European Water 60: 17-23, 2017.

Using cross-over analysis to support water user discussion about investments in water sources for irrigation

M.J. Nikkels[1,2,3*], J.H.A. Guillaume[4], P. Leith[2], N.J. Mendham[2], P.R. van Oel[1] and H. Meinke[2,5]
[1] *Water Resources Management (WRM) group, Wageningen University, Wageningen, Netherlands*
[2] *Tasmanian Institute of Agriculture, University of Tasmania*
[3] *Aequator Groen & Ruimte, Harderwijk, Netherlands*
[4] *Water & Development Research group, Aalto University, Helsinki, Finland*
[5] *Centre for Crop Systems Analysis, Wageningen University, Wageningen, Netherlands*
[*] *e-mail: melle.nikkels@wur.nl*

Abstract: Regional long-term water management plans increasingly depend on investments by local water users such as farmers. However, local circumstances and individual situations vary and investment decisions are made under uncertainty. Therefore, the perceived values of costs and benefits may also vary considerably among water users, leading to non-uniform investment decisions. This variation can be explored by examining cross-over points, that is, points of equal preference when comparing alternatives. In a participatory context, cross-over analysis has the potential to structure and strengthen discussions among actors and enhance social learning. This paper presents a framework to use cross-over points in a group setting to support discussions among farmers about strategic investments in irrigation water. The framework is tested in a case study in the Coal River Valley in Tasmania, Australia, where various water sources are available. A discussion workshop is designed to learn from each other's perspectives and investment rationales. Instead of focusing on "what is best", participants engage in a dialogue about when and why a particular water resource is preferable over others for increasing on-farm water availability. These insights can provide valuable background information for investment decisions by other water users, irrigation scheme designers and water managers.

Key words: Cross-over analysis, discussion support framework, personal preference, investment decisions, irrigation water

1. INTRODUCTION

Changing and variable climatic and economic conditions call for strategic and adaptive decision making regarding strategies to increase sustainable on-farm water availability. Regional long-term water management plans increasingly depend on investments by local water users (Turral et al. 2010). When water user investments are expected to increase regional water availability, a good understanding of how and when investment decisions are made is essential. If multiple water sources are available to water users, comparison of alternatives may lead to a clear preference. However, personal preferences will vary with many variables, including: the heterogeneity of local circumstances and situations; real and perceived uncertainties; personal perceptions of the value irrigation might generate and individuals' tacit knowledge (Dampney et al. 2002). This means that preferences may differ based on the set of factors considered when making a decision, how those factors are integrated, and the values assumed for each of those factors. Farmers have individualised, personal decision rules when making investment decisions, whether implicit or explicit. Assuming that a group of water users would uniformly invest if a model indicates it is "worthwhile" might therefore not be accurate. A better understanding of the personal reasoning that determines water needs and preferences can provide valuable background information for investment decisions by other water users, irrigation scheme designers and water managers.

The concept of cross-over points, i.e. the point where two alternatives have the same preference, shifts the focus to two key questions; (1) *when* does an alternative out-favour another and (2) *what* drives the differences in various settings. Crossover analysis is a broadly applicable concept rather than a specific evaluation method. The concept of a crossover point has been applied in a wide

range of fields and variations, for example in agriculture (Dillon 1993), on farm water storage (Arshad et al. 2014), health care (Boles and Fleming 1996), energy systems (Ekren et al. 2009), psychology of humans (Dixon et al. 2003) and birds (Mazur 2000). The concept has also been used to investigate modelled outcomes/recommendations by assessing sensitivity to assumed values for the factors that are taken into account (Guillaume et al. 2016, Hyde and Maier 2006, Ravalico et al. 2010). Crossover analysis has the potential to enhance learning and guide discussion between actors. However, this can only be done when the analytical power of crossover analysis is put in the hands of end users. So far, none of the crossover examples used the experience and expertise of stakeholders to influence the modelling process, as encouraged by Voinov et al. (2016). Further, the previous applications assumed an objective "optimal" outcome and a decision rule that can be captured in a model. This limits their applicability to the present case of interest, where preferences and decisions are at least partly personal or individual.

In this conference paper, we present a discussion support framework (Nelson et al. 2013) that extends the use of the concept of cross-over points to a group setting, aimed at guiding water user discussion about investments in irrigation water sources. To test applicability of the framework, we describe the set-up for a case study in the Coal River Valley in Tasmania, Australia, where multiple water sources are available. Outcomes of these discussions and the full evaluation of the workshop form the basis for continuing research in this field.

2. METHOD

In this section, we present a step-wise framework for using the concept of cross-over points to guide group discussion. Participants discuss: 1) How factors under consideration would have to change to switch personal preference, i.e. for a cross-over point to occur and 2) Why and how this cross-over point differs from those of other participants. The framework is in the form of a checklist, to provide as general a definition as possible regarding its applicability in various settings and situations. The checklist defines the aims that the framework may achieve (2.1), the conditions that must be met for the framework to be applicable (2.2), and the steps required to achieve the aims given those conditions (2.3). The facilitator plays a significant role, discussed further in 2.4.

2.1 Aims

The proposed framework is considered suitable to achieve one or more of the following aims:

- Exploring the robustness of personal preferences. Cross-over points offer an alternative when specifying the uncertainty in inputs and parameters a priori may be difficult or undesirable (Guillaume et al. 2016). Understanding the conditions under which a preference changes gives an indication about the robustness of the preference. One can assess: How likely is it that these conditions occur?
- Eliciting personal reasoning. The proposed framework encourages participants to share the factors they consider, how they integrate them, and the values of each factor.
- Improving understanding of where differences in preference come from. When comparing with others, participants get the opportunity to reflect on their own personal reasoning and learn to understand why outcomes differ.
- Providing input to regional planning that depends on individual decision making. Sharing decision rules and preferences might help others to make investment decisions, reach consensus, or provide background information for planning.

2.2 Conditions

The framework is only suitable if ALL of the following conditions are met:

- Preferences are subjective; there is no objective optimum, with uncertainty in evaluation of alternatives and where reasoning is at least partly individual, unformalised, and non-explicit. In other words, what is "best" for me might not be "best" for you and we both have a personal decision rule based on explicit and tacit knowledge to decide what is "best".
- There are at least two discrete alternatives to compare, within which participants have a pre-existing preference, based one or more factors (which may be uncertain or incomplete).
- There is a dialogue situation, for example a group discussion, in which participants have experience with the alternatives and are willing and able to share their reasoning, with minimal reason to withhold information. For this dialogue to be enquiring and critical, participants need to be open to reflection. The participants must conceptualise the comparison of the alternatives as a "tame" problem (Rittel and Webber 1973) in that they can provide or explore the explanation for their personal preference.
- There are means to handle the range of experience/expertise. There is a facilitator that can provide a safe environment for the participants, and who can manage the process and "deepen" the discussion/dialogue.

2.3 Overview of steps

1. Define the aim of the application. Guiding questions are:
   - What is the choice to make?
   - Why is there a need to test for robustness of preferences?
   - Why is there a need for discussion/social learning?
2. Analyse the situation. Guiding steps are:
   - Identify alternatives,
   - Identify existing personal preferences,
   - Identify factors that influence personal preferences,
   - Check if all the crossover-over conditions are met (Go/No-go moment). Only if all the conditions are met, proceed to step 3.
3. Design a workshop, with guiding questions:
   - Who will participate?
   - Where does the workshop take place?
   - How long should the workshop last?
   - What are suitable techniques for facilitating dialogue for the group in question?
   - What is the role of the facilitator and participants? (see 2.4)
4. Define the needs for outputs of the workshop. The outputs depend on the aim but should contain:
   - Evaluating
   - Reporting

2.4 Role of facilitator

The main role of the facilitator is to improve the discussion by focussing on the "why?" Quickly pivoting from identifying a preference to the "why" is intended to increase depth of dialogue, drawing on the expertise, experience and reasoning of participants, related to both personal reasoning and definition/understanding of the factors discussed.

The facilitator informally guides discussion between participants, while looking for:

- Differences within the group and where the differences come from (reasoning);
- Agreements, which could be in the form of thresholds, after which none or all of the participants would change preference.

3. RESULTS

3.1 Aims of the application

The project has a theoretical and a practical component. The theoretical aim is to test whether the framework is applicable (yes/no), and worthwhile (tested by evaluating learning and perceived usefulness). The practical aim is to support discussion among experienced water users about irrigation water sources in the Coal River Valley in Tasmania, in order to provide valuable background information for investment decisions by other water users, irrigation scheme designers and water managers.

Farmers in the Coal River Valley in Tasmania have had experience with irrigation water since the construction of the Craigbourne dam in 1986. Since then, the valley has changed more than anyone expected as the benefits of irrigation water were hugely underestimated (Lejda et al. 2009). Water demand is still increasing, leading to development of other irrigation schemes and recently the use of recycled waste water from neighbouring communities.

Experienced water users are likely to have gathered skills and information that influenced their irrigation water demand and therefore preferred water source. What would be their preference if they would have to make an investment decision now? It could be beneficial for other farmers to learn from the insights of those with experience when having to make an investment decision or for other stakeholders when designing new irrigation schemes in comparable valleys.

3.2 Situation analysis

In October-November 2016, we conducted in-depth interviews, consisting of an accompanied survey and a semi-structured interview, lasting 1-2 hours, with 13 members of the executive committee of the Coal River Products Association. The elected members represent the range of enterprises in the valley. The members all know each other and have a history of knowledge sharing as they have organised monthly meetings to discuss a wide range of topics related to farming in the valley since 1967. The interview findings gave us sufficient confidence that all the conditions (2.2) were met to proceed and organise a workshop, with its set-up described in 3.3.

There are currently multiple, very distinct (Table 1) water sources in the valley, three of which we selected as the most relevant to discuss.

- Water from the Craigbourne dam, being the oldest and first source of irrigation water that farmers invested in. http://www.tasmanianirrigation.com.au/index.php/schemes/south-east-stage-1
- The use of treated waste water from nearby municipalities. Waste water from the nearby city of Hobart might provide a future extension of this water source. http://www.taswater.com.au/Customers/Recycled-Water
- Water from South East Stage 3 (SE3), coming from the river Derwent, the flow of which is mainly controlled by releases for hydroelectric power generation. The River Derwent has the potential to sustainably provide much more irrigation water than it currently does, however, the development of irrigation schemes is dependent on investment of both water users and the state. http://www.tasmanianirrigation.com.au/index.php/schemes/south-east-stage-3

All the participants mentioned cost, quality, reliability and manageability as being important for their water source preference. Manageability reflects tradability with neighbours, but also the flexibility for using the water (is the water available on demand or is it provided as a constant flow over the summer?). However, these factors, or "characteristics" as farmers called them, encompass different definitions that might also influence preferences. Depending on what farmers grow with the water, their preference and willingness to pay changes. In a sense, the non-monetary variables can bridge the gap between the cheapest and most expensive source, possibly making the latter worthwhile. One farmer said: "The two characteristics I find most important are high security and

high quality. For that, I pay whatever I need to pay to irrigate my orchard". Another farmer said: "I will deal with whatever reliability or quality but I am really focussed on cost. Cost is actually all I look at; if it gets higher than I want to pay, I will not grow a crop and will sell my stock."

Table 1. Water sources and range of values for the most relevant characteristics

	Craigbourne Dam	**Reuse**	**SE3**
Costs, including both capital and ongoing annual costs to get water at farm gate and costs to put it in the farm dam	Middle	Low	High
Quality	Variable but often too poor for sensitive crops	Comes with restrictions	Almost drinking water quality
Reliability	60-90%	80-100%	95% (according to Tasmanian Irrigation)

We divided the enterprises into three types: livestock, annual cropping and perennial cropping. As shown in Table 2, these enterprises have different demands for water.

Table 2. Demands for water, based on enterprise

	Livestock	**Annual cropping**	**Perennial cropping**
Cost (Willingness to pay)	Low	Middle	High
Quality demand	Low	Middle	High
Reliability demand	Low	Middle	High
Manageability	High	Middle	Low

We also learned that (valuation of) characteristics of both water sources and enterprises have changed in the past and are likely to change in the future. Over the years, the willingness to pay has changed; One farmer stated: "I remember when water from the Craigbourne costed 15 $/ML (1000 m^3) and it went to 20 $/ML and we all thought it was too dear. Sometimes you have got to pinch yourself and realise that I'm about to spend 250,000 dollars just to get access to 50 ML of water. If someone would have told me this 10 years ago, I would have thought he was living in fairyland but perceptions change in what you doing. If I tell other growers about the reality of irrigation water they often don't believe me. However, you really need a crop that generates the value that covers the costs".

3.3 Set-up of the workshop

The workshop was organised at the end of February 2017 in a meeting room at the University Farm. The participants were seated in a U-form, where they could see each other and the facilitator. The workshop was scheduled for an evening, lasting 2.5-3 hours, including introduction to the task, two discussion sessions separated by a tea break, and evaluation and wrap-up.

The facilitator, who also conducted the interviews, presented the outcomes of the interviews with the range of values for the characteristics listed in Table 2. This provided an overview of different perceptions, but does not answer "where these different perceptions come from" and "how these differences affect personal preferences". This is what was discussed during the rest of the workshop.

The discussion questions were focussed on how much one characteristic of the most preferred water source for a type of enterprise has to change before personal preference will shift to an alternative water source. The facilitator introduced discussion with a topic question of the form: "How (much) does a relevant characteristic have to change to switch from initial preference to second best?" Participants were asked to fill in their initial cross-over point via PowerPoint add-in for polling called TurningPoint and indicate how confident they were on a personal sheet. We displayed the range and took the average of the (anonymous) answers.

To begin the discussion, the facilitator asked for a volunteer or picked someone: Would this

change lead to a personal change in preference? Why? Why not? How should it change to make it change your preference? From this initial personal reasoning, other participants added to the discussion why their cross-over point differed (or not). After 15 minutes, or when there was agreement among the participants, the facilitator ended the topic by asking the participants to fill in their final cross-over points on TurningPoint and their confidence, as well as whether (and why) their answer changed, on their personal sheet.

Example questions for perennial cropping, where the assumed preference is SE3 water:

- How much should the price of SE3 water go up before others become relevant? Why?
- How much does the reliability of SE3 have to change before others would become the preferred source? Why?
- How much value/ML do you have to create to still prefer SE3 above alternatives? Why?

3.4 Define needs for outcomes

To test applicability of the framework, we had a note taker to evaluate group dynamics, e.g. engagement, attitude, signs of problems. The note taker also looked for indicators of usefulness of the workshop and checked how (if) the concept of crossover contributed to the conversation.

We also want to provide valuable background information for investment decisions by other water users, irrigation scheme designers and water managers. Therefore, the note taker also made notes of the workshop regarding the usefulness of the discussion for generating transferable knowledge. Given the personal nature of preferences, the reasoning of participants is expected to be more transferrable and relevant for others.

We asked the participants to evaluate the framework and their learning by filling in an evaluation sheet with questions including change in reasoning and perceived usefulness of workshop for others.

4. DISCUSSION

We deliberately are specific about the conditions under which we expect the framework could be used. Yet, the restrictions still allow a broad range of topics to be discussed. Indeed, in informal settings, the authors discussed “What would have made you switch from chicken to vegetarian for lunch today?” and “Under which conditions would you quit your PhD?” The conditions may also be revised as a result of evaluation of the workshop.

The main strength of this framework is its ability to engage participants in a dialogue that explores their preference based on personal reasoning. During the workshop they receive input from others and have a discussion that provides valuable information/insights for both the participants and for outsiders.

A possible risk, anticipated for before the workshop, is that the conversation stays shallow. When reasoning is not sufficiently explicated or incomparable with other participants, the learning experience of participants and the development of transferable knowledge will be hampered. The facilitator has a significant role to play by encouraging participants to explain their “why”, while avoiding imposing their views. Another possible risk is that participants might have an incentive to not share their preference and reasoning as they might fear it can be used against them. Hence, the success of the approach strongly depends on the level of trust amongst all participants. The process must be legitimate and must be seen as legitimate for participants to gain.

During the workshop, the discussions started with focussing on one characteristic of the preferred water source for a particular enterprise. However, in real life, participants might have a combination of water sources, using water to irrigate various enterprises at their farm, which could allow mixing, risk spreading and opportunistic farming. Further, it could also be that characteristics are correlated, which makes it more intuitive to discuss water sources in a slightly different way. For example by focussing on multiple characteristics at the same time or by discussing under which

conditions participants would change enterprise, given a certain water source.

In our application we discussed personal preference within a homogenous group of stakeholders with the same aim: optimise water availability at their own farm. If social learning is "learning together to manage together" (Pahl-Wostl et al. 2007) it would be interesting to test the framework in a more heterogeneous group where preferred outcomes are based on different backgrounds, expertise and scope. An example discussion topic in the Coal River Valley would then be: Under which conditions is reuse water the most suitable water source to increase water availability in the valley?

The cross-over point framework presented in this paper shows promise to further support water user discussions. Follow-up research will focus on the outcomes of the discussions and on the evaluation of the framework. It will provide better insights into the conditions under which such discussions can take place (2.2) and evaluate the contribution of the framework to the aims (2.1). This allows us to explore applicability of the framework in different settings.

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