Supporting Integration: Knowledge co-development in a large multidisciplinary research project on water use and management in Victoria's Goulburn-Broken catchment

Sonya Love, Rural Innovation Research Group, Melbourne School of Land and Environment
The University of Melbourne, Melbourne, Victoria, Australia

Margaret Ayre, Rural Innovation Research Group, Melbourne School of Land and Environment
The University of Melbourne, Melbourne, Victoria, Australia

Ruth Nettle, Rural Innovation Research Group, Melbourne School of Land and Environment
The University of Melbourne, Melbourne, Victoria, Australia

I. Introduction

After a period of extended drought in southern Australia and likely continued impacts of climate variability on natural resource and agricultural systems, national efforts at reforming water policy and management set the context for a large interdisciplinary project called Farms Rivers and Markets (FRM). FRM aims to create opportunities to 'do more with less water' and acknowledges 'the key challenge [of research and policy for integrated catchment management] is to coordinate change'.

The FRM Project aims to integrate research and community knowledge/s in the development of new water management options in the Goulburn-Broken catchment in northeastern Victoria. How do diverse groups develop new knowledge and options for catchment management? We believe that the experiences of the FRM project provide an opportunity to not only 'learn by doing' through action learning approaches to the integration of research knowledge for development of water management options, but to develop an understanding of the processes that can support knowledge co-development in other complex interdisciplinary natural resource management (NRM) projects.

II. Research or development? Supporting knowledge co-development through community engagement

The 'Farms, Rivers and Markets' project primarily understands itself as an interdisciplinary *research* project. The project includes detailed modeling of farm systems and irrigation systems. It also includes ecological research. The project aims to develop better knowledge about the interacting systems of water use and management operating within a case study catchment (the Goulburn-Broken catchment). Central to the project is the integration of the various research efforts in the *development* of new water products and services. A better understanding of the possibilities and constraints within agricultural systems, ecological systems and irrigation delivery systems should enable the identification of opportunities to use water differently. However research outputs alone will not ensure the success of the project; success depends on the integration of research outputs and the development of water management options.

Agricultural and natural resource management (NRM) innovation systems are ostensibly built around the RD&E (Research – Development – Extension) continuum, but often investment and energy are focused on research and extension, with little attention to the domain of 'development. As (Nettle, Brightling *et al*. 2010) write of the Australian dairy industry:

> ...the development process is not well understood by either [research or extension] and usually receives cursory attention. Project designers and leaders have been operating intuitively around what is needed for development...This is likely to be a major limitation to practice change, innovation and resilience...

In our experience, current approaches to development in NRM are likely to be similarly limited. However, development is critical to the success of RD&E, since development processes often enable us to identify which research or extension issues need to be addressed to make progress on complex problems.

Development refers to the work that happens between generating a concept, tool, approach or technology (research) and its promotion, adaptation and use in practice (extension). The development process is about increasing the capacity of a concept, innovation or idea to achieve its purpose. Good development should deliver a qualitative change in the potential of an innovation, by developing an understanding of the opportunities it presents, to whom it is relevant, and the support requirements for its successful use in practice to achieve desirable outcomes. Furthermore, good development should mediate between research-push (which can lead to delivery of tools and technologies poorly suited to users – but may deliver highly innovative solutions) and demand pull (where relevant technologies are delivered but potential opportunities for innovation can be missed).

We identify three key challenges that often hamper development:

- The development role cannot usually be performed by one individual (although leadership and facilitation is crucial (Billaud, Brives et al. 2004)). Good development requires a deep understanding of both research potential, and needs in practice. It also requires an ability to identify and create opportunities to connect research and practice. Development relies on diverse individuals working collaboratively to share their understanding of different elements of systems, ie joint action and social learning (Parson and Clark 1995). This can be organised around either a problem (water quality; animal disease; etc) or around an idea, technology or policy (robotic milking system; assessment tool for nutrient loss risk; etc)(Boxelaar 2004).
- Development requires time, energy and commitment without always producing rewards that are quickly visible. The products of development work may include modifications to research outputs, guidelines for extension and/ or the development or compilation of supporting material. However the primary product of development is design knowledge (knowledge about how, where, when and to whom a research product will be useful, and about what support is required for successful implementation) and design relationships (the relationships between people and programs that enable research to be translated into practice). These kinds of intangible outcomes are often overlooked (Rickards and Price 2009), leaving participants to do un-resourced development work in addition to their 'real' work only because they are motivated by intangible rewards such as developing professional networks, contributing to social good and/ or developing new ideas.
- Development is time consuming, particularly in projects involving many participants from diverse knowledge backgrounds. This is a particular challenge where participants are time-poor.

Understanding the challenges of development can provide a first step towards generating processes that enable and support development. We believe that recognising and resourcing development will lead to better project outcomes (ie more progress towards managing complex problems such as integrated catchment management).

What might be the implications of thinking about the FRM project as primarily a *development* project (including significant and important research components) rather than as a *research* project *per se*? We suggest that this has implications for both method and project design including processes of engaging different actors which we describe below. Furthermore, we propose an epistemological framework for action learning and inquiry that focuses on collective processes of knowledge making.

III. SUPPORTING KNOWLEDGE CO-DEVELOPMENT: IDENTIFYING ACTION AREAS FOR KNOWLEDGE MAKING

There are multiple communities both within the FRM project, and outside the FRM project, who need to be involved in development activities. The project is a multi-disciplinary enterprise involving around 50 researchers across different faculties and multiple universities. The first layer of community engagement actually needs to occur within the project; where communities of researchers engage with one another to integrate findings and co-develop water management options. The second layer of engagement required is between specific research modules and relevant communities of practice; for example, the farm systems modellers need to engage with farmers in order to design relevant experiments and to ensure they develop an understanding of farm systems that reflects real current practice on farms in the catchment. The third layer of engagement is between the FRM project and the communities interested in the project outcomes; namely residents and stakeholders within the case study catchment and across the southern Murray Darling basin. These stakeholders can bring broad understandings of the system and its purposes to the development of water management options.

We propose building community engagement in the FRM project around the establishment of 'action arenas'; social spaces where individuals interact in collective action situations (Ostrom 1990; Davenport and Leitch 2005). Action arenas bring together individuals from two or more communities for a particular purpose (sharing ideas, discussing a problem, developing a product, etc). They may occur at one particular time and place (for example, a workshop) or extend over time and space (for example, an online discussion forum that continues for months or years). Within these action arenas we aim to establish productive working processes that lead to knowledge co-development.[1]

Knowledge co-development occurs when diverse scientific and non-scientific actors work together to develop concepts, tools, approaches or technologies that are appropriate for management. We draw on theories of social learning, action science, and community engagement to explore some of the key processes of knowledge co-development in FRM.

Community engagement for knowledge co-development needs to address the issues of engaging with multiple communities, and of managing different types of participation in the project. We draw on action science theories and methods to inform our design of community engagement for knowledge co-development. In particular, we attempt to describe and establish communities of inquiry within action arenas, and explore within these communities of inquiry the theories of action and problem framing that influences current action. We use this inquiry to inform a deliberative approach to change (Friedman and Rogers 2007). We believe that paying attention to knowledge co-development in this way can result in projects where there is a better connection between research outcomes and practice needs, and consequently more progress towards addressing complex problems.

1 Community engagement activities in large interdisciplinary research projects often provide opportunities for knowledge co-development to occur. Firstly, researchers need to come together and understand one another's work in order to prepare for community engagement; this 'forced' integration prepares researchers to engage in development activities with external stakeholders (Morris et al. 2002) from even more divergent backgrounds. Secondly, community members and project stakeholders have opportunities to engage with researchers both formally and informally through planned community engagement activities; this interaction helps to build understanding across communities and can provide the conditions required for social learning.

IV. A MULTI-DIMENSIONAL FRAMEWORK FOR COMMUNITY ENGAGEMENT: IDENTIFYING MULTIPLE COMMUNITIES AND MULTIPLE ENGAGEMENT PURPOSES

Although the importance of engaging with the people that can contribute to, influence or be impacted by research or policy change is well accepted, research has identified constraints to improving sustainability efforts via community engagement. Harrington *et al*. (2008) identified the discourse for community engagement to be problematic, as concepts relating to community participation have been unclear (who is the community and what constitutes participation?). Second, the focus has been misdirected, with an overemphasis on engaging communities of place (where communities of practice, or communities of interest, may be more important).

We suggest that there are three community types that are central to successful knowledge co-development in the FRM project:

- **Research disciplines**. The FRM team includes researchers from a range of different disciplines (farm systems modeling, freshwater ecology, engineering etc). Core to the project is the development of water management options that address the needs of both farming and environmental uses of water. Developing these options requires detailed research work within disciplines, but also communication between disciplines, and the engagement of each research community with other research communities.
- **Communities of practice**. Water management options will enter the catchment through the practices of farmers, water managers (both environmental water managers and irrigation system managers) and policy makers. Engaging with these communities of practice and understanding the implications of proposed water management options for their practices is central to achieving changes in catchment management. Each of the FRM modules addresses a particular practice group, and developing the linkages between researchers and practitioners is critical to reducing the errors associated with translating research into practice.
- **Communities of interest**. There are two key communities of interest with a stake in the outcomes of the FRM project. The first community of interest is represented by the current steering group. This group includes project funders and others who are interested in how findings from this project can inform catchment management beyond the immediate case study catchment. The second community of interest is the local community, including rural industry groups, catchment residents, and recreational users of water and waterways in the catchment. This group is interested in how water in the catchment is managed since it impacts on their own industries, land, homes, businesses and recreational activities. They may also have knowledge about current water management practices that can inform the development of new water management options. The concept of ‘social flow’ (Alston and Mason 2008) may be useful in identifying the members of this diverse community of interest.

This analysis of community types provides us with a conceptual framework for understanding action arenas that are currently or could potentially be established within the FRM project. We summarise them as follows (represented diagrammatically in Figure 1 below):

- Action arenas that involve multiple research communities within the FRM project (for example whole-of-project team meetings, working groups involving researchers from several modules, informal interactions around the preparation of papers and reports).
- Action arenas that involve interactions between particular parts of the FRM project and particular practice groups (for example, the farmer reference group connects the Farms module with practicing farmers in the catchment; the catchment reference

group connects the Rivers and Markets modules with irrigation managers and environmental water managers; there is also potential to explore ways of connecting the Markets module with policy practitioners).

- Action arenas that involve interactions between the FRM project as a whole and one or more communities of interest within the case study catchment or beyond (for example, the Steering Group provides an opportunity for the FRM project team to connect with catchment management experts; the project may also benefit from developing further opportunities to engage with particular interest groups within the case study catchment, particularly those interest groups whose networks and influence extends beyond the catchment (such as industry groups)).

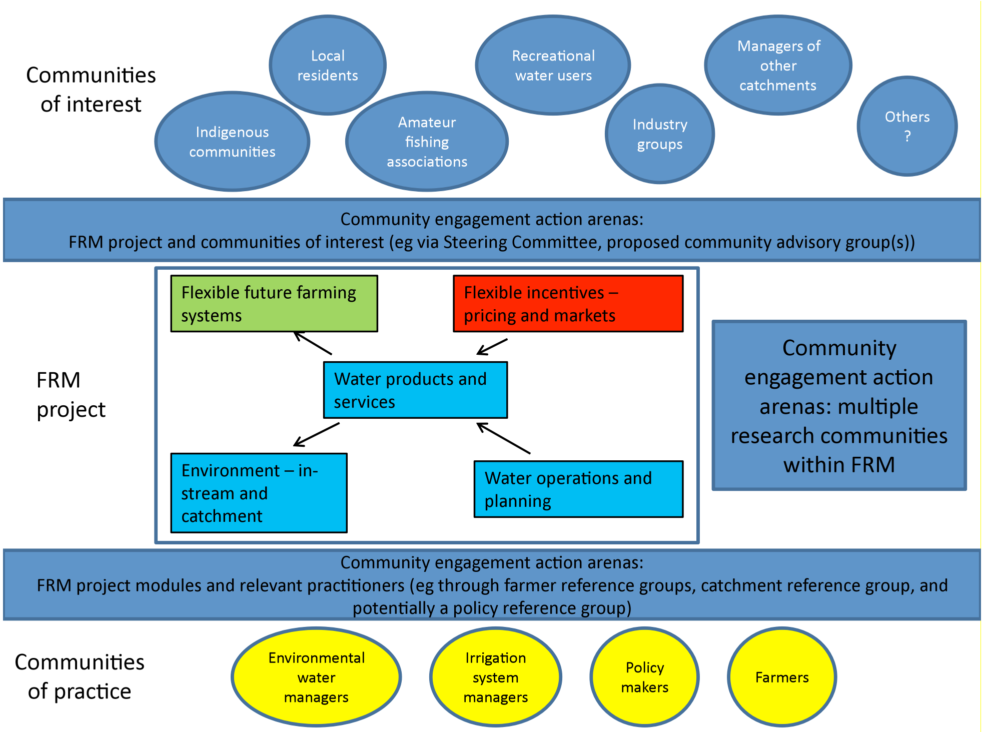

Figure 1. Community engagement action arenas around the FRM project

V. A THEORY OF ACTION AND PROBLEM FRAMING: KNOWLEDGE/S AS DIVERSE SETS OF PRACTICES

The RD&E model of innovation is a widely used conceptual framework for understanding the relationship between science and technology to the economy (Godin 2006, p. 639) In order to locate action and manage investments, this model defines sites of knowledge production and endeavour as located in the separate domains of 'research' and 'development' and 'extension'. In circumscribing these domains, the model effects a strategic distinction between activities that 'represent and describe so-called *real-world* conditions and objects' (what we describe as 'research') and those that translate and adapt or apply these activities and objects— the activities traditionally described as 'development' and 'extension'. Here we want to challenge this distinction by proposing an alternative epistemological framework (or problem framing) that takes all scientific work to be the outcome of collective practices involving humans and non-humans symmetrically. In this framing, 'research', 'development' and 'extension' are dissolved as distinct stages or domains in a project such as FRM. We apply an action research methodology to describe how sets of diverse practices emerge, coalesce and diverge in particular times and places to produce useful knowledge/s for change in integrated catchment management.

Our framework refuses the foundationist epistemology characterised by Western science. This framework has the 'objects' of scientific research endeavours being generated separately from the ‘subjects’ (human actors) or application of scientific knowledge: the people and places we are seeking to describe, mobilise or change as a result of scientific research work. The foundationist view of science has been critiqued widely in the study of science and technology as a strategy for sustaining the privileged stance of technoscience in relation to other knowledges (see (Haraway 1992; Latour 1993; Verran 2000; Law 2004).

In our work in FRM, we are interested in looking at ways of *engaging* the question of ‘doing more with less water’ that does not prescribe a moral imperative designed by a foundationist interpretative framework. This particular frame sees, as Verran explains, ‘some sort of foundation (either the ‘physical entities of the world’ or ‘the concrete practices of the social world’) on which a knowledge-structure of symbols is built’ (Verran 1999, p. 143). This frame is not useful when trying to devise new approaches to sustainability in the context of water use and agricultural production as it prescribes a singular basis for interpretation (that of science). We require an interpretative framework that can account for diverse knowledges and multiple epistemologies: what Mol (2002) calls the problem of ‘difference’. Managing this problem of difference is the work of doing multidisciplinary research for improved catchment management policy and practice.

The commitment of technoscience to singular objects as representations of a ‘true’ reality has been found wanting by postmodern commentators: this commitment does not allow us to deal with the diversity, complexity and contingencies of multiple actors (human and non-human) engaged in multiple knowledge communities (see below) in an endeavour such as FRM. Scholars in the social studies of science, and in Actor Network Theory approaches in particular, have described the production of scientific ‘facts’ as outcomes of collective action involving people, devices, institutions, and texts (data) in networks of action and interaction (Callon 1986; Latour 1987; Mol and Law 1998; Law 1999; Mol 2002).

Shapin and Schaffer (1985) propose a typology of practices for understanding the strategies of knowledge production in scientific work. They propose that knowledge work proceeds through particular types of processes, called ‘technologies’ of knowledge making. The three kinds of knowledge making technologies they identify—literary, material and social technologies—are mutually co-constituting: they generate particular outcomes (for example, objects, encounters, actions) from the various combinations and links between various technologies or what we call here ‘knowledge practices’. In this framework, knowledge is generated or performed (Mol 1998) in embodied and collective processes using historically achieved social, cultural and political resources. In taking inspiration from Shapin and Schaffer (1985), we understand knowledge to be made in the collective material, textual (semiotic or representational) and social practices of doing R,D and E (in this case ‘doing FRM’). This typology of knowledge practices allows us to see how differences across so-called ‘scientists’’ and ‘practitioners’’ knowledge/s can be managed to achieve a working sameness. A working sameness allows people to go on together doing useful work despite the tensions and diversions that necessarily arise when people bring different knowledge/s and worldviews to bear on a situation. This working sameness is located in the methods or ‘practices’ that disparate communities—for example, farmer practitioners and agricultural systems researchers— use to generate knowledge and its attendant ‘objects’ and truth claims.

Analyses of innovation typically involve focusing on the connections and agency of social elements (people, their roles and membership of institutions) (for example see (Klerkx 2010) Here we want to extend this agency to things (so-called material objects and devices) and representations (texts, data) and places (i.e. the Broken River) as actors in the generation of new knowledge for sustainable management in the Goulburn-Broken catchment. What different does this make to our analysis? It means that we can look for points of intervention and to design a process for developing new knowledge that is achieved out of the work of coordinating, not just people, but our material resources—cows, The University of Melbourne Dookie College Campus, the Broken River etc.—and the symbols (texts, data etc) we use to translate the objects of our research/learning to different times and places. By making our coordinating and translating practices transparent and recognising them as knowledge-generation-in-action, we can better recognise and facilitate what we call here ‘tools for knowledge co-development’.

VI. Tools for Knowledge Co-Development in FRM: An Example

We explore knowledge co-development in FRM as a series of key moments where sets of material, textual and social practices align or evolve or diverge. These moments are characterised by the application of ‘tools for knowledge co-development’, which are the particular combinations and performances of social, material and textual practices in FRM. ‘Doing FRM’ is therefore managing different sets of emergent practices embedded in multiple knowledge communities. Generating tools for knowledge co-development involves re-configuring, creating and coordinating new ways of working together our social, material and textual practices.

We have established three case studies of knowledge co-development within the FRM project. These case studies have been chosen to reflect different aspects of knowledge co-development; in particular across the different community types discussed earlier in this paper. Within the case studies we will use an action science methodology as we aim to support the communities of inquiry for knowledge co-development. Here we will briefly introduce the emergence of one key tool for knowledge co-development in the FRM project. It involves the ‘FRM Disciplines’ knowledge community, which is made up of the FRM researchers and other FRM project team members.

Modelling Interactions Matrix: a tool for knowledge co-development

Two whole-of-(FRM)project team meetings have been held so far in the FRM project in 2009/2010. All researchers working on the project were invited to attend each workshop and these full day events aimed to build connections—relationships between researchers and their particular research programs—and identify points of collaboration. Specific activities were designed by the Farm and Catchment Network and Innovation Research (FRM) sub-project researchers to facilitate these connections and progress work planning involving integration between various FRM sub-projects and research modules. One such activity involved researchers in the project in a workshop discussing the various ‘modelling needs’ they have in their work programs. This was a facilitated workshop discussion with guiding questions. Researchers participating in this discussion came from different programs of research in FRM. The aim was to produce clarity about the points of intersection and exchange between people generating data, insights and computer models in FRM. The outcome of this discussion was a matrix of ‘modelling interactions’ (Table 1). This table is a tool for knowledge co-development. It is a textual (or representational) practice that translates a lively conversation between researchers into a plan for action. It is a material practice in that its material form—copied from the electronic whiteboard during the workshop, copied to computer and then printed for inclusion in the workshop report—achieves a transportability for the agreed plan of action in ‘modelling interactions’. The table, we suggest, is equally a social practice as its generation as part of lively conversation at the workshop is accomplished out of the collective and embodied practices of conversation, gesturing, and group dynamics.

VII. Conclusion

We have introduced the FRM Project and a framework for understanding how knowledge co-development is being performed and facilitated through the Project. We have also identified an epistemological challenge of managing difference/sameness as integral to doing integration for sustainable resource futures. Using a typology of practices, as an analytical framing for knowledge co- development, allows us to identify tools for knowledge co-development that emerge in particular combinations of social, textual and material practices. These tools are the sites of action learning in FRM as we together negotiate how to go on together to produce new knowledge for improved catchment management.

TABLE I. Stylised Matrix of Modelling Interactions Required to Progress FRM

What modelling needs Modelling activity	Farms	Water Resources	Ecology incl hydraulics	Control	Markets Whole System	Economics	What is missing
Farms		Water Avail ML and reliability; Timing (from ecol)		Lead time	Water products to be eval by farm	Prodn models	Resilience measures; whole catchment landuse; thresholds for infrastructure
Water Resources	Vol & timing		Vol & timing	Flow release factor of safety vs lead time	Water products to be eval by farm	Priority uses as fn water availability	Whole catch landuse. Scale up from rep farms
Ecology		Flow regimes for scenarios/ systems			Water products designed to meet specific env demands		Can only assess spec aspects of ecol outcomes
Control	Hourly demand patters Desirable lead times	Inflow forecasts; Surf/GW interaction & Evap loss @ short timescales	Rates of change; limits; Env water demand		System dynamic control modellig		Business case. Spec short term ecol demand. Scheduling.
Market whole systems		Water avail over time + farm+ env		Delivery, efficiency as fn lead time			Utility fns for farms and ecol. Linking demand to objective.

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