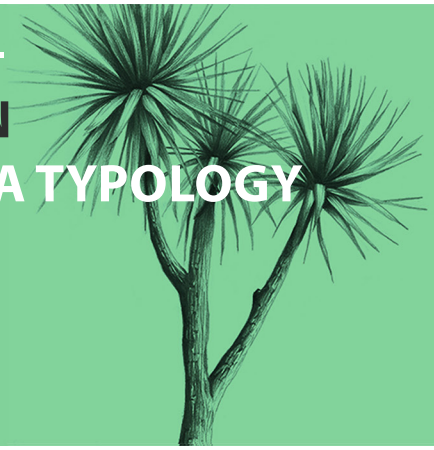
BARRIERS TO ADOPTION OF NO-COST OPTIONS FOR MITIGATION OF AGRICULTURAL EMISSIONS: A TYPOLOGY



Motu Note #24
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INTRODUCTION

Purpose

This typology is intended as background for assessing the existence and significance of barriers to adoption of no-cost mitigation options in agriculture. It is based on a literature review, including the extensive literature on barriers to technology adoption more generally. Its purpose is to identify and categorise possible or potential barriers that might exist, based either on theoretical considerations or analogies to barriers observed in other contexts. Possible barriers are included here whether or not we have identified any evidence of their existence in agriculture, in order to describe the potential universe of barriers that might be investigated in future research.

Definition/scope

We consider "no-cost mitigation options" to be investments, technologies or practices whose adoption (1) reduces the environmental impact of a farm, and (2) does not reduce the profitability of the farm, measured in conventional financial terms. This means that any benefits (e.g. aesthetic) or costs (e.g. psychological) that are associated with adoption but which are not typically included in financial analyses are not considered in determining whether an option is "no-cost" in this context. Under this definition, "no-cost" implicitly incorporates also so-called negative-cost options, i.e. those that reduce environmental impact and improve profitability.

The search for "barriers" to adoption of such measures is agnostic as to what extent farmers seek to reduce the environmental impact of their activities due to their own personal values. Assuming no one actively prefers a dirty environment, and given broad public and regulatory pressure to reduce environmental impact, we would expect that "no-cost options" as defined above would be widely utilized. We use the term "barriers" broadly to include any factor that might explain why farmers might eschew a no-cost option. It is hoped that this typology will allow answers and explanations given by farmers and others to be usefully and systematically categorised.

Because barriers are defined herein explicitly with respect to no-cost adoptions, many reasons why a given action might not be undertaken are not included. For example, the reality that particular options might be very expensive or not work very well are not considered as barriers, because an action with those properties would be expected to reduce profitability.

OVERVIEW

It is useful to identify broad categories of barriers in order organise thinking about them. Any attempt to group or characterize barriers is inherently somewhat arbitrary; some barriers might fit into more than one category. Other ways of

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describing the broad categories might be equally valid. The categorisation is intended simply to facilitate thinking about what kinds of situations might be most important. Because different people might think about barriers from different perspectives, we err on the side of including multiple characterisations, even though this makes the categories somewhat duplicative and overlapping.

We group the identified potential barriers into seven broad categories:

a) Efficient or arguably efficient refers to situations in which the simple financial profitability test fails to measure correctly the true economic impact on the farmer, so that the option appears to be no-cost, but in fact is costly to the farmer when properly analysed. In a sense, "barriers" in this category are not really "barriers" at all, but rather explanations as to why a classification of an option as no-cost may not really be appropriate. We include these possibilities here because they may arise as explanations for non-adoption in surveys or interviews, and this will allow their categorisation.

b) Informational refers to situations in which no-cost options are not utilized because of imperfect availability of information.

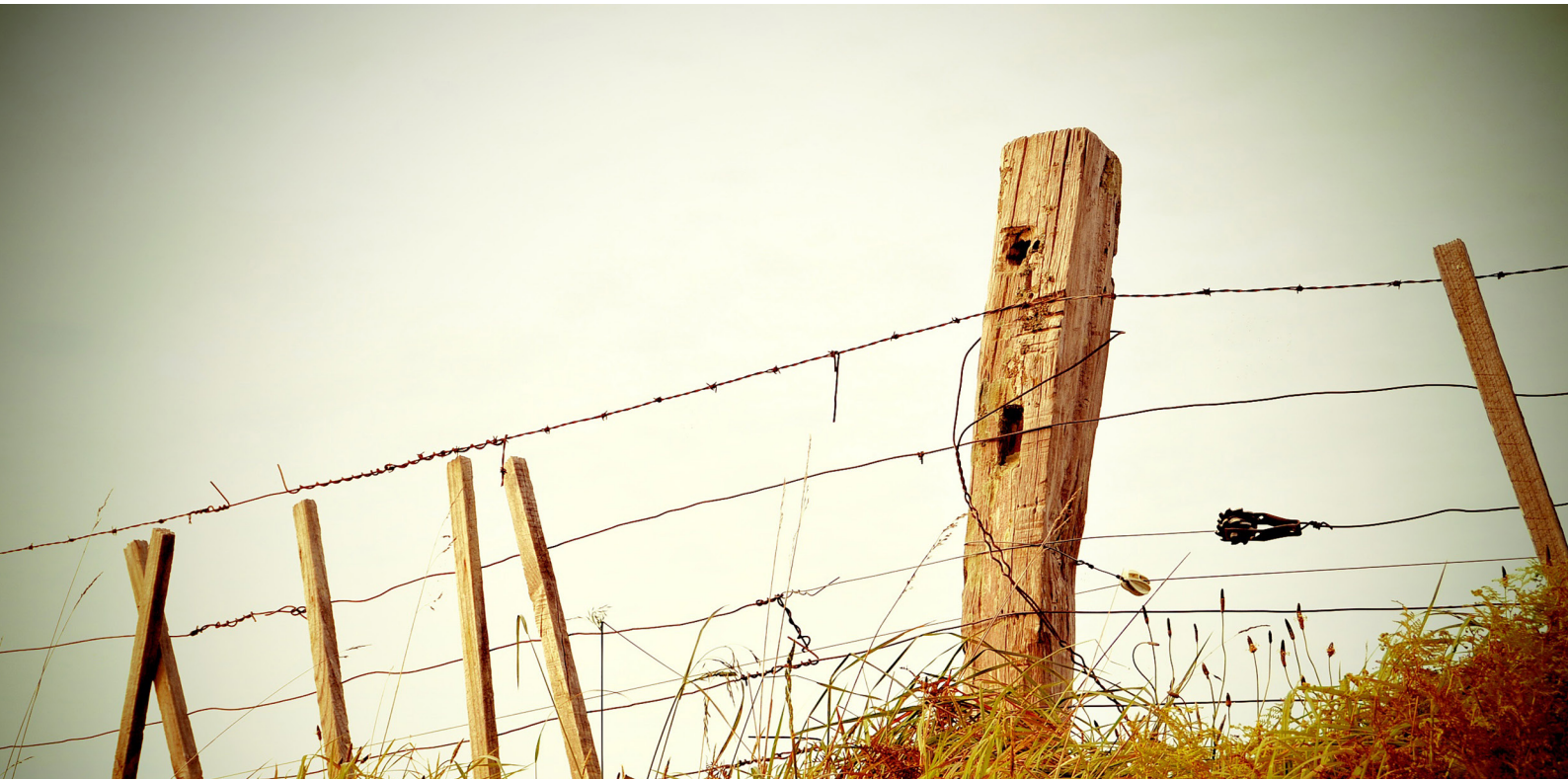
c) Market structure/institutional refers to situations where market or institutional failures inhibit adoption. This is a broad category, and overlaps to some degree with Categories b and d.

d) Externalities can be a source of barriers if a portion of the financial costs or benefits of an option are borne by a party other than the one that decides whether or not to adopt the option. Such separation of impacts from decision-making can potentially arise because of land-holding or contractual relationships, or because of impacts that spread through a supply chain.

e) Regulatory or policy barriers are those due to existing or potential constraints from public policy or the law.

f) Risk and uncertainty can inhibit the adoption of new technologies or practices. This can operate both through rational calculation of the financial consequences of risk and through cognitive inabilities to process uncertainty. This category is therefore a mixture of potential barriers that could fall under Category a (real costs and hence not really a barrier) or Category g (behavioural barriers). Nonetheless, because risk and uncertainty may be top-of-mind considerations for farmers, it may be helpful to highlight as a separate category.

g) Behavioural barriers arise when cognitive biases tend to push economic agents away from rational profit maximisation in a predictable or systematic way.



POTENTIAL BARRIERS

A. Efficient or arguably efficient

No-cost options are typically identified by engineering-economic analyses that quantify the costs and benefits of different options using a combination of data, models and other tools. But any such analysis considers only a finite number of aspects. In some cases, considerations that are economically relevant for at least some users may have been ignored. If so, then this consideration can be thought of as a barrier, in the sense that it is an explanation why an option deemed no-cost is not being adopted in at least some contexts. Alternatively, if this consideration is the reason an option is not being adopted, then the option is not truly no-cost, so the issue of barriers is moot.

Since our goal with this typology is to provide a framework for understanding behaviour and survey responses, we catalogue these arguably efficient possible reasons for non-adoption without worrying about they are truly "barriers" or not. To the extent any of these are determined to be empirically significant in the present context, the question of whether they indeed represent barriers to no cost adoption will be addressed at a later stage.

1. Mis-match of modelling parameters and farmer conditions: Any analysis of an option's performance has to make assumptions about everything from the cost of fertilizer to the discount rate to apply to future benefits (cost of capital). If assumptions are made that match a given farmer's reality, then a costly option for the farmer may appear no-cost in the model.

2. Option value: New technologies are often introduced at a relatively high price, which falls after introduction because of learning-by-doing and other factors. This can result in a situation where it might be profitable to purchase the new technology today, but it will be even more profitable to postpone adoption and convert later when the price falls. If the technology is long-lived so that it would not make sense to replace it frequently, then a dynamic profitability analysis may suggest that the optimal course of action is to wait, despite the current profitability of adoption (Jaffe & Stavins, 1995; Baerenklau & Knapp, 2007). In the literature, this dynamic optimality is characterized by saying that there is an "option value" of waiting that offsets the present-day profitability of adoption.

3. Risk aversion: in calculating the profitability of adoption, a forecast must be made of future costs and benefits. Such a forecast is inherently uncertain. If future benefits (e.g. energy or other operating cost savings) are more uncertain than costs (e.g. initial investment expenditure), then a risk-averse purchaser would rationally discount those uncertain future savings below the expected value or most likely value. This could lead an investment that appears profitable under the most likely future conditions to be unattractive once the risk is taken into account (Jensen, 1982).

4. Heterogeneity of preferences or conditions: The analysis underlying the conclusion that an option is no-cost must be based on some range of typical user circumstances. The option may be no-cost for the typical user, but it might be that there are still many users with different circumstances such that the option is not no-cost for them (Griliches, 1957; Pike, 2008).

5. Variability and model incompleteness: Modelling of technology performance under typical conditions may fail to capture losses under some circumstances that are not necessarily offset by gains in other years because of non-linearities or financial constraints that lead to failure if performance in a single year is too poor. That is, the average effect over different conditions may be negative even when the effect is positive under average conditions. If the modelling does not consider the full distribution of effects, this could look like a barrier.

6. Adjustment costs or learning: The conclusion that an option is no-cost may be based on analysis of performance after the user has learned how to adapt to it. If adaptation costs are high enough or the learning period is long enough, its eventual benefit may not justify bearing these adaption costs. Potential users might rationally conclude that the overall discounted present value of adopting the option is negative (Vanclay, 1992).

Special thanks to Edmund Lou, Oscar Montes and Andrew Reisinger for important comments and suggestions that have helped to shape this typology. Thanks also to the project team for support and recommendations.

B. Information

Information is typically not free and is often transmitted by non-market mechanisms. If potential users do not have the information necessary to understand the value of a no-cost option, this will impede its adoption.

1. Information on existence: Potential users may be unaware of the no-cost option (Newell & Siikamäki, 2014; Feder & Umali, 1993; Marra et al., 2003; Cary & Wilkinson, 1997).

2. Information on context-specific performance: Potential users may know of the option, and know that it is no-cost in many settings, but be uninformed as to how it will likely perform under their specific circumstances (Baumgart-Getz et al, 2012).

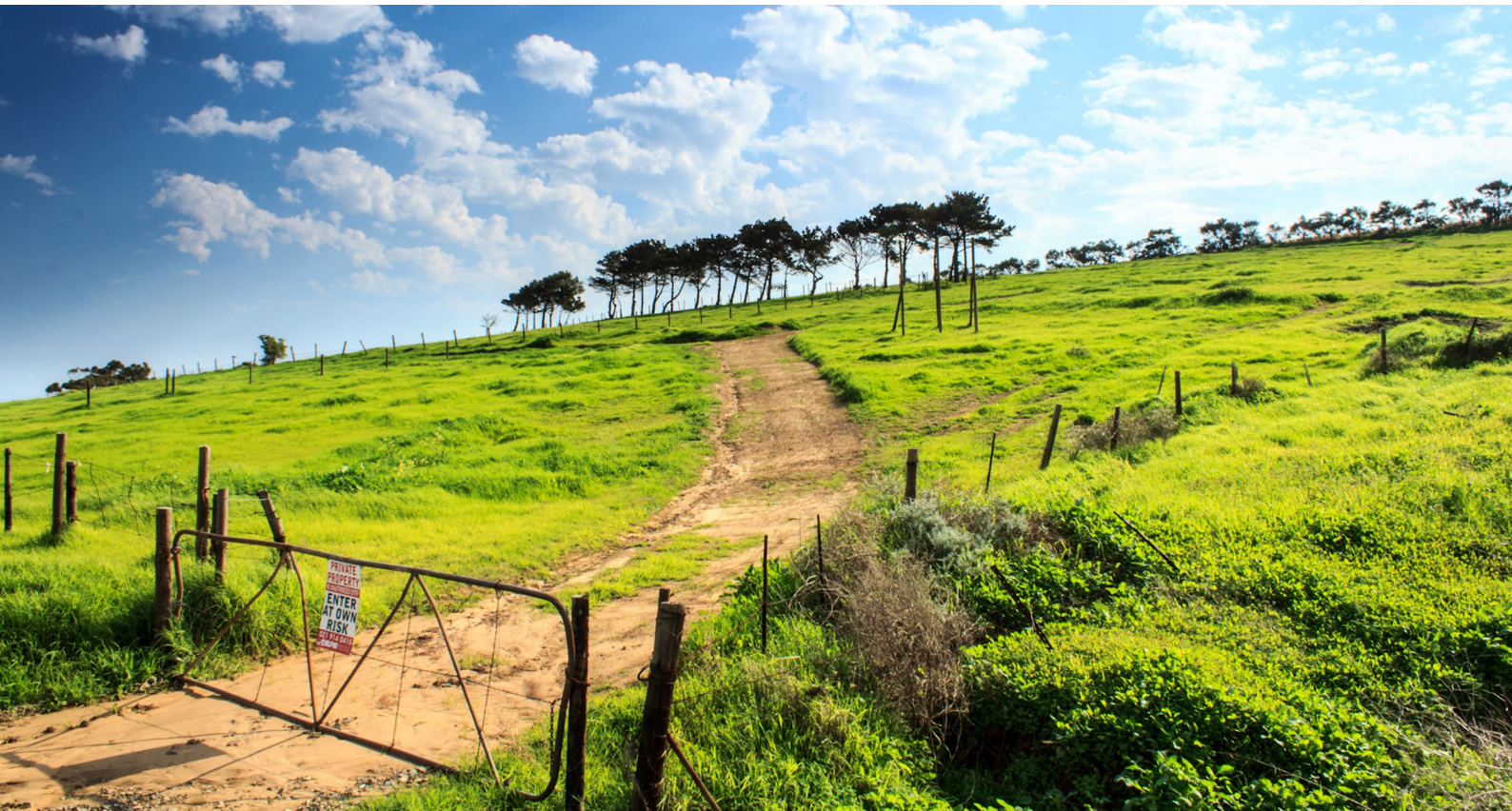
3. Systems interactions may be important: The option may interact with other aspects of farm operations in complex ways, making the potential user unsure of the bottom-line impact, and/or concerned about unintended consequences (Rodriguez et al., 2009).

C. Market structure and institutions

1. Principal/agent or split-incentive problems: If some of the benefits of an investment are enjoyed upstream or downstream in the supply chain from the party making the investment, an option that is no-cost for the supply chain as a whole might not be no-cost for the party making the investment (Jaffe & Stavins, 1994).

2. Inadequate diversity of offerings: If there are fixed costs to offering different versions of an option, and diversity is necessary in order to match the features of the option to different users' circumstances, then the market may offer too few variants on the option, so that some users cannot find one that fits their situation.

3. Capital market failures: If an option requires significant up-front investment, then imperfections in capital markets might make it impossible for some users to finance investment in no-cost options. If, for example, farmers are constrained to seek bank financing from only a small number of local institutions, and those institutions are uncomfortable with their overall level of exposure to farm debt, then a farmer might not be able to get a loan to finance an improvement, even if that improvement pays for itself over time.



4. External drivers: External factors (e.g. demands from up or down the supply chain) may preclude use of some options (Kaine et al., 2004). That is, the new option may require inputs to come in a different form, which, though not more expensive, suppliers do not want to be bothered to offer. Or, on the other side, the option may change the form or timing or other configuration of outputs in a way that is not truly inferior, but purchasers simply do not want to accept.

5. Inappropriate or inadequate extension programmes: Extension in agriculture may fail to match the learner needs (Brown & Bewsell, 2010; MacKay et al., 2011).

D. Externalities

1. The engineering or modelling costs of an option may properly include real costs and benefits that are, for institutional or contractual reasons, not borne by the farmer-decision-maker. For example, a farmer who leases land from another land owner may not be able to capture all of the long-term benefits of changes in land-use practices. Or for historical reasons a farmer may get irrigation water for free, and so not include water savings as a benefit. In these cases a fundamentally no-cost option may not appear as no-cost from the perspective of the farmer decision-maker.

2. Farmers' adoption decisions have impacts on their neighbours, through the spread of knowledge about technologies (Marsh et al., 2000), and potentially through 'learning curve' phenomena that lower the cost of a technology as its use increases. Since we have defined "no-cost" options in terms of their profitability to the individual farmer, effects of options on other farmers should not enter either the modelling that yields the no-cost conclusion nor the farmers' decisions. Therefore such externalities are not truly barriers to no-cost adoption. They are, however, potential barriers to socially desirable adoption. Hence we note them here for completeness.

E. Regulation and policy

1. Safety or other verifications: Product safety, occupational safety or other rules may require some kind of costly verification of compliance when a new practice or technology is introduced. Such compliance costs could be seen as an example of real costs of the new technology, but in some contexts rigidity or ambiguity in compliance definitions or procedures might arbitrarily or inappropriately disadvantage new technologies, in which case they might be thought of as a barrier in their own right.

2. Environmental side effects: Option may have environmental side-effects that are restricted by existing regulations.

3. Need for new regulatory regime: New technology may require new regulatory structure or monitoring regime to be established before it can be implemented.

4. Inadequate/inappropriate regulation: Existing regulatory incentives or extension practice may be misaligned with new option (Pannell, 2008; Morrison & Lockwood, 2013).

5. Uncertainty (or ambiguity) of regulatory constraints: If potential adopters have difficulty figuring out which regulations apply or how existing regulations will be implemented with respect to a new technology, they may be reluctant to adopt.

F. Risk and uncertainty

As noted above, risk and uncertainty surrounding future outcomes associated with new technologies or practices may lead to real or apparent barriers to adoption of no-cost options.

1. The benefits and costs of an option may vary over different conditions of weather, public policy, prices for other inputs and for products, or other external conditions. This may mean that a farmer would anticipate that the option would increase

profits for some future periods and decrease profits in other periods. An apparent no-cost option would be one for which the predicted net of such increases and decreases is at least zero. But if the consequences of a bad period are non-linear, or if the farmer faces financial constraints on ability to weather bad times, then a mixture of good and bad outcomes that is in some sense net neutral may nonetheless be unacceptable.

2. In addition to such possible variation over time periods, there may be fundamental uncertainty about the magnitude of the overall net benefit. Positive net benefit may depend on assumptions about the performance of the option or about average prices for inputs or outputs that are themselves inherently uncertain. If the uncertainty asymmetric affects costs and benefits differently, then adoption of the option may systematically increase the farmer's overall risk, thus discouraging adoption even if the expected value of the consequences of adoption are non-negative.

G. Behavioural

It is now well established that economic decision-makers' cognitive processes can lead to systematic biases or deviations from optimal decision making. Some of these biases are quite specific; others relate to more generic deviations from optimal analysis. In some cases, it may be difficult to identify the exact nature of the cognitive failure, or there may be several potential failures that yield observationally equivalent outcomes. Hence the different types of behavioural barriers may overlap or be difficult to distinguish from each other. Again, since our goal is to maximize the extent to which observed behaviour or survey responses can be fitted into the typology, we include different ways that researchers have characterized these possible barriers, even if they are somewhat duplicative.

1. First-cost bias: In the context of an investment with significant up-front costs, that is paid off by a stream of benefits over time, decision-makers have been observed to place a disproportionately large weight on the initial cost (Hausman, 1979). This could discourage selection of investment options that are no-cost if the up-front costs and subsequent stream of benefits are evaluated in an unbiased way.

2. Salience bias: Decision-makers are observed to focus on particularly obvious or salient issues and ignore or discount issues that are not as obvious but may still ultimately be important (Hossain & Morgan, 2006; Ghadim & Pannell, 1999). Potential cost savings that are a small percentage of total costs, or are in categories of cost that are a small percentage of total costs may be overlooked because they do not seem salient to the decision-maker.

3. Loss aversion or regret aversion: Rational profit-maximizers balance potential gains and potential losses in a symmetric manner, but decision-makers have been observed to place disproportionate weight on avoiding losses (Gonzales et al., 1988; Shadbolt & Olubode-Awosola, 2013). If the outcome of an investment is uncertain, then loss-aversion may discourage investment even if the probabilistic expected value of the investment is positive.

4. Inadequate managerial capability: Implementation of new technologies or practices may require specific skills, or a high level of overall managerial capabilities. It may be that the cost of securing these skills or capabilities is factored into the analysis that determined that an option is no-cost, but if the skills or capabilities are simply not available the option will still not be undertaken (Nuthall, 2006).

5. Social norms/prestige: New practices may be perceived to go against social norms or other bases of prestige (Beedell & Rehman, 1999; Burton, 2004; Moran et al. 2013; Henrich & Gil-White, 2001).

6. Standard practice norms: Farmers may be influenced by desire to maintain conformity with practices of others (Moran et al., 2013).

7. Habitual behaviour: Farmers may be reluctant to change traditions or old ways of doing things (Rodriguez et al., 2009).

8. Trust/credibility: Farmers may not adopt new technologies if they think the source of information is not trustworthy (Carr & Tait, 1990).

9. More generally, farmers may perceive on some level that new technologies or practices would be helpful, but just not want to be bothered to deal with them. On some level, this could be seen as a mixture of the effects of habit and low salience, but it might be easier to test its significance with farmers in this vaguer form.

It is worth noting that some of these "biases" correspond to ideas in the Theory of Planned Behaviour (TPB), one of the dominant psychological models of human decision-making (Ajzen, 1991; Ajzen, 2005). TPB considers that decisions regarding any new practice are determined by three fundamental beliefs: behavioural beliefs that shape the attitudes (positive or negative) towards the behaviour, normative beliefs that determine the importance of subjective norms that may approve or disapprove the implementation of the behaviour, and control beliefs that help form the perceived control over the behaviour. Attitudes towards the behaviour, subjective norms and perceptions of behavioural control jointly constitute the central determinants of an individual's intention and action to perform the given behaviour. Speaking loosely, biases G.1-G.3 can be associated with behavioural beliefs, G.5-G.7 with normative beliefs and G.4 with control beliefs.

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