Chapter 2.

Determinants of farmer behavioural change

This chapter reviews studies regarding the determinants of adoption of environmental management practices in agriculture in general and then specifically the determinants and motivational influences related to climate change mitigation and adaptation.

Results are inconclusive as regards which factors consistently determine the adoption of agricultural best management practices. With regard to mitigation practices the key findings from the literature are as follows: (i) main factors influencing the adoption of mitigation management vary with types of techniques, (ii) both financial and non-financial incentives affect farmers' behaviour, (iii) relationship with neighbouring farmers has significant effects on adoption of mitigation practices, and (iv) the attitudes and beliefs of farmers must be taken into account when designing appropriate incentives.

Moreover, previous studies have shown that psychological and socio-economic factors simultaneously influence adaptation decisions, and understanding how farmers actually weigh the qualitative and quantitative aspects when making decisions may assist policy makers to better understand inter-relationships among these factors to aid them in policy design.

There is a large body of literature which has tried to understand the primary determinants of farmers' behavioural change. Among these studies, there is a literature regarding the determinants of adoption of environmental management practices in agriculture. However, compared to the uptake of conservation management (i.e. of water and soil), there is quite limited empirical research on the determinants and motivational influences specially focusing on mitigation and adaptation behaviour. Accordingly, the relationship between determinants and general farmer's behavioural change is reviewed in Section 2.1. The extension of these findings for mitigation management is made in the following section. Finally, adaptation behaviour is reviewed in Section 2.3.

2.1. Farmer behaviour for conservation management[1]

As a pioneering study, Gasson (1973) analysed the driving forces inducing farmers to participate in conservation schemes, suggesting that a better understanding of motivation could lead to a more adequate explanation and prediction of farmers' economic behaviour. In her study, empirical research on how farmers' behaviour is linked to their attitudes, values and goals was conducted. The main contribution of the many post-Gasson studies is today the established recognition that farmers' goals and values are complex, and that dividing them into behavioural types on the assumption of simple profit maximising behaviour is increasingly difficult to sustain (Defra, 2006). For example, in addition to the single objective (maximising income), McGregor *et al.* (1996) identify that farmers' decisions are influenced by:

- objectives and goals in farming;
- attitude towards the traditional/ethical approach to farming;
- stress and the ability to cope with stress, satisfaction with and optimism about farming, attitudes to legislation;
- risk-taking, autonomy, management attitudes;
- conservation attitudes;
- quality and quantity of information;
- who is involved in the decision making process;
- the individual's ability to solve problems; and
- aspects of their personality.

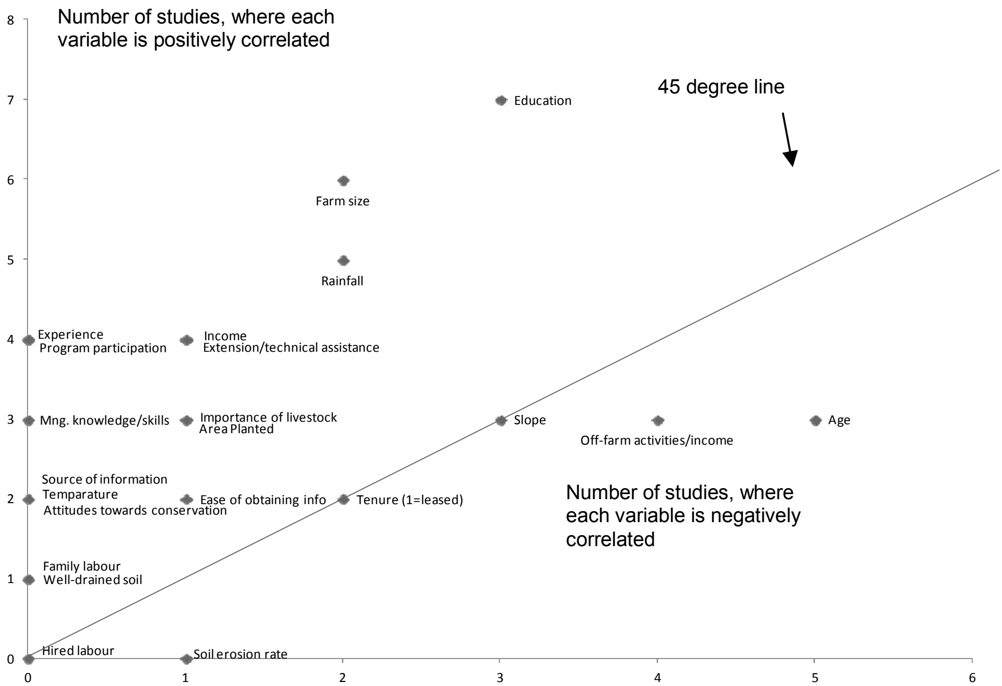
Most of the previous studies used self-reporting questionnaires to elicit farmer data in a particular study area. With respect to the methods of elicitation and the techniques for subsequent analysis on research to understand the behaviour and motivations of farmers, Defra (2006) summarised their methods and the important differences among the most commonly used techniques. In a typical research project, analysts select a number of potential independent variables for inclusion in the analysis.

General overview

Several recent studies have reviewed the previous findings on farmers' motivation for conservation agriculture. Knowler and Bradshaw (2007) synthesised recent research on farmers' adaption of conservation agriculture to identify independent variables that regularly explain adoption behaviour based on the results of 31 recent empirical analyses. Most of these analyses are case studies of North American and African countries. Figure 2.1 shows the results of frequency analysis for independent variables from conservation agriculture adoption analyses adopted from Knowler and Bradshaw's (2007) database. In this figure, the vertical and horizontal axes represent respectively positive and negative correlative sign with conservation agriculture adoption, and data are plotted as the number of indices where the coefficient of conservation agriculture adoption was positive or negative. Not all of their data are cited here, but selected data were used to construct this figure in the cases in which more than five samples (independent variables in 31 recent empirical analyses) are available. It should also be noted that *all* of the variables also contain insignificant results (not recorded herewith).

This frequency analysis is useful for policy makers seeking to find universal relationships across the several studies. Household characteristics will be important in influencing the adoption decision for conservation agricultural managements. As shown in Figure 2.1, "farm size" correlated positively with the adoption of conservation agricultural practices in six previous studies, but two negative correlations were also observed. Regarding the "education" level of the farmer, several studies showed a positive correlation with the adoption of conservation practices; however, some analysis also found a negative correlation and insignificance. Similarly, the age of the farmer does not demonstrate a clear relationship. In addition, differences between owned land and leased land are not clear. Regarding the geographical differences between North America and Africa, Knowler and Bradshaw (2007) found that studies from North America tend to show a more positive significant effect of "education", "land tenure" and "farm size" on adoption than do studies in African regions.

Figure 2.1. Factors influencing the adoption of conservation agriculture in recent studies



Source: OECD, based on Knowler and Bradshaw (2007).

Consequently, the main finding is that there are few variables in past analyses that universally explain the adoption of conservation agriculture. Knowler and Bradshaw (2007) conclude that efforts to promote conservation agriculture will have to be tailored to reflect the particular conditions of individual locations. There is no simple formula to explain which factors may be the most important in a given case, suggesting that understanding local conditions is key.

Similarly, Prokopy *et al.* (2008) reviewed literature that focused on the adoption of agricultural best management practices in the United States in order to examine general trends in the categories of capacity, awareness, attitudes and farm characteristics; they used a vote count methodology and counted every instance of positive, negative and insignificant relationships in 55 studies. The results once again were inconclusive as to which factors consistently determine the adoption of best management practices.

Financial incentives

Financial incentives are used in one of the programmes in the studies cited above, to encourage the adoption of conservation agriculture. In economic terms, addressing externalities through the adoption by farmers of agri-environmental management practices is essentially the "private provision of public goods". However, where farmers are not likely to receive compensation for production of public goods (including because some public goods are provided by the collective actions of many farmers in a given area or watershed), they may not be motivated to produce them (Hellerstein *et al.*, 2002). A farmer will adopt conservation agriculture if the expected net return from participation is at least as high as it would have been if he or she chooses not to participate.

As explained in Annex A, the supply of public goods tends to be socially sub-optimal. This problem has been resolved at both a theoretical level (e.g. Falkinger, 1996) and through experiments (e.g. Falkinger *et al.,* 2000) by using a simple financial incentive. Falkinger showed that a tax-subsidy scheme in which governments reward and penalise deviations from the mean contribution would produce an efficient level of public good provision. Bracht et al. (2008) empirically compared the performance of two incentive mechanisms in public goods experiments. One mechanism was the "Falkinger mechanism" and the other was the compensation mechanism, which allows agents to subsidise other agents' contributions (compensation mechanism) in laboratory experiments. They found that although both mechanisms lead to an increase in the level of contributions to public goods provision, the "Falkinger mechanism" predicts the average level of contributions more reliably than the compensation mechanism.

On the demand side, in order to estimate the appropriate amount of financial incentive, demand for agricultural public goods has been evaluated by standard methodologies such as Contingent Valuation Method (CVM), conjoint analysis (choice experiment), replacement cost methods, travel cost method and, where appropriate, benefit transfers (OECD, 2003).

However, in practice, the relationship between financial compensation and participation in a programme is not expressed by a simple formula. As plotted in Figure 2.1, a positive correlation was found in some studies (e.g. Napier and Camboni 1993, Swinton, 2000), but an insignificant relationship was also found in other studies (e.g. Traore *et al.*, 1998, Soule *et al.*, 2000, Nomura and Yabe, 2007). As featured in Wynn *et al.* (2001), compensation alone may not ensure the success of a conservation programme. Recently, Blandford (2010) reviewed three types of incentives that influence participation in voluntary programmes in his Presidential Address to the Agricultural Economics Society (AES):

- personal satisfaction from environmental stewardship;
- market-based incentives through such factors as consumer preference for green products; and
- government-created positive and negative incentives.

Poe *et al*. (2001) studied the attitudes of farmers: one study of farmers in the New York State area showed that even if they were fully compensated for the cost of participation, only 78% would agree to participate; and when only nominal compliance costs are involved the likelihood of participation falls dramatically. Vanslembrouck *et al*. (2002) found that economic factors were only given by 20%-30% of farmers as the primary reason for not taking part in country side stewardship measures by using survey information in Belgium. Dunlap and Van Liere (1984) showed that improving the environment is a significant motivation for appropriate environmental behaviour only when basic economic and survival needs are met. Wandel and Smithers (2000) found that despite getting information and financial incentives to motivate the adoption of conservation tillage, many farmers rejected this due to the many constraints it imposes. Without a change in attitude, there is unlikely to be significant change in the effectiveness of voluntary programmes.

Another important insight concerning financial incentives is the motivation to "crowd out". A growing body of experimental evidence indicates that financial incentives can be a deterrent to co-operative behaviour (Gowdy, 2008). Kverndokk and Rose (2008) reviewed recent literature on how price incentives interact with moral motivations and considerations. Price incentives may crowd out moral motivations to contribute to a public good, such as a good environment, as it may change the responsibility of the problem from the individual to the regulating authority (Frey and Oberholzer-Gee 1997, Brekke *et al*., 2003) with the result that the net effect may be low. A number of experimental studies show that monetary incentives can be a deterrent to co-operative behaviour. For example, Frey and Oberholzer-Gee (1997) show theoretically and empirically that intrinsic motivation is partially destroyed when price incentives are introduced. In short, the price mechanism becomes less effective. This implication was introduced in Brekke *et al*. (2003) which tried to provide a framework for formal analysis of the relationship between moral motivation, economic incentives, public policy and actual consumer choice. They found that moral motivation is not incompatible with utility maximisation and public policy may have indirect effects on behaviour through its effects on moral motivation. Consequently, financial incentives and motivation are not characterised by a linear relationship. However, since the reverse situation can also be also found, depending on the form (process/design) of policies, generalisation is difficult.

In order to understand the reasons for non-adoption, despite financial incentives, the existence of dual motivations could be one economic explanation. Seminal works by Lynne (i.e. Lynne 1995, 1999, 2006; Sheeder and Lynne, 2009) show that decision-making by farmers reflects a compromise between private and collective utility. The divergences from the economically rational choice could also be understood by applying behavioural economics (an overview is provided in Kahneman, 2003). Further insights on the application of behavioural economics are given in Section 4.

As reviewed in this chapter, farmers do not consider only direct monetary incentives. Indeed, there is a consensus in the literature cited that a financial incentive is not enough when considering behavioural drivers, although there is acknowledgement that the overall picture is not entirely clear. Research on motivation (psychological factors, such as attitudes) is reported in the next section.

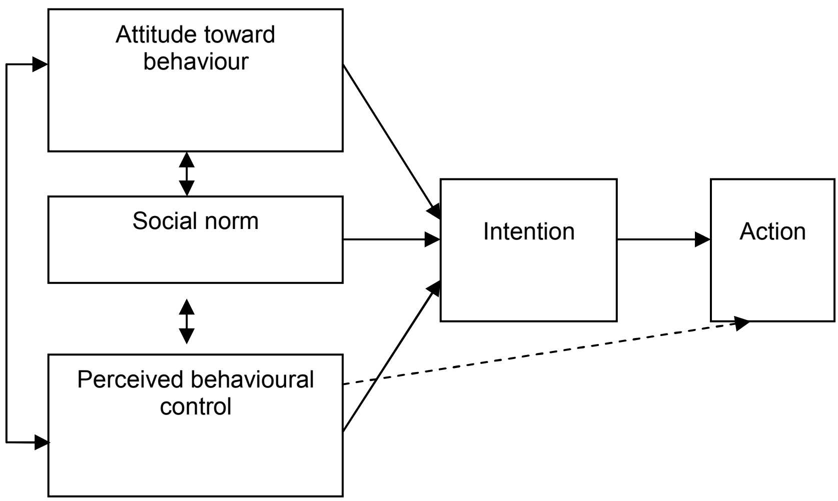
Non-financial incentives

Research on farmer behaviour has recently drawn on the principles of social psychology (Beedell and Rehman, 2000). Regarding environmental attitudes, Morris and Potter (1995) argued that farmers' conservation-oriented attitudes in marginal environmentally sensitive areas (ESAs) could tip the balance toward participation. In order to increase participation, it was suggested that policy makers (and those administering policy) specifically target non-participants. The importance of farmers' environmental attitudes for participation was also pointed out by Wilson (1996) from a case study on environmentally sensitive areas in the United Kingdom. It highlighted that environmental attitudes are important variables to explain farmers' dispositions toward conservation and participation behaviour in the ESA scheme, in addition to age, education, length of residency, farming philosophy, and the existence of semi-natural habitats on farms.

Among several theories that try to explain behaviour, the most commonly used is "The Theory of Reasoned Action" (TORA) (Ajzen and Fishbein, 1980) and its extension to "The Theory of Planned Behaviour" (TPB) (Ajzen 1988, 2005). TPB consists of behavioural intentions, attitudes, subjective norms, and perceived behavioural control.

TPB can be used to predict behaviour and explore the underlying motivations for adopting a particular behaviour. TPB assumes that an individual's behaviour is influenced by three determinants: 1) beliefs about the likely outcomes of behaviour (attitude toward behaviour), 2) beliefs about societal norms (subjective norms); and 3) beliefs about an individual's control over the outcomes of a behaviour (perceived behavioural control). In the aggregate, these beliefs influence an individual's intention to adopt that behaviour. Figure 2.2 illustrates how TPB considers behavioural intentions to be formed, and remains a useful conceptual idea to analyse farmer behaviour (e.g. Sherrington *et al*., 2008, Armagen and Ozden, 2009).

Figure 2.2. Theory of planned behaviour



Source: Adapted from Ajzen (1991).

According to Artikov *et al.* (2006) and Hu *et al*. (2006), who adopt TPB to analyse influence factors of climate forecasts on farmer decisions, TBP can be elucidated as follows:

$$A \approx I = f(Attitude, Social\_norms, Perceived\_control) \quad (1)$$

where A is action, I is intention, and f is a function of the causal factors on intention and action.

- ***Attitude***: Farmers who believe that the use of climate information has a high probability of helping them increase their profits, and who value increased profits, would be more likely to use that climate information.
- ***Social norm***: Social norms can be considered as a person's perception of the social pressure to the behaviour in a particular way.
- ***Perceived behavioural control***: Perceived behavioural control reflects an individual's various beliefs about personal access to or control over

various resources and factors and the extent to which various factors will constrain or facilitate his/her ability to perform the action.

Their results quantify the relative importance of attitude, social norm, perceived behavioural control, and financial capability in explaining the influence of climate information, and short-term and long-term forecasts on agronomic, crop insurance, and crop marketing decisions. The decision analysis in their paper addresses this challenge by combining economics, public policy, and the insights from other social sciences.

The TPB framework, among other research, shows the importance of attitudes. Based on the literature review on motivations and determinants, Kabii and Horowitz (2006) presented a conceptual model to show hypothesised relationships between motivational factors and five constructs: 1) nature conservation equity; 2) economic dependence on property; 3) confidence in permanent covenant mechanisms; 4) nature conservation ethics; and 5) private property rights.

According to these studies, in addition to socioeconomic and structural factors, it is acknowledged that participation depends on farmers' attitudes. However, how and to what extent is not uniform. An Italian study (Defrancesco, 2008) shows that besides income factors, the farmer's future in the business, and the relationship with neighbouring farmers and their opinions on environmentally friendly practices, all have significant effects on the adoption of agri-environmental measures. This report concludes by suggesting that farmers' attitudes and beliefs, as well as local behavioural influences, must be taken into account when designing and communicating agri-environmental measures.

Recently, behavioural science and cognitive psychology have involved the participation of economists. One example of the importance of behavioural science in the adoption of conservation management is the effect of co-operative behaviour. Many experimental results and field evidence suggest that people are willing to choose co-operative behaviour only if others do so. They are also willing to contribute more to a good social cause if they think other people are contributing, and teams seem to act more altruistically than individuals (Brekke and Johansson-Stenman, 2008). Regarding the problem of designing institutions, co-operative action also needs to be considered in policy design. On this point, advisory systems, extension, diffusion of innovation and training have a crucial role in shaping attitudes and motivations. According to Defra (2006), farmers tend to trust their own experience more than other social references.

Incorporating behavioural findings into economic modelling approaches

Recently, findings on farmers' behaviour are being incorporated into policy analysis models (see Defra, 2006 for a review). Assessing the treatment of behavioural issues in agricultural policy models, which are essentially economic models, is a challenging task as economics is a behavioural science. Economic theory is based on a number of fundamental behavioural assumptions: consumers' utility maximisation, producers' profit maximisation and perfect information. When economic agents engage in the act of exchange, in perfectly competitive markets without any distortions, it leads to the maximisation of overall social welfare (Defra, 2006).

Lynn (1995) has already tried to combine social psychology theories (Theory of Reasoned Action, or its extension, TPB) with traditional economic analysis, with respect to farmer's technology adoption. Burton (2004) addressed the importance of motives, values and attitudes that determine the decision-making processes of individual farmers through discussing the "behavioural approach" in the context of advances in socio-psychological theory.

With respect to the public goods provision model, Andreoni (1989, 1990) proposed a "warm-glow model". The utility function is modified by including "own contribution to public goods directly", where individuals maximise $u^i(c_i, g_i, G)$ instead of $u^i(c_i, G)$ (see Annex A for traditional public provision models). Andreoni shows that public goods provision depends on the amount of "impure" altruism. This formulation is more consistent with empirical findings (Bernheim and Rangel, 2007).

2.2. Mitigation management

Agriculture contributes to climate change through actions that produce GHGs, but it can also contribute to the solutions (e.g. carbon sequestration; energy crops that displace fossil fuels; changes in livestock diets). The effectiveness of GHG mitigation methods depends largely on the farmer or land user's response to any potential economic benefits or penalties and motivation including attitudes towards global climate change issues.

Application of key findings from the literature to the mitigation management

As stated in the Stern review (Stern, 2007), policies to reduce emissions need to be based on the removal of barriers to behavioural change, as well as carbon pricing and technology policies. However, few researchers focus on farmer behaviour in relation to mitigation management. Although such studies are limited, farm level mitigation management is, similar, and even overlaps, with the conservation management discussion reviewed later in section 3.1. Best practices for reducing GHG emissions are widely known and previous findings can be extended to this context. Representative management for GHG mitigation in crop farming is summarised in Table 2.1.

Table 2.1. Measures for GHG emission mitigation from crop farming

Measure	Example
Cropland management	Agronomy
	Nutrient management
	Tillage/residue management
	Water management (irrigation, drainage)
	Rice management
	Agroforestry
	Set-aside, Land-use change
Management of organic soils	Avoid drainage of wetlands
Restoration of degraded lands	Erosion control, organic amendments, nutrient amendments
Manure/biosolid management	Improved storage and handling
	Anaerobic digestion
	More efficient use as nutrient source
Bioenergy	Energy crops, solid, liquid, biogas, residues

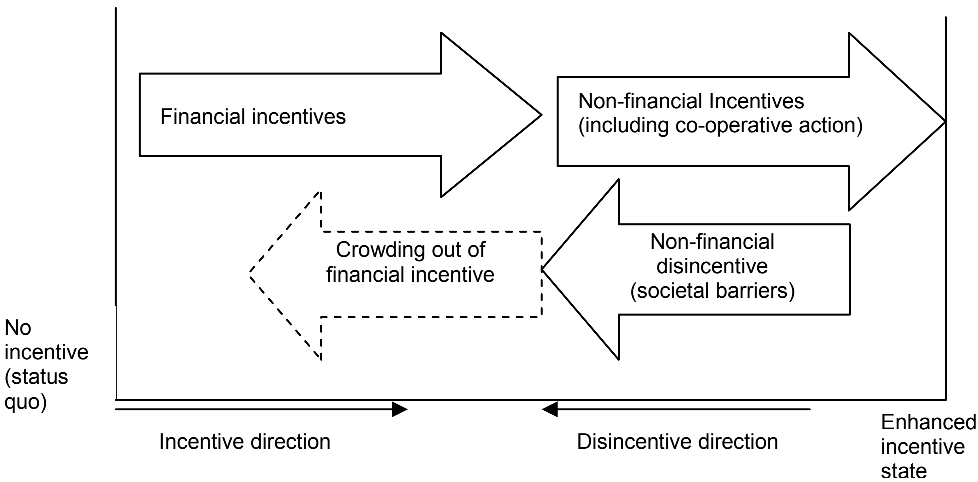
Source: Adapted from Smith *et al*. (2008).

Concerning attitude and behavioural issues, for example, Blackstock *et al*. (2009) reviews the literature relating to the provision of information and advice as a mechanism to encourage farmers to mitigate diffuse pollution. Their paper presents findings from a literature review of influences on farmer behaviour and synthesises three main areas of research: psychological and institutional theories of behaviour; shifts in the approach to delivery of advice (from knowledge transfer to knowledge exchange); and the increased interest in heterogeneous farming cultures. In addition, Ovchinnikova *et al*. (2009) elucidate the attitudes and behaviour of carbon offset providers, which have not yet entered the market, using experimental economics techniques. While trading of credits allows farmers to obtain credits to reduce their GHG emission reductions, the authors found that environmental considerations are powerful motivators and subjects are willing to forgo pecuniary profits for the sake of "doing-the-right-thing." The World Bank (2009) expressed concerns in its *World Development Report 2010* that individual behaviour is often neglected and that an emerging body of social-psychology research needs to examine the barriers and drivers of individual behaviour in relation to both adaptation and mitigation.

There is a lack of sufficient empirical evidence to conclude as to which behavioural determinants are universally significant across countries. However, the main findings in the literature are relevant in the climate change context. As shown Figure 2.3, financial and non-financial incentives could enhance behavioural change, and disincentives, such as societal barriers and crowding-out effects of financial incentives, may affect behaviour at the same time. However, the generalisation of the "crowding-out" effect needs to be treated with caution because it depends on each situation. The key findings from the literature can be summarised as follows.

- The principal factors which influence the adoption of mitigation management vary with types of techniques. Regarding household characteristics and biophysical characteristics, there is no simple explanation as to which factors may be most important in a given case, suggesting that understanding local conditions is key.
- Financial and non-financial incentives affect farmers' behaviour. At the same time, these could also be a barrier due to the crowding-out effect of financial incentives.
- Regarding motivation, the relationship with neighbouring farmers also has significant effects on adoption of mitigation management. Self-interest and shared interest are relevant.
- The attitudes and beliefs of farmers, as well as local behavioural influences, must be taken into account when designing appropriate incentives.

Figure 2.3. Incentives and disincentives*



* This figure is symbolic and the magnitude of each incentive indicated in the figure is hypothetical. There is no consensus on this in the literature.

Characteristics of climate change

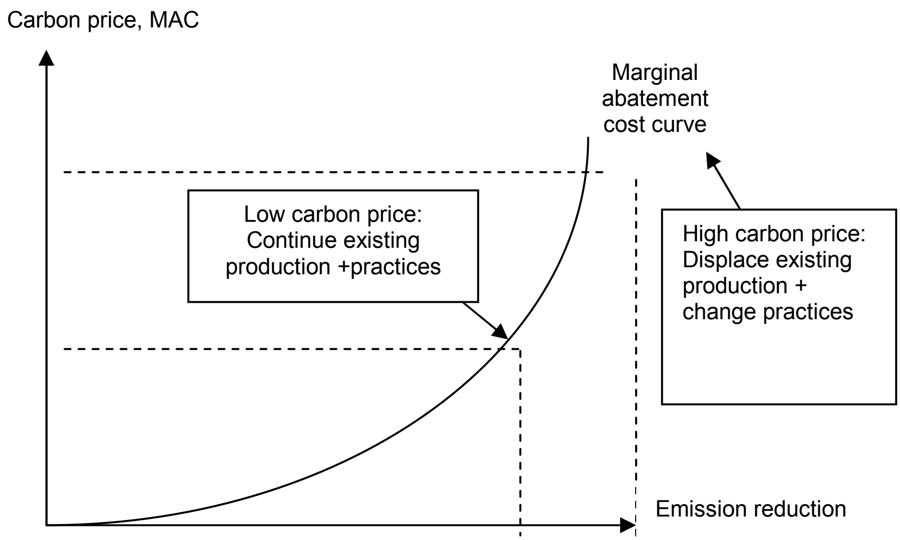
Regarding behavioural change in relation to mitigation in comparison to other environmental issues (especially regional and local environmental issues), there are several specific issues concerning climate change: effect of carbon prices (financial incentive or disincentive), consideration of co-benefits (financial incentive), and priorities compared with other environmental issues (motivation and attitude).

Carbon prices and behavioural change

Depending on farm practices, mitigation options entail additional costs to farmers.[2] Sending clear signals on the costs and benefits of mitigating activities, and providing a real or implicit price of carbon to create incentives, are important for policy implementation. According to economic theory, it is socially profitable to reduce GHG emissions up to the point where the marginal abatement cost is equal to the carbon price, if the carbon market is well developed. As the basis for a cost-effectiveness criterion, in addition to the shadow price of carbon (SPC) which is derived from the estimation of the present value of damages associated with GHG emission, an alternative benchmark can be given by, for example, the European Union Emission Trading Scheme (EU ETS) which provides an opportunity, a cost approach to assessing whether a mitigation measure is worthwhile (Wreford, Moran, and Adger, 2010).

As shown in Figure 2.4, at low prices, the dominant strategies are those consistent with existing production methods, such as change in tillage practice, fertiliser application, diet formulation and manure management, while at higher prices land use change that displaces existing production methods, such as biofuels (and afforestation), and allow the use of more costly animal feed-based mitigation options, are privately and socially beneficial (Smith *et al.*, 2008). Unless the price of carbon is raised sufficiently high, such schemes are likely to be of limited economic interest to farmers.

Figure 2.4. Carbon price and marginal abatement cost



The role of co-benefits in decision making

Incentives and disincentives cannot be assessed solely on their effects of climate change. Recently, Le Foll (2010) stated that compensatory aid is necessary to cover the extra costs arising from meeting some environmental objectives and payments for services rendered to society through the supply of "public goods" in the European Union. In this context, in order to strengthen the financial incentive for mitigation management, understanding the co-benefits and trade-offs of farm management for GHG mitigation is necessary.

The co-benefits and trade-offs of a practice will vary from place to place because of the differences in climate, soil, or the way the practice is adopted (Smith *et al.*, 2007). For instance, the potential positive externalities (co-benefits) and trade offs are as follows.

- *Reduced tillage*: to alter soil organic matter, increasing soil water-holding capacity and lead to the need for less irrigation water (but can also be negative because pesticide application will be increased).
- *Expanded conversion of agricultural lands to grasslands or forests*: to stimulate wildlife populations (but this is also negative for food production).
- *Diminished use of fertiliser: to alter the chemical content of runoff from agricultural lands affecting water pollution, water quality, and ecology of streams, rivers, lakes and aquifers*. Such alterations might improve the characteristics of the waters in these regions for use by non-agricultural water consumers (but could influence food production).
- *Diversion of agricultural lands into energy production*: to reduce CO_2 emissions that might induce technological improvement in agricultural crops, and permit expanded electricity generation at lower cost (but this is also negative for food production and possible non-inducement of innovation).

Smith *et al*. (2007) have surveyed the co-benefits and trade-offs. However, the quantitative valuation of these effects are complicated both physically and economically. From the economic viewpoint, although the Choice Experiment, Replacement Cost Method (CVM) and Experimental Economic Approaches have been used for decades,[3] universal consensus for the valuation techniques has not been developed among academia, or the OECD. Each method has its advantages and disadvantages.

DeFries *et al.* (2004) also pointed out that very few land management practices for mitigation of GHG yield purely win-win outcomes, and most involve some trade-offs. In a win-win situation, an immediate goal (e.g. water purification) may increase in value if the longer-term goal is to maintain ecosystem functions (land preserved).

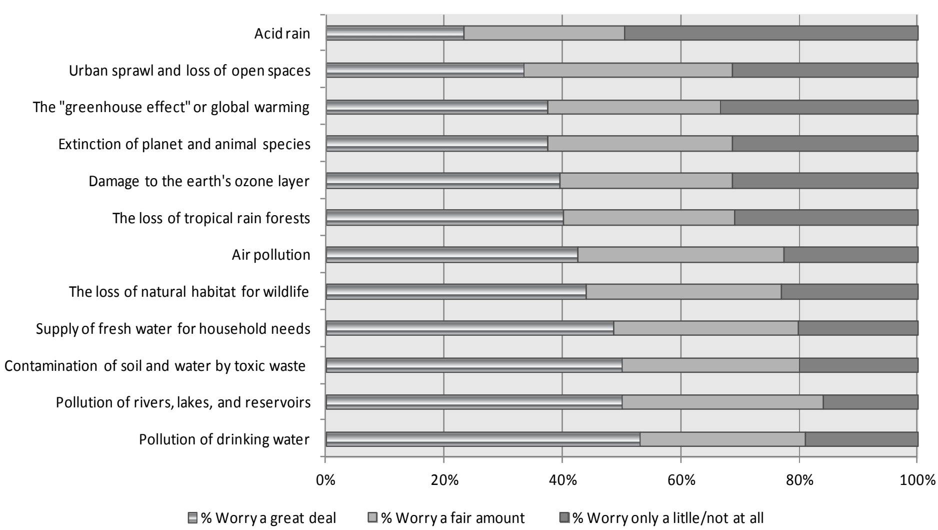
Such co-benefits and trade-offs would play an important role in the decision-making process regarding the selection of appropriate policies and measures at the national or regional level (UNFCCC 2008). McCarl *et al.* (2003) showed the conceptual equation for the cost of mitigation, including the cost of co-benefits, and pointed out that governments may have to play an active role in the assembly, measurement, producer education or market delivering as well as in providing payments for some mitigation (sequestration) related actions.

Is it also necessary to mention that the co-benefits related to land use management for GHG mitigation are not only ecosystem functions but also societal benefits. For example, regional development may be encouraged by creating new employment (e.g. afforestation/ reforestation) (Yedla and Park, 2009). All of these co-benefits and trade-offs could affect farmer behaviour and be determined by farmer behaviour.

Priority of climate change

As reviewed in relation to TPB, environmental knowledge and attitudes play a role in behavioural change. At present, some surveys (Figure 2.5) show that individuals rank climate change lower than other environmental issues (loss of rain forest, water pollution and soil quality, although some of these are linked to climate change). Individuals tend to rank climate change lower than other environmental issues perceived as "closer to home" and visually apparent (World Bank, 2009). It should be also noted that responses and attitudes for the survey on climate change could also be affected by how the question is designed (Krosnick, 2010), and will vary across countries and groups in society.

Figure 2.5. Climate change priority among environmental problems in the United States (2008)



Source: Gallup Poll (April 21, 2008), *www.gallup.com/poll/106660/Little-Increase-Americans-Global-Warming-Worries.aspx.*

2.3. Adaptation management

Damage of climate change on agriculture can be greatly reduced if economic agents adapt efficiently. In this section, key elements needed to understand behavioural change for adaptation decisions are synthesised based on the literature.

Drivers for farm level adaptation

Adger *et al*. (2007) has stated that adaptive capacity is defined as the ability to respond successfully to change, and includes adjustments in both behaviour and technology. For example, Mendelshon and Neumann (1999) estimated damage to agriculture using a cross-sectional empirical analysis of US mid-western counties to measure the sensitivity of yields and profits to climate compared to agronomic models which did not include adaptation. The damage to agriculture was estimated to be 50% less as a result of farmer adaptation.

A wide variety of agricultural adaptation actions to climate change is reported in Smit and Skinner (2002) (see also Wreford *et al*., 2010). They noted that decision-making with respect to adaptation to climate change is not likely to be considered as separate from other agricultural decisions, and most adaptation options are modifications to on-going farm practices. In this sense, the main findings from the previous section of this chapter should be borne in mind. Consequently, if progress on implementing adaptation to climate change in agriculture is to occur, there is a need to better understand the relationship between potential adaptation options and existing farm-level and government decision-making processes and risk management frameworks. Wall and Smit (2005) identify several climate and weather risk adaptation strategies currently in use, with close links to sustainable agriculture practices, based on data from Canadian farmers. They concluded that the mutually supportive relationship between sustainable agriculture and climate change adaptation could be used by farmers to justify more government support for sustainable agriculture policies and programs.

Farm production practices for adaptation include diversification of activities and intensification of crop and livestock production (including crop substitution), changing land use and topography, irrigation, and timing of operations. For example, crop diversification has been a focus of government attention and promotion in Canada, not only in light of anticipated climate change, but also because recent agricultural policy reforms have significantly altered the production and risk environments of prairie producers. However, individual farmers have generally become more specialised in their cropping patterns since 1994 because of start-up costs and achieving economies of scale. Other risk-reducing strategies (crop insurance or securing of off-farm income) may also be preferred by producers (Bradshaw *et al*., 2004)

At both the farm and government levels, adaptation decisions are continuous (Table 2.2). Individual decisions for adaption are influenced by internal stimuli to the farm household, such as the risk of income loss and environmental perception, and the external stimuli that affect the agricultural system at large, such as macro-economic policy and institutional frameworks (Chiotti and Johnston, 1995). In addition, farm level adaptation strategies can be categorised as on-farm production practice management and farm financial management (insurance and risk management).

Table 2.2. Farm level and public level adaptation strategies

Farm level	Public level
Crop and farm income insurance	Investment in research and development (e.g. develop heat resistant products)
Diversification of production	Promote adoption of new technologies and practices
Adjust the timing of operations	Provide institutional support to diffuse information on climate change and adaptation possibilities (e.g. extension services, early warning systems)
Migration (move to cities or other rural regions)	Promote efficient use of resources (e.g. ensure market efficiency)
Adjust intensity of input use (e.g. fertiliser, irrigation)	Review policies to create an environment which is conducive to efficient and sustainable adaptation (e.g. water rights, environmental policies, trade policies, domestic support)
Adopt new production tillage (e.g. conservation tillage)	Enhance agricultural trade to spread the impact of regional supply shortage over the international market

Source: OECD (2008).

As reviewed in section 2.1, extensive literature exists on adoption of new technology, agricultural innovation and extension. Farmer perceptions of risk and uncertainty, institutional and government intervention can all affect innovation (Sunding and Zilberman, 2000), as can social learning and farmer-to-farmer interactions (Pretty, 1995). Connectedness, integration and diversity help the adoption of agricultural conservation technology (Warriner and Moul, 1992), but there is no simple formula to explain what factors may be most important in a given case, suggesting that understanding local conditions is key.

Recently, Tarnoczi and Berkes (2010) pointed out that information from government and producer organisations can be important for the co-production of knowledge that can lead to successful adaptation, based on 28 semi-structured interviews of producers in Alberta and Manitoba, Canada. They emphasised the importance of providing specific technical/regional information to specialty farmers. Accordingly, producer organisations could undertake bridge building by linking policy makers to farmers with local knowledge and experiences by implementing extension strategies at the farm-level.

Real farmer assumption

In the context of measuring the impact of climate change on agriculture, discussion of the "smart farmer-dumb farmer" assumptions have been made since the early 1990s. Previous studies in which no adaptation is assumed ("dumb farmer," Easterling *et al*., 1992a) versus farmer-agents blessed with perfect foresight ("smart farmer," Easterling *et al*., 1992b or "clairvoyant farmer", Reilly and Schimmelpfennig, 2000) could be compared. Schneider *et al*. (2000) suggested that these could be compared to "realistic farmers". The kinds of decision rules adopted by realistic farmer-agents to deal with climate change involve a range of issues.

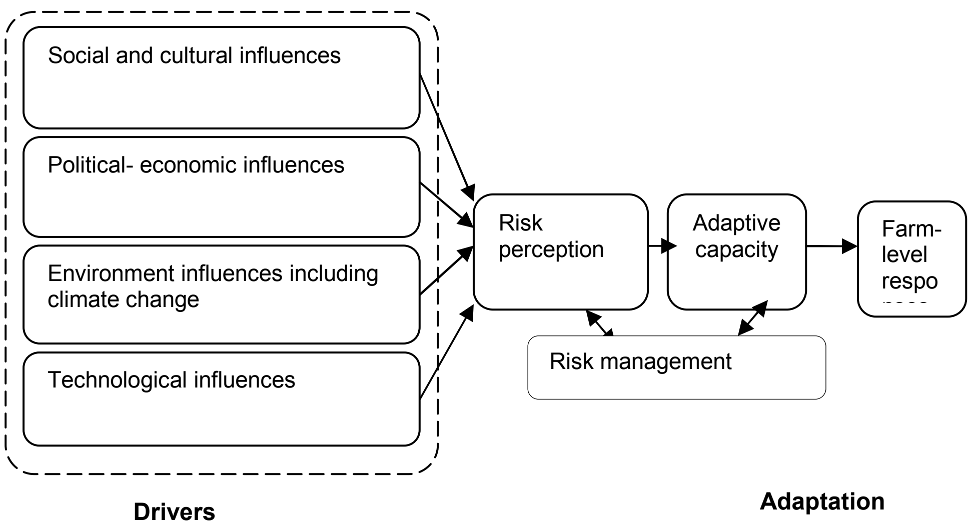
Farm financial management also involves decision making by producers and includes the use of crop insurance, investment in crop shares and futures, participation in income stabilisation programs, and diversification of household income. Adaption strategies are also closely related to the risk management strategy of farming as underlined by the fact that climate change may have some impact on agricultural risk (OECD, 2009). With respect to risk management, several studies (e.g. Turvey, 2001) have identified sources and types of farm-level risk due to climate change. In addition, Easterling (1996) and Chiotti *et al*. (1997) considered how these risks might be managed through adaptation. This study provides valuable insights into agricultural decision-making with respect to adaptation in light of the uncertainties associated with climate change, especially those associated with variability and extremes. While there are such several such options that can improve the economic performance of the farm, appropriate actions depends on regional and local biophysical conditions.

Previous studies commonly assumed that farmers were risk-averse. However, behavioural change under uncertainly is not simple. Repetto (2008) illustrates the characteristics that accompany decision-making under uncertainty in relation to climate change (see chapter 3):

- Because of myopic[4] decision-making, people assign a relatively low priority to climate change because its effects are perceived to occur in the future, not the present.
- Decision makers tend to make small adjustments based on the *status quo* (termed "*anchoring*").
- People tend to resist and deny information that contradicts their value or ideological beliefs. This may relate to the fact that individuals rank climate change lower than other environmental issues.

Tarleton and Ramsey (2008) tried to assess what farmers think of climate change and how it fits into their risk management strategies using farm surveys in Manitoba, Canada. Figure 2.6 depicts the conceptual framework which is provided in their study. Given that climate change risks are perceived in the context of a wide range of other influences or conditions, adaptation is specified as a response to perceptions of risk brought about by external stimuli as evidenced by farm-level responses.

Figure 2.6. Framework of farm-level adaptation



Source: Based on Tarleton and Ramsey (2008).

Previous studies have shown that psychological and socio-economic factors simultaneously influence adaptation decisions, and understanding how farmers actually weigh the qualitative and quantitative aspects when making decisions may assist policy makers to better understand inter-relationships among these factors to aid them in policy design.

Notes

1. “Conservation management” represents as several forms of conservation management practices in agriculture which could contribute to reduce negative externality and enhance positive externality.
2. Note that MAC (marginal abatement cost curves) show there can be win-win action, but not taken up by farmers.
3. Stated preference methods such as CVM and the choice experiment are the means of valuing non-market benefits. CVM has been the most commonly used non-market valuation method, while the choice experiments are relatively new valuation techniques. On the other hand, the replacement cost method is a revealed preference method, and involves the estimation of how much it would cost to replace the externality benefit by a substitute. (e.g. Hanley *et al.*, 1997, see for further explanation).
4. Myopic decision making means ignoring information that is both relevant and available for important decisions at a given time.