerning women's participation in decision-making processes (Timsina *et al.*, 1992; Kalinda *et al.*, 2000; Masur, 2000; Ozkan *et al.*, 2000; Debasish *et al.*, 2005) have found that male family members tend to dominate decision-making about farm management, especially in relation to matters of financial management. Despite this, it has also been observed that in decisions relating to production or marketing management, men and women tend to make decisions jointly.

However, these studies do not place a strong emphasis on whether women's participation in the decision-making process is beneficial to farm management decision-making or examine why women's role in decision-making is important. Therefore, in terms of family members' partnership and better decision-making, the importance of women's participation in the decision process needs further study.

Normative Event (NE): Studies dealing with rational decision models especially under conditions of uncertainty and risk

Although both *AE* and *NE* research deal with decision issues or decision events, *AE* is very different from type

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NE due to the different approach that is adopted to the research problem. This difference can best be described as the former type entailing a descriptive study whereas the latter type is normative in its approach.

In the studies on a particular decision event, especially in normative decision studies, decision makers are assumed to have profit-maximising or cost-minimising intentions amongst their multiple objectives. In these cases, the decision makers' goals, objectives and values are also assumed to be known. Further, the consequences of alternative decisions may be known, probabilistically known or unknown depending on the decision issues under consideration.

Type *NE* decision research aims for an optimal and rational decision model which farmers *should* consider when they choose one alternative over another, especially in uncertain or risky situations. Type *NE* research is typically carried out on the basis of economic theory, for example, subjective expected utility theory (Backus *et al.*, 1997) or multiple criteria decision models (Piech and Rehman, 1993; Strassert and Prato, 2002).

Normative Evaluation (NEval): Studies focusing on the evaluation of the outcomes of decision behaviour

The main purpose of type *NEval* decision research is to assess or evaluate the consequences of decision-making on the basis of the assumption that the farmer as a decision maker tries to maximise his/her profit function. However, this type of research concerning the evaluation of decision outcomes was found to be relatively rare in both the normative and descriptive decision research that was published during the period under review.

To evaluate the economic or environmental impact of decision-making, a multi-criteria decision-making (MCDM) model (Martinez-Cordero and Leung, 2004; Qiu, 2005) or a farm household optimisation model (Bernet *et al.*, 2000) is employed. Buysse *et al.* (2005) and Varela-Ortega *et al.* (1998) have used this approach to evaluate the impact of decision-making on the nutrient balance of dairy farms and the impact of the changes of policies on decision-making respectively.

From an examination of type *NEval* research, it is evident that decision outcomes can be evaluated in various ways such as by economic performance, environmental benefit, or the impact of policies. The evaluation of decision outcomes is critical to recognising the importance of farmers' decision-making. However, other aspects like farmers' values or preferences also need to be considered because the outcome of decisions can also be evaluated in a subjective manner. For example, the level of the decision-makers' satisfaction could be varied according to their values on different aspects of farming, from leisure time to profit.

Prescriptive Aid (PA): Studies aimed at developing decision tools or means to help farmers make better decisions

In type *PA* research, a number of web-based or computer-based systems and software programs have been developed to help farmers or advisors collect and analyse various types of information effectively and use it to inform their decision-making (Kerr *et al.*, 1999; Bracke *et al.*, 2001; Morag *et al.*, 2001; Pomar and Pomar, 2005).

However, as the use of computers and access to the Internet has increased among farmers, PA research generally focuses on the development of new decision support systems (DSS). In spite of their potential usefulness, DSS remain unavailable or unhelpful to many farmers, particularly those who are relatively poor, old or less educated, even in developed countries. Therefore to be effective, *PA* research should not only deal with the development of user-friendly DSS but also be accompanied by the appropriate delivery of education or extension programs to train and equip farmers to make better decisions.

Trends in FMDM research

Further analyses were conducted as part of the process of reviewing the FMDM publications since 1990. The initial stage of analysis was directed at detecting any noticeable trends in the type of research being published, the second stage at identifying patterns of publication by the country of origin, and the third stage focused on the aspect of the research. The results are presented and briefly discussed below.

Trends by year and country

The number of FMDM research publications increased significantly from 39 articles during the period 1990–1994 to 79 articles during the period 2000–2006 (see Table 5). As the circumstances surrounding farm management have become more complex and also increasingly affected by unpredictable variables, it is evident that researchers' concerns about farmers' behaviour and decision-making have also been increasing. FMDM research has been consistently dominated by Prescriptive Aid (PA) research, representing one third of all publications, followed in order of frequency by AE, AF, APa, NE, Apr and finally NEval.

Further, there have been an increasing number of publications within the categories *Analytical Event (AE)*, *Analytical Pattern (APa)* and *Prescriptive Aid (PA)* during the first half of the 2000s compared to those published in the first half of the 1990s. It was also observed that there has been a decrease in category Analytical Process (APr) publications since the second half of the 1990s. The number of normative decision studies (*Normative Event (NE)* and *Normative Evaluation (NEval)*) has continued to increase steadily over time.

Four nations dominate the publication of research in this area, with half of all publications coming from the USA (35), India (29), the UK (17) and Australia (11). It

is noteworthy that India has played such a significant role in publication, and also that a large proportion of its publications are of type *Analytical Pattern (APa)*. This is a domain relatively neglected elsewhere that deals with family management patterns and more specifically, the role of women in farm management.

Trends by aspect of farm management

Only 68 of the 183 FMDM research articles that were reviewed dealt with farmers' decisions across the whole span of farm management, while the remaining articles focused on decision behaviour in particular farm management areas such as production or resource management (Table 5). As environmental issues (e.g. soil or water management) and production management (e.g. issues related to organic products) have increasingly become matters of social concern in terms of sustainable farming or consumer-oriented agriculture, the need for decision-making studies on these farm management areas has increased in recent years.

On the other hand, in spite of the importance of marketing and financial management in farmers' business performance, relatively few studies have been published on these aspects of FMDM research. In particular, as shown in Table 6, few *Analytic Process (APr)* and *Analytic Event (AE)* studies have been carried out in the financial management research area.

Consequently, it is apparent that one trend in the FMDM research has been a move away from a broader understanding of farmers' decision-making (e.g. types *AF* and *APr*) to a more detailed analysis of the specific decision matters (e.g. types *AE* and *NE*) leading to the development of decision support systems (type *PA*).

4. Research methods used in descriptive FMDM research

Research methodology can normally be divided into two main categories. These categories are qualitative and quantitative research. These two approaches to research methodology have markedly different philosophical backgrounds, use different research questions and styles of research design, including the ways data are collected and analysed, and apply very different modes of interpretation and description to the resultant findings. Generally, the aim of qualitative research is to add to the body of knowledge through improved understanding of the nature and meaning of social phenomena on their own terms, while that of quantitative

Table 5: Farm management decision-making research by year and by country

Type	By year			By country					Total
	1990–94	1995–99	2000–06	USA	India	UK	Australia	Others	
<i>AF</i>	9	7	12	8	2	6	1	10	28
<i>APr</i>	1	10	3	2	1	–	3	8	14
<i>AE</i>	2	13	14	5	4	3	–	17	29
<i>APa</i>	5	8	11	1	17	–	–	6	24
<i>NE</i>	4	8	9	4	3	1	–	13	21
<i>NEval</i>	–	1	4	1	–	1	–	3	5
<i>PA</i>	18	18	26	14	1	6	7	34	62
Total	39	65	79	35	29	17	11	91	183

Table 6: Farm management decision-making research by aspect of farm management

Type	Whole farm management	Managerial ability	Production management	Marketing management	Financial management	Resource management	Environmental management	Total
AF	7	9	2	1	2	4	3	28
APr	6	4	3	1	1	1	1	14
AE	6	3	8	1	1	7	4	29
APa	20	1	1	1	2	1	1	24
NE	8	1	7	1	2	1	2	21
NEval	3	1	2	1	1	1	1	5
PA	18	13	9	2	5	11	4	62
Total	68	30	31	5	11	24	14	183

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research is to add to the body of knowledge by building on formal theory that explains, predicts and controls the phenomenon of interest (Morse, 1994; Merriam, 1998b; Golcic *et al.*, 2005). Qualitative research often incorporates numeric data such as descriptive statistics, and may employ sampling procedures based on principles fundamental to quantitative research.

Analytical FMDM research tends to use qualitative methods more frequently than normative or prescriptive research, and it was observed that only 6% of normative and prescriptive research studies reviewed for this study used qualitative methods to collect data. This difference tends to be because of the nature of analytical FMDM research. Among the analytical FMDM research papers reviewed, 73% used both qualitative and quantitative methods to collect data concerning farmers' decision behaviours by surveying large numbers of farmers using structured questionnaires and analysing this data using simple statistical methods. The remainder of these studies reported collecting data through qualitative methods such as in-depth interviewing or participant observation, and analysing this data by using 'thick' description. Furthermore, almost all analytical FMDM researchers visited the field to collect qualitative and quantitative data by meeting with farmers personally, while only 5% of studies relied on the use of a mail survey for the purpose of surveying large numbers of subjects.

Qualitative methods in analytical FMDM research

In analytical FMDM research, the most commonly reported method of collecting data was by communicating with farmers personally in the field (e.g. in-depth interviewing or participant observation). In order to determine farmers' beliefs, values and actual decision behaviour, most researchers also expressed a preference for going into the field.

The case study is one of the most common qualitative methods used in descriptive FMDM research. Researchers conducting case study research tended to use non-random samples in specific study areas (Bandong *et al.*, 2002; Bohnet *et al.*, 2003; Le Quang and Mensvoort, 2004) or specific study groups (Streeter, 1992; Ohlmer *et al.*, 1998; Murray-Prior and Wright, 2001; Vaarst *et al.*, 2003; Blackett *et al.*, 2006) in accordance with their research purposes, and interviewed their subjects using open-ended or semi-structured questionnaires. For example, with respect to conducting research with a specific study group, Streeter (1992) carried out in-depth interviews with four farmers and one grain purchaser to explore the impact of electronic information systems on decision-making, and Vaarst *et al.* (2003) used similar techniques to survey 20 farmers who had converted to organic farming within the last two years. Murray-Prior *et al.* (2001) also selected two groups of farmers, a development group and a test group, to develop models of Australian wool producers' production and marketing decisions and to test the refined models.

Some researchers also visited farmers several times over several years (Ohlmer *et al.*, 1998; Bandong *et al.*, 2002). Ohlmer *et al.* (1998) undertook 18 case studies of individual farmers to determine how they made

decisions, and they studied two cases longitudinally for three years through repeated interviews. Bandong *et al.* (2002) carried out surveys in four irrigated rice sites in the Philippines over a span of eight years (1984–1991) to explore farmers' insecticide decision-making protocol. They also visited farmers who were selected randomly across the four sites to interview them and record field notes.

In analytical FMDM research, the data collected through the above qualitative methods were analysed by 'thick' description (Streeter, 1992) and using the decision tree method (Murray-Prior and Wright, 2001; Le Quang and Mensvoort, 2004). Vaarst *et al.* (2003) used a grounded theory approach to categorise the data they collected.

Quantitative methods in descriptive FMDM research

Most of the analytical FMDM research using quantitative methods employed a combination of qualitative and quantitative data obtained in three main ways: the structured interview; mail surveys; and statistical data sets. Quantitative data were analysed through various statistical methods (e.g. from the simple mean, variance or factor analysis through to complicated empirical analysis) to test the decision model or to explore the relationships that existed among various factors.

The first method of data collection, and the most common method used in descriptive FMDM research, involved going into the field and conducting structured interviews with large numbers of farmers who had been selected randomly (Gonzales-Intal and Valera, 1990; Willock, J. *et al.*, 1999; Solano *et al.*, 2003; Chianu and Tsujii, 2004; Selvaraju *et al.*, 2005). For example, Gonzales-Intal *et al.* (1990) collected data on crop diversification from six case studies in the Philippines by conducting structured interviews with 266 farmers who had been selected randomly to test cropping decision tree models. Similarly, Chianu *et al.* (2004) interviewed 160 Nigerian farmers in four villages using a structured questionnaire to investigate the factors affecting farmers' decisions to adopt or not adopt inorganic fertiliser.

The second method of data collection involves undertaking a mail survey that can sample a larger number of farmers with various characteristics from a wider range of study areas. This method also requires less time and expenditure than conducting surveys in the field (Tassell and Keller, 1991; McGregor *et al.*, 1996; Stirm and St-Pierre, 2003; Bragg and Dalton, 2004). Nevertheless, a mail survey may face some problems. These relate to the quality of the data as well as the response rate. Most researchers conducting mail surveys express some concerns about these issues. In some cases, respondents may leave questions blank or skip over them, and they may misunderstand the meaning of questions. These problems can cause the data quality to be compromised, with consequences for both the accuracy and the value of analyses.

The third method of data collection relies on the use of statistical data, for example, data generated through livestock breeding data sets or farm accounting systems (Woldehanna *et al.*, 2000; Kirchner *et al.*, 2004). Some studies have employed secondary data or accessed databases relating to their research goals as a comple-

mentary method (Timsina *et al.*, 1992; Rogers and Vandeman, 1993; Lindgren and Elmquist, 2005). Although this method allows cross-sectional data or time-series data to be collected that allow statistical analysis, the scope for the analysis of various and complex situations (e.g. complicated decision behaviour or processes) may be limited.

Consequently, it can be concluded that qualitative methods, in which researchers typically go into the field, for example to conduct interviews with farmers using semi-structured or open-ended questionnaires, are a common and useful method for analysing diverse decision situations, processes and patterns. In addition, the quantitative approach, in which data are analysed by statistical methods, is also useful for exploring relationships between the variables and factors that affect the decision-making process.

5. Conclusion

In this paper, FMDM research has been reviewed to document the kinds of research that has been published since 1990 and a scheme for its categorisation proposed. Prescriptive FMDM research (*type PA*) that aims to support farmers' decisions by developing various computer systems or software dominates FMDM research. However, it could be argued that studies that improve understanding of decision processes should be conducted prior to development of decision support systems because better understanding can be the foundation of developing more useful decision support systems. A notable feature of this analysis is the relative paucity of studies into marketing, financial and environmental aspects of management (respectively 5, 11 and 14 of 183 studies) despite the growing evidence of the importance of these dimensions to sustained success of farm businesses.

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ways in which to improve outcomes from human activity systems based on agriculture.

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