Unpacking systemic capacity to innovate: How projects coordinate capabilities across agricultural innovation system levels

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Abstract
Problems in agriculture are increasingly recognised as complex, uncertain, operating at multiple levels (field to global value chains) and involve social, economic, institutional, and technological change. Combining these changes to address agricultural problems is a non-linear process in which innovation emerges from distributed collaboration among heterogeneous actors interacting with and responding to continuously changing external environments. This has implications for how research organisations support innovation and navigate complexity to achieve impact. Few studies have systematically evaluated how research project actors coordinate capabilities across multiple levels from the individual to the network and adaptively respond to changes in the innovation system to successfully create impact.

To address this gap, this paper presents an analytical framework based on the broader concept of innovation capacity. Innovation capacity is built through practices, routines or processes to mobilise, combine and create resources and capabilities to successfully innovate. Capabilities can be divided into: (a) innovation capabilities, which are the processes for exploring and exploiting opportunities to innovate, (b) adaptive capabilities, which are the development and adaptation of resources and capabilities toward the changing environment in which innovation is undertaken, and (c) absorptive capabilities, which are the processes for acquiring, assimilating and transforming external knowledge. These capabilities operate at and are linked across different levels in the innovation system to create innovation capacity at multiple levels in the agricultural innovation system.

The analytical framework is applied to two innovation projects tackling agricultural problems of differing complexity; sustainable land management in New Zealand hill country and improving lamb survival on-farms. Application of the framework highlights the importance of evaluating the interactions among project resources and capabilities at multiple levels to understand how these were successfully coordinated to create individual, organisational, project and network capacities to achieve impact.

Key words: innovation capacity, agricultural innovation systems, complex problems, innovation phases, sustainable land management, lambing

Highlights

- To create impact, projects coordinate capabilities from the individual to network.
- An analytical framework is used to evaluate coordination of innovation capabilities.
- Actor networks formed during agenda setting are later essential for creating impact.
- Building innovation capacity is an important project outcome leading to impact.
- Study findings provide guidance on capabilities needed to create project impact.

1 Introduction

Problems in agriculture are increasingly recognised as complex, uncertain, operating at multiple levels (from the field to global value chains) and involving social, economic and institutional, as well as technological system changes (Schut et al., 2014a; Schut et al., 2014b; Spielman et al., 2009). This is recognised in the agricultural innovation systems approach which conceptualises innovation as a co-evolutionary process of interactive development of technology, practices, markets and institutions (Klerkx et al., 2012). The creative, non-linear change process of innovation means that an agricultural innovation system (AIS) has the characteristics of a complex adaptive system (Douthwaite and Gummert, 2010; Hall and Clark, 2010; Spielman et al., 2009). Therefore, aspects of complexity relevant to AIS are the large number of actors and artefacts (e.g. technologies, organisations, institutions and infrastructure) comprising the system (Schut et al., 2014b), the high interdependence among actors and artefacts, as well as the interactions across levels from individual to network to socio-technical and institutional systems (Giller et al., 2008; Schut et al., 2014a) within the ecological system (Olsson et al., 2014). Together these result in complex systems having low decidability, i.e. it is difficult to predict the outcomes from interactions among actors and artefacts (Axelrod and Cohen, 2000).

Adaptive management is a way of working within the low decidability of a complex system (Klerkx et al., 2010; Westley et al., 2011; Westley et al., 2013). Innovating within an AIS that is complex and adaptive requires a *systemic capacity to innovate* (Hall, 2005; Schut et al., 2014a). This innovation capacity is the capability of actors to continuously identify and prioritise constraints, and in response mobilise new and existing capabilities and resources, i.e. adapt to realise opportunities in a dynamic systems context (Hall, 2005; Leeuwis et al., 2014; Schut et al., 2014a). Recent studies of agricultural innovation projects highlighted the importance of actors at project-level evaluating and adaptively responding to changes not just within the project, but also in the external social, technical and institutional environment (Beers et al., 2014; Klerkx et al., 2010; Schut et al., 2014a), which consists of several scales or levels (Schut et al., 2013). Limited monitoring of the external institutional environment can result in inadequate actions on the part of project actors, hampering success (Beers et al., 2014; Hueske et al., 2014; Klerkx et al., 2010). Few studies have systematically explored how project actors coordinate resources and capabilities to build innovation capacity across multiple levels from the individual to the network to enable adaptation to changes not just in the external environment but across all levels within an AIS (Hueske et al., 2014; Schut et al., 2014a).

Where studies have considered innovation capacity across innovation system levels they have focused on interactions between two to three levels only. Pant (2012) considered the interactions between individual and organisational capacities, Nettle et al. (2013) the interactions between project and external innovation system levels, Beers et al. (2014) and Klerkx et al. (2010) the interactions between innovation networks and their external environment, Markard and Truffer (2008) and Musiolik et al. (2012) explored the linkages between organisations, formal networks and the technological innovation system, and Hueske et al. (2014) the interactions between individual and organisational levels and the external environment. Given little is documented on how capabilities at different levels in the innovation system are coordinated to successfully build innovation capacity, we draw on agricultural innovation systems literature, complemented with literature from technological innovation systems, open innovation and innovation ecosystems, to describe capabilities and capacities at different levels of the innovation system (Boly et al., 2014; Leeuwis et al., 2014; Pant, 2012; Wang and Ahmed, 2007). This provides a framework for exploring how project actors coordinate capabilities to build innovation capacities across multiple levels of the AIS. The application of this framework is demonstrated in two case studies both of which had been successful in tackling contrasting complex problems.

The rest of the paper is organised as follows. The next section details the analytical framework used for developing a nested understanding of innovation capacity in an AIS. This includes a review of the literature to identify the capabilities and capacities observed at different levels within the AIS. The paper then introduces the two case studies, along with the data and methods of analysis. This is followed by presentation of the results as timelines and coordination of capabilities and capacities at different levels of the case study innovation systems. We conclude with key insights on how project actors can combine capabilities at different levels of the AIS to successfully build innovation capacity to move through the innovation process.

2 Analytical framework

2.1 Developing a nested understanding of innovation capacity

Considerable research has been undertaken in the field of agricultural innovation systems (Hall, 2005; Lambrecht et al., 2014; Leeuwis et al., 2014; Nettle et al., 2013; Pant, 2012), technological innovation systems (Markard and Truffer, 2008; Musiolik et al., 2012), open innovation (Chatenier et al., 2010; Hueske et al., 2014; Rufat-Latre et al., 2010; Smart et al., 2007; Traitler et al., 2011), and open innovation ecosystems (Adner, 2006; Adner and Kapoor, 2010; Boly et al., 2014; Rohrbeck et al., 2009) to elucidate the specific features of innovation capacity. These studies differ in the level at which they explore innovation capacity, ranging from individuals (Chatenier et al., 2010; Hueske et al., 2014) to organisations or firms (Brusoni and Prencipe, 2013; Rohrbeck et al., 2009; Rufat-Latre et al., 2010; Traitler et al., 2011) to projects or programmes (Douthwaite and Gummert, 2010; Nettle et al., 2013) to networks (Musiolik et al., 2012; Smart et al., 2007).

To systematically analyse how innovation capacity is realised across levels we have adapted Boly et al.'s (2014) innovation capacity measures framework using the concept of dynamic capabilities (Helfat et al., 2009) and elaborating on how capabilities and capacities are linked. Innovation capacity is built through the practices, routines or processes used to mobilise, reconfigure and create resources and capabilities. Resources are tangible financial and physical artefacts, as well as institutions (e.g. incentives for innovation such as intellectual property rights) used in the innovation process (Musiolik et al., 2012); what Wieczorek and Hekkert (2012) call 'structural conditions'. There are three distinct capabilities needed to mobilise and reconfigure resources and capabilities to build innovation capacity (Boly et al., 2014; Wang and Ahmed, 2007): (a) innovation capabilities, which are the processes for exploring and exploiting opportunities to innovate (Smart et al., 2007; Wang and Ahmed, 2007), (b) adaptive capabilities, which are the development and adaptation of resources and capabilities toward the changing environment (Wang and Ahmed, 2007), and (c) absorptive capabilities, which are the processes for acquiring, assimilating and transforming external knowledge (Boly et al., 2014; Smart et al., 2007; Wang and Ahmed, 2007). Capacity is having the right combination of capabilities in sufficient amounts to be able to successfully innovate (Boly et al., 2014; Hall, 2005).

Capabilities and resulting capacities operate at different levels in the AIS (Boly et al., 2014; Leeuwis et al., 2014; Musiolik et al., 2012; Pant, 2012; Wang and Ahmed, 2007); (i) individual-level, operating at the action and cognitive process level, (ii) organisational-level, which is comprised of individuals brought together to achieve organisational goals, (iii) project-level, where individuals and organisations come together for a period to develop technological, social, economic and institutional innovations, (iv) network-level of individuals and organisations, which projects will use to access resources and capabilities, and (v) the AIS-level, which provides the structural conditions that enable or constrain innovation capacity within the network and its subsystems (Klerkx et al., 2010; Schut et al., 2014a; Spielman et al., 2009). Capabilities and capacities are linked across different levels of the innovation system (Hueske et al., 2014; Musiolik et al., 2012; Smart et al., 2007) (Figure 1). Individuals mobilise and reconfigure their own capabilities in order to build individual innovation capacities. These individual innovation capacities then are the resources that organisations can mobilise and reconfigure using their organisational capabilities in order to build organisational-level innovation capacities, which in turn serve as capabilities that a project can draw on. Feedbacks are also possible. For example, network capacities can serve as a capability at the project-level.

Particular capabilities and capacities are needed at strategic points in the innovation process (Hall, 2005; Lambrecht et al., 2014; Schut et al., 2014a; Schut et al., 2014b). The innovation process begins with problem-oriented phases: (i) agenda setting, when the initial scope of the problem and stakeholders are defined; (ii) describing problems, when the spatial and temporal aspects of the social, economic, institutional and biophysical systems relevant to the initial problem scope are described, including various drivers in these systems; and (iii) explaining problems, when processes and interactions in the systems are elucidated through experimentation, modelling and stakeholder dialogue (Giller et al., 2008). Innovation then moves to the solution-oriented phases of (iv) exploring solutions, when potential innovation pathways to address the problem are developed and the consequences and trade-offs of these are explored; (v) designing solutions, when a preferred solution pathway is identified and resources and processes for its implementation are determined; and (vi) implementation and monitoring, when the solution pathway is implemented, along with monitoring activities for evaluating progress toward the desired change (Giller et al., 2008; Schut et al., 2014b). While we have described these phases linearly, in reality they will occur non-sequentially and iteratively (Graffy, 2008).

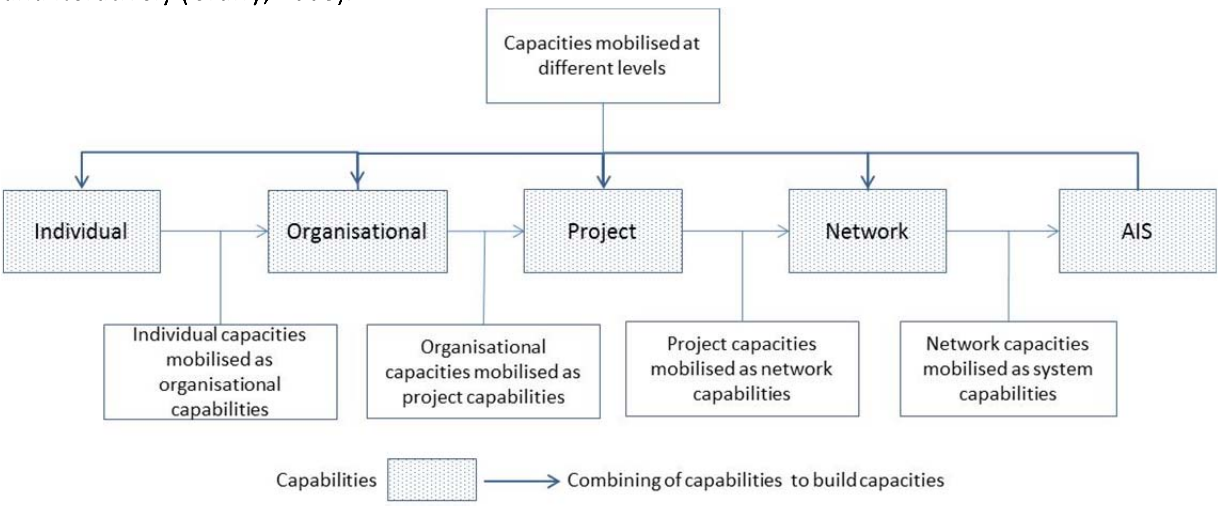

Figure 1: Analytical framework

Table 1 presents capabilities and capacities that have been observed in the literature. This demonstrates that different innovation capacities have been observed at different levels of the innovation system. It also shows that innovation capacities at one level have been observed as capabilities at other levels of the innovation system. For example, at the individual-level being able to recognise possibilities in emerging problems supports the formation of networks around a vision of promising options. Finally, capabilities at one level can contribute to innovation capacity at other levels.

Table 1: Capabilities and innovation capacities identified at different levels within the AIS

	Capabilities			Innovation Capacities
Levels	**Innovation capabilities**	**Adaptive capabilities**	**Absorptive capabilities**	
Individual	Individuals motivated to participate[1,6,9] Facilitative leadership for working to meet individual & collective interests[3,13,14,20] Awareness of network partner motivations[13] Develop, maintain and use effective networks[13,19] Able to generate new ideas for action[5,14,22]	Transformational leadership for supporting change[3] Individual reflexivity[5] Develop, maintain and use effective networks[13,20]	Leadership to foster culture of openness[14] Intermediation roles to facilitate interactions[4,11,19,22] Develop, maintain and use effective networks[6,13,20,23] Link with others to access, share and process external knowledge[5,6,11,12,15]	Individuals are able to recognise possibilities in emerging problems & opportunities[6,22] Changes in individual knowledge, understanding, discourse, vision and attitudes[6,19]
Organisation	Conceptual understanding of change in complex systems[6] Culture of embracing change & risk-taking[15,22] Work to support stakeholder & own interests[5]	Conceptual understanding of change in complex systems[6] Iterative process of experimentation to implement organisation specific innovation capacities[14] Organisational reflexivity[20] Learning organisation & adaptive management[24,25,26,27]	Fosters creativity, diversity and challenge to organisational status quo[28,29,30] Demonstrates transparent ethical behaviour towards collaborators - supports collaborators agenda and goals[31] Demonstrates trust in collaborators - shares knowledge and resources[31]	Openness to new ideas & actions[5] Ability to diversify risks and share social, economic, institutional and technological uncertainties[14,19] Ability to actively manage interdependent & unpredictable interactions among network partners[17,18,19,20]
Project	Heterogeneous actors with a broad range of skills & experience[7,8,11,13,15,20] Members of project have awareness of each other's views, resources & interests[7] Institutions to avoid free-riding by network	Situation where the challenge is greatest[10,16] Foresight activities[1,19,22] Monitoring & evaluation[6] Reconfigure network	Link with others to access, share and process external knowledge[5,6,11,12,15] Actively seek to bring	Ability to select, combine and strengthen solutions[6] Capacity to take risks, experiment with social and technical options, and assess

	partners[13] Knowledge acquired through interaction, learning, research, experimentation & experience[1,6,8,9,16,17,20] Facilitate interactions among partners[8] Project champions[8,9,10,15] Balance individual & collective interests[13] Mediate power imbalances[13]	membership & interactions to deal with changing circumstances[1,9,19,20] Flexibility in solutions to allow revision[13,20] Project reflexivity[5,8,19,20]	together heterogeneous partners to achieve collective action[7,8,9,11,15,16,17,20] Pool complementary resources to build networks[16,20,21]	the trade-offs from these[2,15] Capacity to continuously identify & prioritize problems & opportunities[1,6,22] Capacity to mobilise resources & form effective networks[1,20,23] Ability to actively manage interdependent & unpredictable interactions among network partners[17,18,19,20]
Network	Wide network of specialised actors that can potentially act to each other's benefit[6,7,9,17] Form networks around vision of promising options[6,19,21] Shape institutions, capabilities & supply chain as part of solution[1,11,15,16,21] Intermediation roles to facilitate interactions[4,11,19,22] Allow network membership & interactions to reconfigure to address complexity[17,20,21,23] Institutional entrepreneurship to influence governance-level[14]	Stakeholder involvement in shaping and setting solution pathways[1] Innovation brokers to access new network partners[4,19] Allow network membership & interactions to reconfigure to address complexity[17,20,21,23] Confront conflicting external stakeholder concerns[22]	Network interactions to co-develop knowledge[2,4,7,11,17,20,23] Innovation brokers to access new network partners[4,19]	Capacity to mobilise resources & form effective networks[1,6,20,21,23] Ability to select, combine and strengthen solutions[6,21] Capacity to take risks, experiment with social and technical options, and assess the trade-offs from these[2,15] Ability to embed innovation in ongoing processes of change[6,19,20,21,22] Enhanced network reputation in AIS[21]
AIS	Institutions to support social & technical experimentation by networks[2,9,15,17,21] Institutions for sharing risks and benefits[15,20,21]	Institutions that allow dynamic & rapid responses to changing circumstances[2,21]	Institutions to stimulate knowledge sharing & interactive learning[4,5,21,22]	Upscaling and outscaling of innovation capacity[11]

[1] Hall (2005) [2] Röling (2009) [3] Nettle et al. (2013) [4] Klerkx et al. (2009) [5] Pant (2012) [6] Leeuwis et al. (2014) [7] Beers and Geerling-Eiff (2013) [8] Douthwaite et al. (2009) [9] Douthwaite and Gummert (2010) [10] Douthwaite et al. (2002) [11] Hermans et al. (2013) [12] Adner (2006) [13] Chatenier et al. (2010) [14] Rufat-Latre et al. (2010) [15] Traitler et al. (2011) [16] Rohrbeck et al. (2009) [17] Brusoni and Prencipe (2013) [18] Adner and Kapoor (2010) [19] Klerkx et al. (2010) [20] Smart et al. (2007) [21] Musiolik et al. (2012) [22] Hueske et al. (2014) [23] Lambrecht et al. (2014) [24] Fernandez-Gimenez et al. (2008) [25] Senge (1990) [26] Argyris and Schön (1978) [27] Argyris and Schön (1996) [28] Foster (2014) [29] Yang and Konrad (2011) [30]King and Anderson (1990) [31] Hosmer (1995)

3. Methods

3.1 Case study selection

Using the descriptions of capabilities and capacities at different levels of the innovation system (Figure 1), we explore two case studies to understand how these projects coordinated capabilities to build innovation capacities across multiple levels of the AIS and at different phases in the innovation process.

The two project-level case studies involved problems of differing scale and complexity. The first is a farm-level improvement, aimed at lifting lamb survival through genetic selection and farm management (Everett-Hincks and Dodds, 2008). The second case study is about farm-scale innovation, aimed at reducing the risk of erosion of hill and steep land for improved economic, social and catchment outcomes (Manderson et al., 2012). Case-study research is suited to the study of our research question as knowledge of which resources, capabilities and capacities are prevalent at different phases and levels within the innovation system is limited. In such a research setting, gathering rich information will help identify new aspects and new phenomena (Yin, 2014).

3.2 Data and Analysis

For each of the case studies we gathered data using actor linkages and innovation journey analysis, along with semi-structured interviews and secondary data to understand key events in more depth. Actors at different AIS levels were identified using actor network mapping (Ortiz et al., 2013) conducted in workshops and interviews. These described the individual-, organisation-, project- and network-level actors and the capabilities they contributed to the project (Beers and Geerling-Eiff, 2013; Douthwaite et al., 2009; Douthwaite and Gummert, 2010; Hermans et al., 2013).

Innovation journey analysis (Spielman et al., 2009; Van de Ven et al., 1999) was conducted in workshops and interviews to identify important events during the life of the case study projects. Semi-structured interviews and secondary data, including project proposals, contracts and reports, were also used to explore in further depth how projects coordinated capabilities to build innovation capacity at different levels. Five individuals who participated in the sustainable land management project were interviewed and eleven from lamb survival. These individuals were from research, policy, industry, funders and end user groups. Each interview took between one and two hours. The interviews were recorded and transcribed, provided to interviewees that had requested a copy of the transcript for review, and then coded in NVivo v. 10 (Bazeley and Jackson, 2013) by the lead author using the analytical framework as the coding structure. The lead author conducted thematic analysis of the coded interviews (Merriam, 2014) to identify how capabilities were coordinated across different-levels by exploring recurring themes across interviews.

4 Results

Key events in the timeline of each of the case studies are first described, followed by an in-depth analysis of capability configurations between levels at each phase of the innovation process.

4.1 Event analysis of lamb survival

Lambing percentage is a significant influence on New Zealand sheep farm profitability, and lifted from 100% in the early 1990s to 125% in 2006 (Everett-Hincks and Dodds, 2008; McDermott et al., 2008). Several factors contributed to this increase; selection for fecundity, introduction of more fertile breeds, changes in farm management (e.g. better nutrition, mid-pregnancy shearing, better disease control, and hogget lambing) and new technologies (e.g. pregnancy scanning). As lambing percentage increased, the proportion of ewes bearing twins and triplets increased (Dalton et al., 1980), as has lamb mortality (Amer et al., 1999). Other changes in sheep farming have made it more challenging to manage multiple-bearing ewes. More of sheep are being farmed on hill country with less easy country available and the number of stock per labour unit had increased (Dooley and Lovatt, 2010).

The lamb survival case study was a series of research projects over a ten year period from 2003 (Dooley and Lovatt, 2010) (Figure 2) and involved stakeholders operating at different levels of the AIS (Table 2). The research identified factors affecting lamb survival, along with management and genetic solutions to improve these (e.g. Everett-Hincks & Dodds 2008); an improved lamb survival sheep selection index, a feed allocation table to improve ewe body condition from conception through to lambing, a standardised lamb post mortem protocol, a Land Assessment Tool to identify fields with reduced lamb mortality risk, and temporary lamb shelter. An economic assessment of the benefits of the research projects undertaken from 2006 to 2008 (Dooley and Lovatt, 2010) estimated a NZ$9.6 million benefit in the season ending in 2010 (Dooley and Lovatt, 2010).

The lamb survival project (Figure 2) began as part of a large research programme developing genetic markers for traits that improved sheep production. The programme was led by Ovita Ltd., a consortium of industry, research and Government organisations, established in 2003 with 50:50 public:industry funding to commercialise genetic tests. AgResearch, a partner in the consortium, undertook the majority of research for Ovita. To collect the large amount of data required to identify genetic markers, the lamb survival project leader advertised for sheep farmers to volunteer collecting and providing data on their farms, flocks, and lambs that survived and died. AgResearch scientists tagged, collected and post-mortemed the dead lambs to identify the cause of death. This research identified dystocia, a difficult birth, which can damage the foetus leading to death due to organ rupture, haemorrhage or localised subcutaneous oedema (Everett-Hincks & Dodds, 2008), as a major cause of lamb mortality in ewes giving birth to multiples. By mid-2004 Ovita prioritised traits for genetic markers which could be successfully commercialised. Because of the low heritability of lamb survival and its multiple causes it was determined that a commercial test for lamb survival genetics was unlikely to be found during the programme timeframe, so the research on lamb survival genetic markers ended. At the same time, other researchers working on lamb survival, along with vets, questioned the conclusion that dystocia was a major cause of lamb mortality. Previous research identified starvation and exposure as major causes of lamb mortality, and the post-mortem protocol used was questioned, particularly by vets. The research on lamb survival was, however, able to continue through Meat and Wool NZ funding of an in-depth study of dystocia.

The project leader then applied for and received funding from the Ministry of Agriculture and Forestry (MAF) Sustainable Farming Fund to use the data collected during the Ovita funded phase to identify potential management solutions for improving lamb survival. The project was funded with the condition that the project leader collaborated with three other projects on lamb survival being led by farm advisors and vets. One project was on the use of temporary lamb shelters, the other was on monitoring ewe body condition to improve lamb survival rates and the third was developing a land assessment tool to identify suitable paddocks for lambing. The Sustainable Farming Fund project identified improved ewe body condition at mating and through pregnancy as an important way to decrease the incidence of dystocia and hence lamb mortality.

After the Sustainable Farming Fund project the project leader worked with Landcorp to undertake feed management trials to improve ewe body condition and triplet lamb survival on a thousand tripleting ewes. These large commercial scale trials provided strong evidence to farmers attending field days of increased lamb survival from improved ewe condition. At the same time, a second phase of Ovita was funded and lamb survival was again included. By the end of this second phase a genetic test for improved lamb survival was close to development.

Table 2: Key actors in the lamb survival case study

Levels	Actors
Individual	Project Leader from AgResearch Individual scientists Participating ram breeders Participating sheep farmers Research manager at Meat & Wool NZ Landcorp farmers, geneticist and farm management scientist
Organisation	Ovita Ltd. Foundation for Research, Science and Technology (FRST) Meat & Wool NZ (now Beef & Lamb NZ) AgResearch Ltd. (Government-owned research institute) Catapult Wool Equities Meat Board Wool Board Landcorp (Government-owned farming company)
Project	Project Leader Ovita Ltd. AgResearch Ltd. scientists Participating ram breeders Participating sheep farmers Farm advisors and vets in Sustainable Farming Fund Project
Network	Ovita Ltd. Meat & Wool NZ Industry Working and Advisory Group Landcorp Ministry of Agriculture and Forestry (now Ministry for Primary Industries) Sheep vets Farm advisors Scientists researching lamb survival Ram breeders Sheep farmers Rural media
AIS	Sheep Improvement Ltd Central Progeny Test Ram breeders Sheep farmers

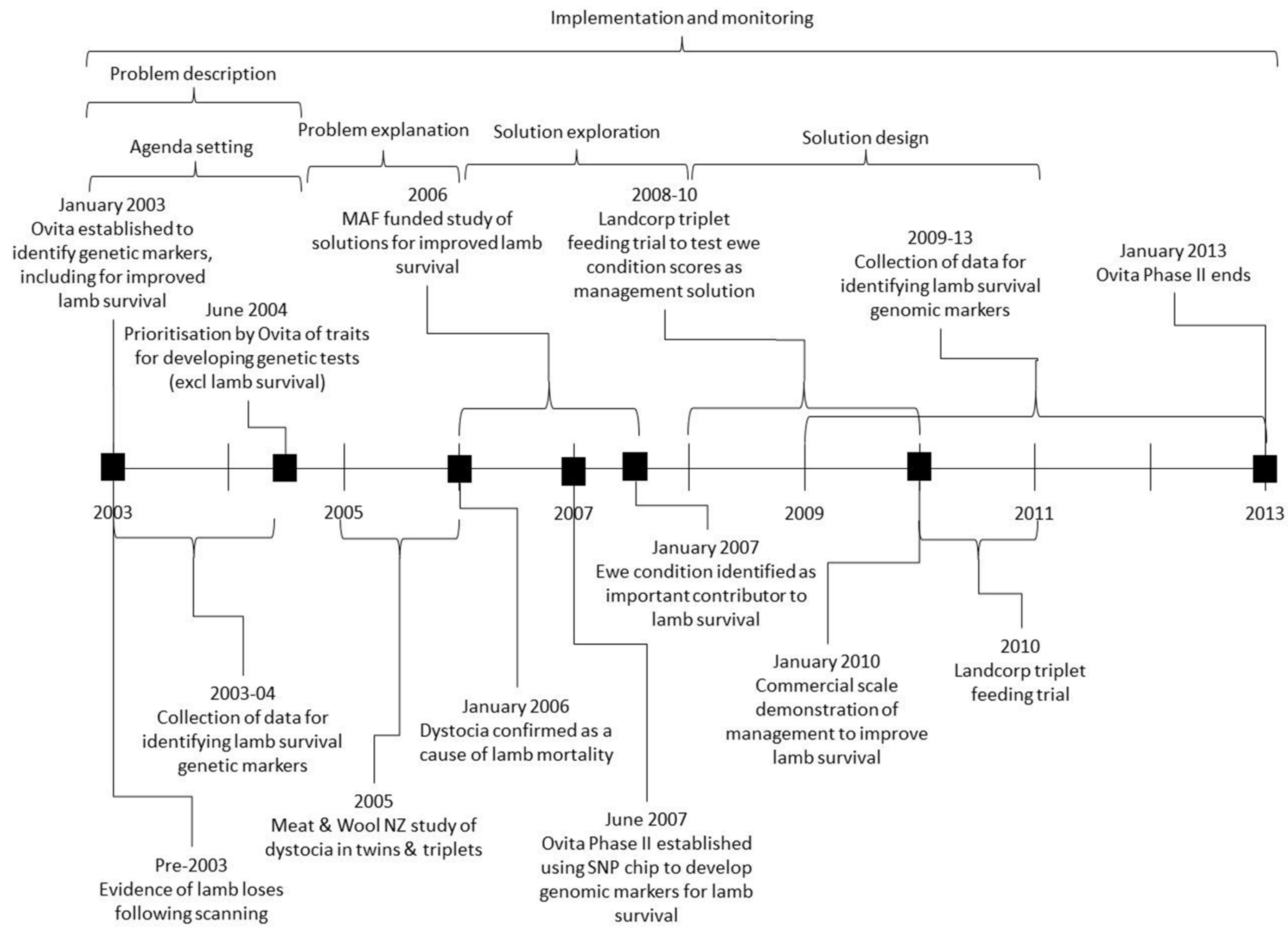

Figure 2: Timeline of activities in the lamb survival case study

4.2 Capability coordination between levels in the lamb survival case

The timeline (Figure 2) identifies the six phases in the innovation process that are further analysed below in terms of how capabilities at multiple-levels were coordinated to progress each phase.

4.2.1 Agenda setting: Prioritising genetic markers for improved sheep traits

Ovita's agenda was to identify, develop and commercialise genetic tests for traits to improve sheep production. The genetic tests could then be sold to sheep breeders and farmers to support genetic improvement of their flocks. Reflecting an AIS-level agenda at the time, the partners in Ovita had a biotechnology start-up focus, which aligned with interests in biotechnologies to increase sheep industry productivity and to generate revenue from biotechnology commercialisation (Figure 3). For example, in the early2000s the Government-funding agency, Foundation of Research, Science and Technology, operated as an investor focusing on economic returns from research, as described by a researcher in the project, by "…*developing a pipeline for commercialisation because that's what the government was looking for at the time which was develop new products that are going to make a lot of money*". There was five years of negotiation among the Ovita partners to identify how the organisations could pool their capabilities at the project and network-levels to meet their individual and collective agendas. For example, AgResearch focused on creating spin-out biotechnology companies and Catapult provided commercialisation and market knowledge capability.

During the life of Ovita there were changes in project- and network-level partners as organisational agendas changed. Catapult was purchased by a company whose interests did not align with the interests of Ovita, Wool Equities withdrew funding, and Meat and Wool NZ and AgResearch shifted from having a start-up focus to a focus on delivering on-farm impact. Negotiating these changes required individuals and organisations to understand the interests of the partners and balance their own agendas with those of the partner organisations.

At the project-level the inclusion of lamb survival was driven by an Industry Working and Advisory Group. Lamb survival was a trait with a low likelihood of a genetic marker being identified, but of high potential value to the industry, due to high prices for lambs and evidence of lower lamb survival in higher fecundity sheep breeds. Ovita's capacity to take on this risk was offset by the inclusion of other traits in the trials. Two scientists provided Ovita with confidence that it was technically feasible to identify genetic markers for lamb survival. One scientist had learnt of a method for identifying the causes of lamb mortality from an international conference. The other had identified from their research that it was possible to assign genetic markers to individual causes of lamb mortality.

At the project-level as Ovita approached the end of its funding period, traits for commercialisation were prioritised based on the likelihood of a test being commercially available by project end. Lamb survival was not one of these traits, and so funding ended in June 2004. At the project-level breeders participating in the lamb survival project lobbied to continue the research; however, they were unsuccessful. By the time a second phase of Ovita was funded in 2008, the network formed was able to make use of advances in technologies for whole genome selection using SNP chips, which could be used for a bundle of traits influenced by multiple genes, such as lamb survival.

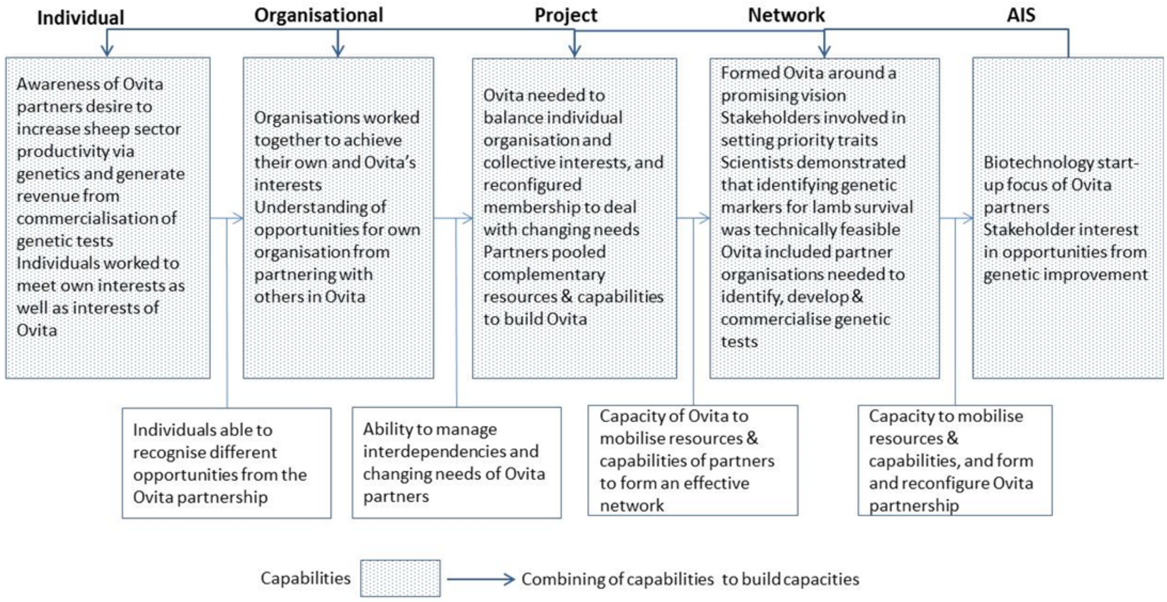

Figure 3: Capabilities and capacities used set agendas in the lamb survival project

4.2.2 Problem description: Identifying causes of lamb mortality

The project deliberately took a systemic approach to describing lamb mortality (Figure 4), collecting genetic data from sires, ewes and their lambs, along with post-mortems to establish the cause of death, and data on weather and farm management. Taking a systemic approach to problem description was driven by the low heritability of lamb survival, which meant data on the many factors influencing lamb survival was needed to isolate genetic influences.

This systemic approach was possible because of the capability of the project leader who had studied farm systems at the undergraduate and post-graduate level. The project leader fostered a culture of openness in the project, which enabled the project to draw on the knowledge of farmers involved. This was further supported by farmers' individual innovation capabilities; having a systemic perspective of farm management, and already experimenting with practices to improve lamb survival. This increased the systemic understanding in the lamb survival project, as reflected by a farmer involved; "*…our lambing percentage was not static but it's not following along with the scanning…and what are we missing, what's holding us back, what aren't we doing well, etc so we did a bit of that analysis in-house*".

AgResearch aligning a team of scientists with the agenda of Ovita created a misalignment with other organisational interests. AgResearch built up a team of scientists that were focused on delivering solutions that provided commercial opportunities for Ovita. This increased the capacity of AgResearch to deliver demand-driven research; however, it reduced the capacity of individual scientists to deliver peer-reviewed science, due to IP, creating a risk that these scientists may not be able to access resources for science-led funding.

At the project-level, the lamb survival project utilised Ovita resources to co-develop a systemic knowledge of lamb survival through on-farm research and interaction with farmers. This included scientists meeting face-to-face with the farmers to review data and results. This was enabled by the project team having individuals with a range of skills and knowledge, such as genetics, farm systems, and statistics. This meant the project could provide a farm system perspective and create a network of actors working collectively to improve lamb survival. That network of actors increased the capacity of the project to access on-going funding for exploration and design of solutions.

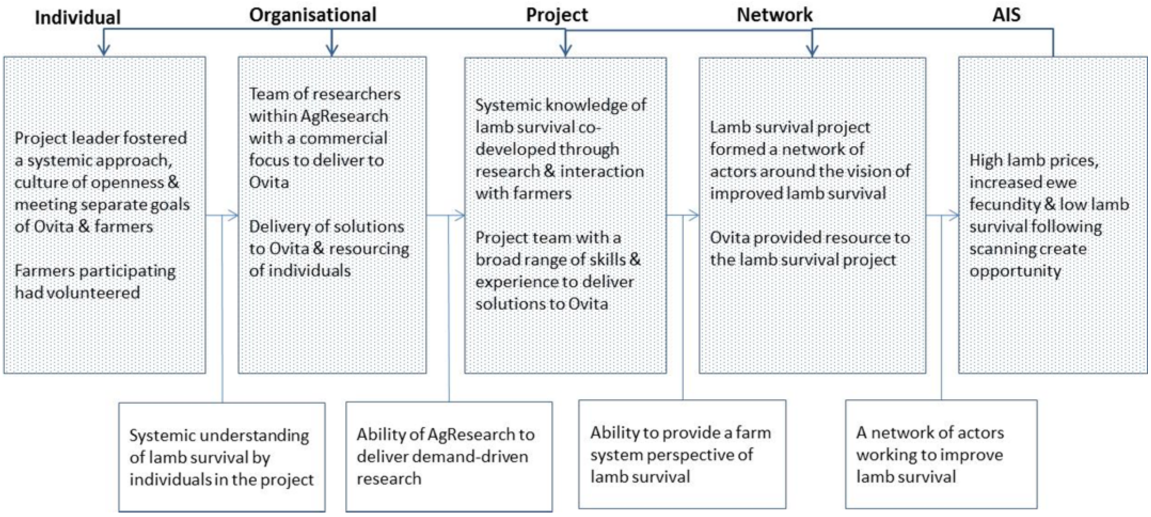

Figure 4: Capabilities and capacities used by the lamb survival project to develop an understanding of the problem

4.2.3 Problem explanation: Dystocia due to poor birth weights and ewe condition as a cause of twin and triplet lamb mortality

Lamb post-mortems during the problem description phase identified dystocia as commonly associated with lamb mortality in ewes giving birth to multiples. When Ovita funding ended, the project leader used a connection with the research manager at Meat and Wool NZ to access funding to continue research on understanding the causes of lamb mortality (Figure 5). This aligned with Meat and Wool NZ's agenda to develop a consistent message to farmers on the causes of lamb mortality, to avoid the confusion created by scientists and vets providing differing advice. To this end the research manager resourced and facilitated the formation of a network of scientists working on lamb survival, and later the Sheep Councils, to enable co-development of knowledge for improving lamb survival, e.g. a standardised post-mortem protocol.

At the project-level Meat and Wool NZ funding was used to undertake on-farm observation of lambing and collection of additional data, such as ewe condition scores. This established the link between ewe condition from mating to birth and the incidence of lamb mortality due to dystocia (Everett-Hincks et al., 2005; Everett-Hincks and Dodds, 2008). Meat and Wool NZ funding also increased the innovation capacity of the project by linking to a wider network of scientists to access their knowledge of the causes of lamb mortality and strengthen the project's network of actors. Meat and Wool NZ funding ended when lamb survival became less of a priority.

At the individual-level, the leader of the lamb survival project used targeted venues to legitimise dystocia as a cause of lamb mortality. For example, a paper was presented at the New Zealand Society of Animal Production (Everett-Hincks, 2007) to convey to vets that the findings were credible and the post-mortem protocol was published in an international vet journal. Lamb post-mortems were demonstrated at farmer field days, and the project leader involved vets in discussing the results of these post-mortems.

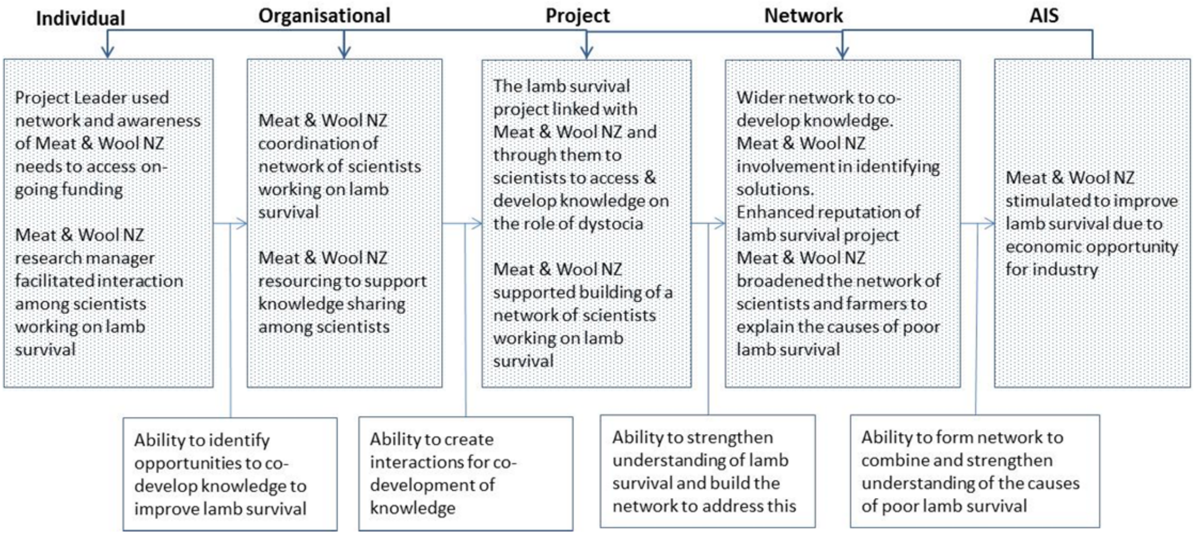

Figure 5: Capabilities and capacities used by the lamb survival project to explain causes of lamb mortality

4.2.4 Solution exploration: Improving lamb survival

MAF Sustainable Farming Fund created an opportunity for the lamb survival project to explore solutions, including the use of lamb shelters, allocation of fields for lambing, and feeding practices to improve ewe condition. This opportunity to increase project innovation capacity was created by MAF requiring four separate projects to co-operate as a condition of receiving funding.

At the individual-level (Figure 6) the leader of the lamb survival project played a central role in facilitating the collaboration with the proposers of the other projects. The collaboration increased the capacity of the projects to select solutions to achieve their common agenda of improving lamb survival. To enable the project leader to facilitate the collaboration, AgResearch was supportive at the organisation-level of sharing funding and capability, and the formation of new partnerships to achieve organisational goals, i.e. increasing sheep industry productivity. AgResearch also provided accountancy, legal and administrative capability.

At the project-level, participants in the three projects developed an understanding of each other's views, capabilities and interests to be able to pool capabilities and resources in the project. This increased the project's capacity to combine and strengthen solutions for improving lamb survival, for example by exploring the influence of feeding practices on lamb survival from mating through to after birth. The collaboration also broadened the network of actors working to co-develop solutions to improve lamb survival. This increased the capacity of the network to develop, select, combine and strengthen solutions.

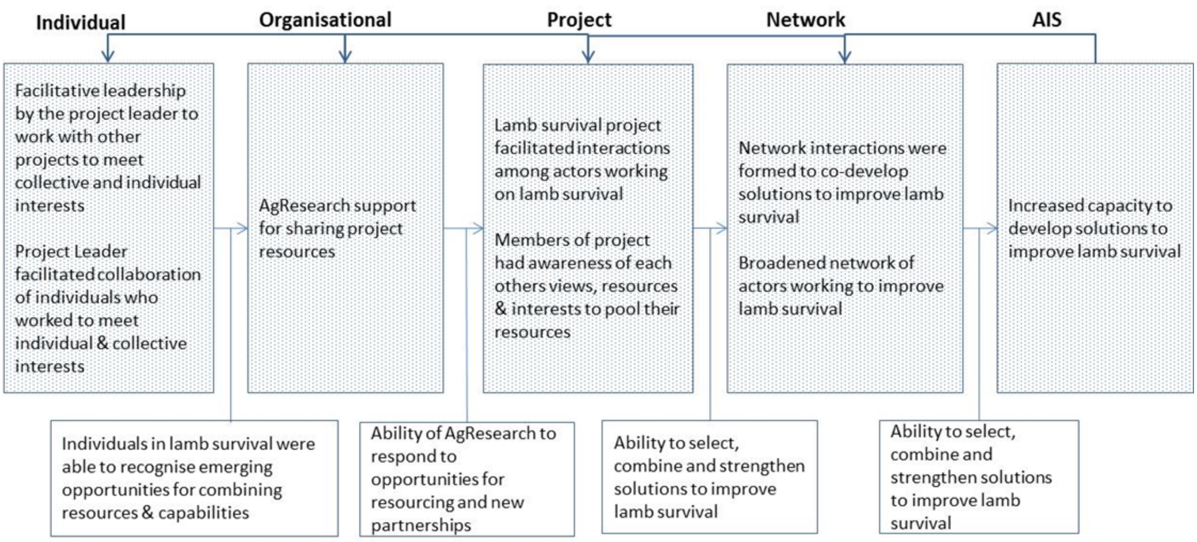

Figure 6: Capabilities and capacities used by the lamb survival project to explore solutions

4.2.5 Solution design: Commercial-scale demonstration of feeding practices to improve ewe condition

The identification of improved ewe body condition as reducing the incidence of dystocia and starvation exposure deaths, demonstrated the need to develop feeding practices to improve ewe condition. A Landcorp-funded project created an opportunity to implement, test and demonstrate feeding practices for improved ewe condition from mating through to lambing and how this influenced lamb survival (Figure 7). These commercial-scale demonstrations were critical to farmers viewing this as a credible and low-cost way to increase lamb survival.

At the individual-level the project leader used their network connections to partner with Landcorp, which was undertaking in-house trials on lamb survival, to move to solution design. These connections were formed by a Landcorp farmer already being a participant in the project and the interactions the project leader had with a geneticist at Landcorp. These networks helped the project leader to understand and ensure that the project activities delivered to the Landcorp goal of increased per hectare productivity from genetic improvement.

At the organisation-level Landcorp could provide a commercial-scale demonstration of the benefits of improved ewe condition for increased lamb survival. Landcorp, as a Government-owned land manager, actively pursued opportunities to contribute to wider industry agendas. Their large size also gave Landcorp the capacity to take risks that smaller farms could not take. By partnering with Landcorp the project team therefore increased its capacity to take risks in designing feeding practices at the commercial scale and strengthened the network, particularly in terms of stakeholder involvement in solution design. This increased project-level innovation capacity. For example, two scientists employed by Landcorp provided knowledge of genetic and farm management influences on lamb survival.

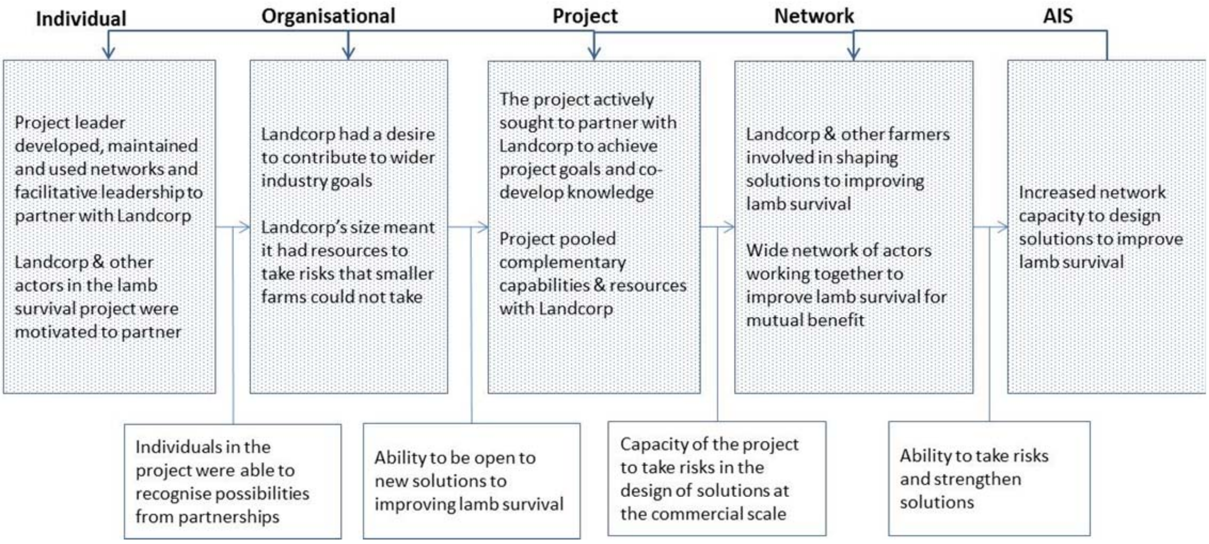

Figure 7: Capabilities and capacities used by the lamb survival project to design solutions

4.2.6 Implementation and monitoring: Building capacity to manage for improved lamb survival

Genetic selection and feeding practices to improve ewe condition developed by the project were implemented by Landcorp and other farmers (Dooley and Lovatt, 2010). Activities to support implementation, such as sharing information through field days, farm demonstrations and media, occurred through the life of the project. At the project- and individual-level the close interaction of the project leader and scientists with participating farmers, by scientists getting out on farms and meeting with farmers one-on-one was essential. This interaction increased the absorptive capacity of the farmers to implement new technologies for improving lamb survival (Figure 8). For example, how to use sheep improvement records and identify causes of lamb mortality to enhance selection for lamb survival. There was also increased adaptive capacity through identification of the opportunity to improve lamb survival, as described by a farmer in the project; "*…there's a whole momentum shift* *to actually feeding stock better, instead of accepting that 125% is the norm all of a sudden 145% is the norm.*"

The interactions and openness of the project leader also increased the innovation capacity of the research team by helping to understand how farm management decisions influenced lamb survival and how to most effectively provide results to farmers to increase their absorptive capacity; as described by a project funder "*…that willingness for farmers to be involved to offer up suggestions seemed to be really strong in this project*." Landcorp's economic size enabled it to have innovation capability in-house, which meant it already was familiar with how research projects operate and had capacity to absorb knowledge developed. By contrast smaller farms lacked this capacity. This was compensated for by the participating farmers volunteering to contribute, the farmers already experimenting with solutions, by these farmers partnering with other farmers involved in the project, and direct face-to-face interaction between scientists and farmers. However, it was acknowledged that this came at the cost of other organisational goals of the science provider; as described by a project funder "*…the issue is that for [*project leader*] to maintain that level of involvement and engagement with industry takes time and takes them away from perhaps their other obligations to AgResearch to write papers…*"

At the network-level, the leading sheep breeders and farmers, Landcorp, vets, farm advisors, rural media, other scientists working on lamb survival from both within and external to AgResearch, and Meat and Wool NZ increased the project capacity to disseminate knowledge and solutions. Rural media ran articles on project findings, Landcorp participated in field days, and one participating farmer was Chair of the regional breeding group. This network was built over the life of the project through interactions facilitated by the project leader and was further built by Ovita's networks with commercial providers of genetic information.

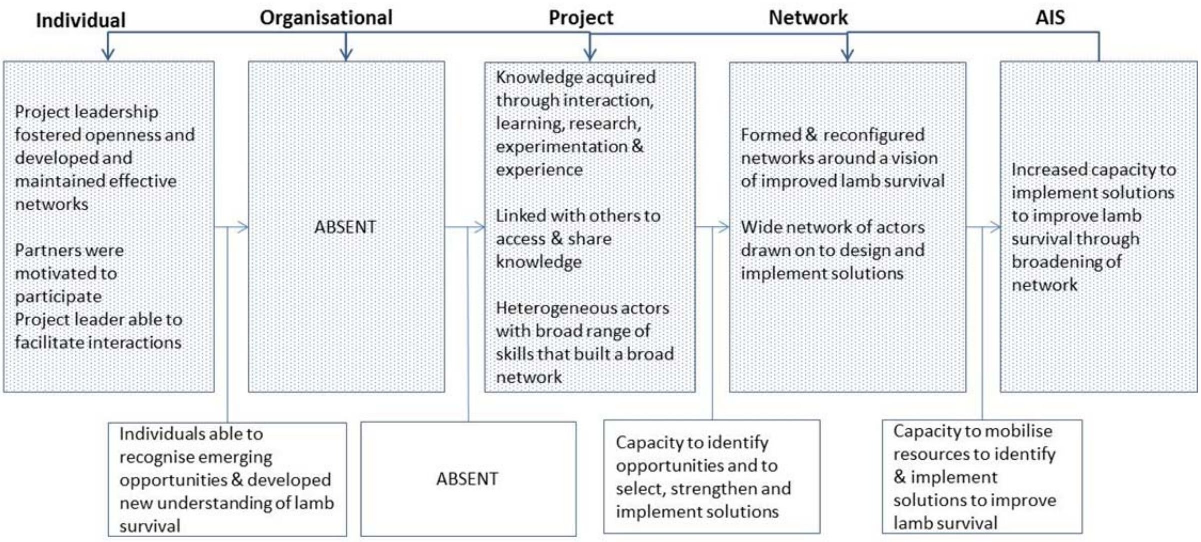

Figure 8: Capabilities and capacities used by the lamb survival project to implement solutions

4.3 Event analysis of sustainable land management

In February 2004 heavy rainfall over three days in the Manawatu-Wanganui region of the southern North Island, New Zealand, resulted in 80,000 individual landslides over 1.6 million ha (Hancox and Wright, 2005). The resulting erosion, flooding and damage had a direct cost of NZ$300 million (Manderson et al., 2012; Mitchell and Cooper, 2011). Some of the hill country in the region is at risk of erosion, and due to vegetation clearance had experienced accelerated erosion over the past 100 years. The region had a history of erosion management prior to the late 1980s, with Catchment Boards implementing soil and water conservation plans to manage the land at risk of erosion. During the 1990s, however, Government reforms reduced soil conservation activity, with only 1,000 ha per year of soil conservation plans undertaken during the 1990s to early 2000s (Manderson et al., 2012).

The magnitude of the environmental and economic impact of the storm stimulated the development of the Sustainable Land Use Initiative (SLUI), a community based initiative co-ordinated by the regional council for the Manawatu-Wanganui region (Horizons). SLUI is a three way partnership between landowners, rate payers (via Horizons) and central government. The initiative used several activities to support sustainable land management (Figure 9) (Anon., 2009; Mitchell and Cooper, 2011). Central to these activities are Whole Farm Plans and a range of incentives to farmers to offset the costs of making land use changes, based on where the benefit of the action resided. In addition to funding from the central government hill country erosion fund and matching dollars from Horizons and farmers, central Government funds for carbon forestry (e.g. Afforestation Grant Scheme and Emissions Trading Scheme) were also used.

The Sustainable Land Use Initiative worked with actors at multiple-levels of the AIS (Table 3) to take a 'mountains to the sea' approach, which drew on research begun in the early 1990s (Mackay et al., 1991). The approach centred on developing and implementing Whole Farm Plans, in which trained individuals worked with landowners to map and conduct a SWOT analysis of the land and soils resources of the farm, vegetation and infrastructure, discuss the performance of the current farm business, establish a set of personal and business goals for the business and develop a long-term programme to achieve the goals and then a 5 year work programme, that includes an annual review (Horizons Regional Council, 2007; Lovatt, 2009; Manderson et al., 2012). The establishment of SLUI was prompted by a community meeting in September 2004 led by the then Chairman of Horizons. A month later local government elections lead to a new Chairman, and a new Chief Executive followed soon after. They continued the formation of SLUI governance and technical advisory groups. The latter group recommended and demonstrated the potential benefits of whole farm planning.

Central Government support for SLUI was achieved through Horizons coordinating visits in mid-2004 by the then New Zealand Prime Minister to meet with people affected by the storm and to see first-hand the devastation caused. This was instrumental in facilitating MAF financial support for SLUI through the establishment in 2007 of the Hill Country Erosion Fund that was also accessible to other regions with extensive hill country. The identification of the areas of highly erodible land in the region, which could be targeted to reduce the risk from future storms, was used to gain central government and wider stakeholder support for SLUI. This information was also used in a report to Horizons on the cost and feasibility of SLUI, and later to demonstrate the environmental and economic benefits of SLUI by identifying the proportion of land within Whole Farm Plans that had been planted, hence quantifying the mitigated potential erosion. Additional evidence of the environmental benefits of SLUI came from a monitored reduction in sediment loads in the region's rivers.

In June 2013 support from central Government through the Afforestation Grant Scheme ended, following a decision to discontinue the scheme, in part due to a decline in the value of carbon. This scheme had been very popular amongst land owners, and over-subscribed each year it had been run. This also made it much less attractive for farmers to plant trees under the Emissions Trading Scheme. This reduction in funding meant that the number of hectares planted in production forestry was scaled back. By mid-2014 SLUI had developed 513 farm plans covering an area of 380,000 ha, through NZ$40 million invested by central and local Government, and a further NZ$20 million by land owners (Lovatt, 2009).

Table 3: Key actors in the sustainable land management case study

Levels	Actors
Individual	Former Chair of Horizons Incoming Chair of Horizons Incoming CEO of Horizons Horizons' project champion Individual industry leaders Local mayors Prime Minister Prime Minister's advisor AgResearch scientist Landcare scientist
Organisation	Horizons Regional Council AgResearch Ltd. (a Government-owned research institute) Landcare Research (a Government-owned research institute) Ministry of Agriculture and Forestry (now Ministry for Primary Industries) Federated Farmers
Project	Sustainable Land Use Group Technical Advisory Group Horizons land management staff
Network	Prime Minister's Office Leading hill country farmers Farm advisors Beef & Lamb NZ Local mayors Landcare Trust Rural community leaders Industry stakeholder groups, e.g. Federated Farmers Massey University Geological and Nuclear Sciences (a Government-owned research institute)
AIS	Industry stakeholder groups, e.g. Federated Farmers Rate (tax) payers Hill country farmers Dairy farmers

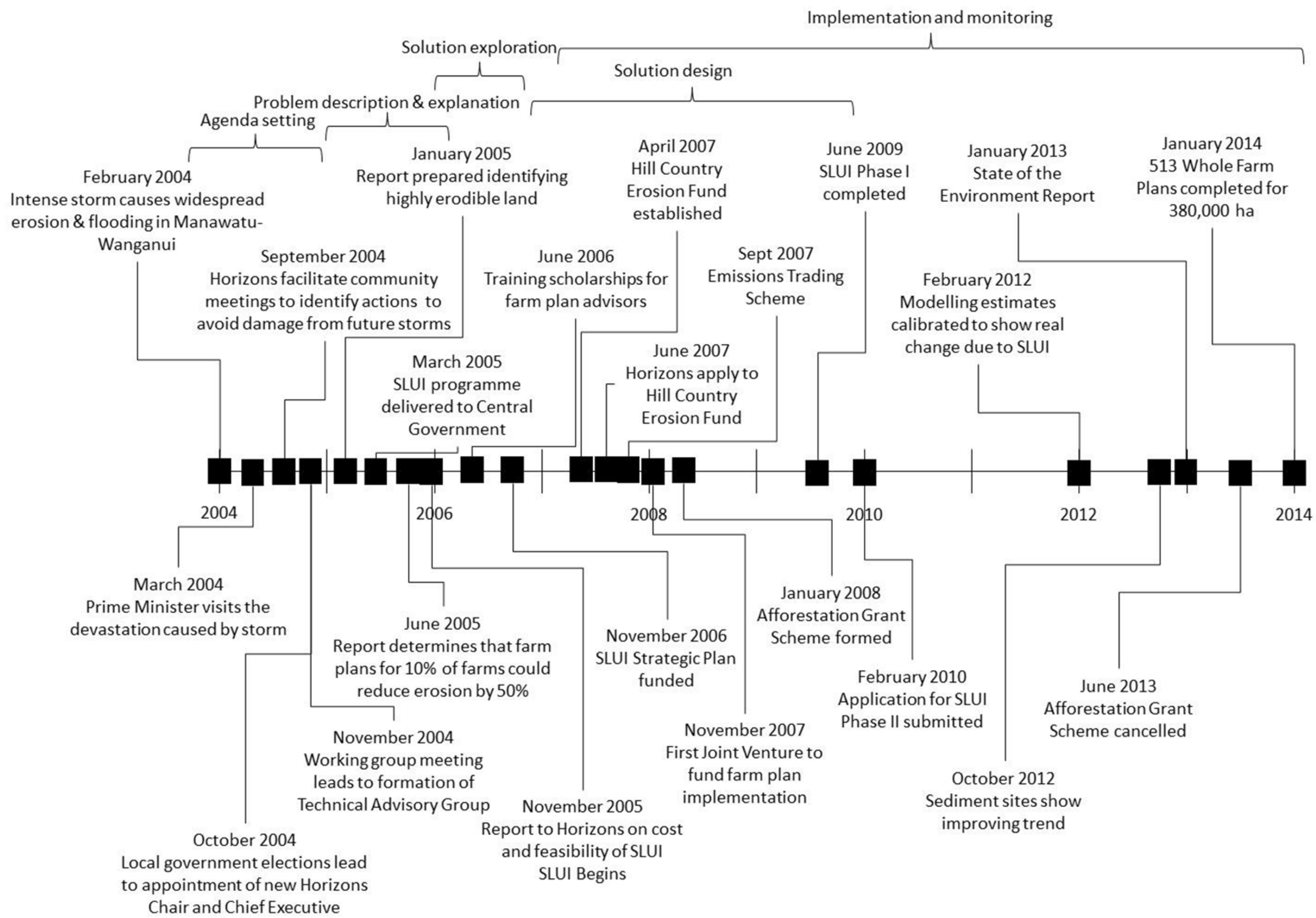

Figure 9: Timeline of activities in the sustainable land management case study

4.4 Capability coordination in the sustainable land management case

The timeline (Figure 9) identifies the six phases in the innovation process of the sustainable land management case. These phases are further analysed below in terms of how capabilities were coordinated at multiple-levels to progress each phase.

4.4.1 Agenda setting: Never again

The Sustainable Land Use Initiative was established as a response to an AIS-level crisis created by the widespread devastation to Manawatu-Wanganui from the 2004 storm. In September 2004, the then Chair of Horizons called a community meeting to discuss an agenda to prevent the level of devastation occurring again and also obtain a mandate from community to affect changes in land use and management to reduce the risk from future extreme events (Figure 10). The timing of this meeting was critical; late enough that communities had made some recovery, but not so late that the memory of the impact had faded. The meeting galvanised the commitment of rural and urban communities to address this challenge by recognising the impact of the storm on all communities and the costs of rebuilding the flood management infrastructure to avoid future devastation. The Chairman was a key individual, able to bring together diverse actors around a common agenda. An outcome from the meeting was the formation of the Sustainable Land Use Group (SLUG), made up of representatives of stakeholders and key influencers, and later MAF as a partner and financial contributor. SLUG was deliberately inclusive to gain the support and mandate of stakeholders.

At the individual-level a new Chairman, followed shortly after by a new Chief Executive, continued the initiative with the new council. They used their connections with stakeholders to make SLUG inclusive, as well as to gain central government support. The community meeting and the broad stakeholder representation on SLUG were a way for SLUI to increase innovation capacity by mobilising resources and capabilities from a network of actors and to demonstrate wide community support. The latter was critical for accessing funding from central Government; as observed by the former Chair of Horizons "*…my advice to anyone that wants to achieve change with the government today; you can't go in there alone, go there with a team of others who represent and know that it will make a difference*."

At the project-level SLUG developed an agenda that was deliberately inclusive to gain wide support. The goal was resilient communities. This meant that hill country farmers could strengthen their businesses so they could invest in sustainable land management. Communities downstream would be less likely to again face the devastation of the 2004 storm. Government would not experience again the cost of rebuilding infrastructure. Lowland farmers would not have siltation on productive landscapes and urban communities would not have to fund ongoing flood protection works. This agenda underpinned a key principle described by a participant in SLUI; that "*everyone contributes* [financially] *because everyone is a beneficiary*".

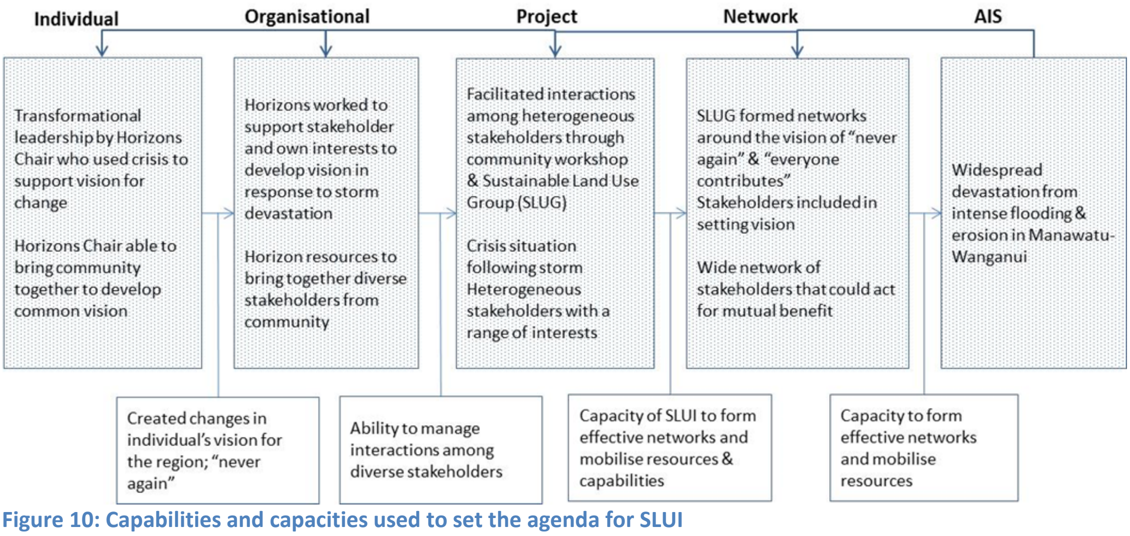

Figure 10: Capabilities and capacities used to set the agenda for SLUI

4.4.2 *Problem description and explanation: Identifying highly erodible land*

Having set the agenda, the SLUG increased project-level innovation capability by drawing on experts to define the problem, as well as explore and design plausible solutions. A Technical Advisory Group (TAG) was formed from soil, land use and farm system scientists in Government research institutes, and technical staff at Horizons (Figure 11). Prior to 2004 some of the individuals that came to make up TAG had already discussed the causes of erosion and potential solutions with Horizons. This drew on over two decades of research that highlighted the areas prone to erosion in the Manawatu-Wanganui, the need to retire areas of farms that were erosion prone, and the assertion that this could be done with limited impact on overall farm production (Mackay et al., 1991; Manderson et al., 2012). The TAG used its farmer and farm advisor networks to gain their input to understanding the problem.

The TAG was supported by the agenda set by SLUG and changes in organisation-level capabilities within Horizons. A change in the culture of Horizons, brought in by the new Chair, provided a mandate for the TAG to take a whole of region and farm system view of the issue. As a participant in SLUI described it; "*we don't want to be building stop banks forever and a day down here, we're treating the disease at the source*". This contrasts with the option to cut the sustainable land management group being explored by Horizons prior to the February 2004 storm.

An important role of the TAG was to reduce project-level risks by providing SLUG with confidence that SLUI could be implemented, and to provide confidence to MAF that SLUI was technically feasible and was not only driven by Horizons. This assisted Horizons in obtaining central government support by demonstrating that the programme could achieve central government goals of sustainable land management and resilient rural communities. The interaction between Horizons and the other Regional Councils with government in a wider conversation on sustainable land use was instrumental in the development of the Hill Country Erosion Fund in 2007. This fund was available to all regions with soil erosion, however, the bulk of the dollars went to Horizons to support SLUI. Importantly, storms in other New Zealand regions in 2004 and 2005 kept the issue on the political agenda.

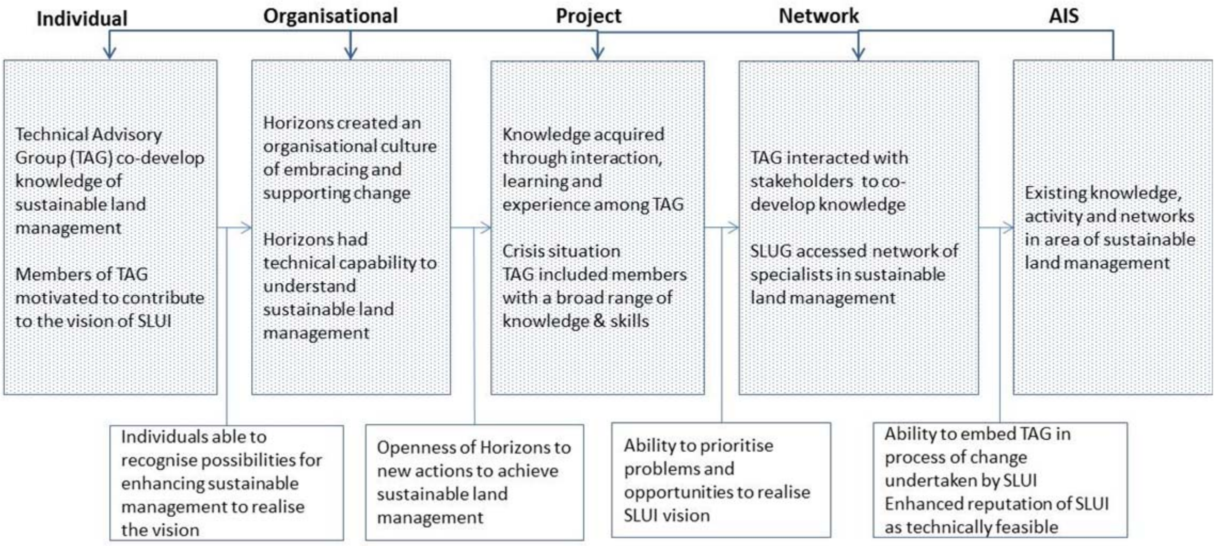

Figure 11: Capabilities and capacities used by SLUI to explain the problem

4.4.3 *Solution exploration: The cost and feasibility of SLUI*

The TAG identified and mapped the areas within the Manawatu-Wanganui with highly erodible land by catchment, established priority catchments, and proposed the use of Whole Farm Plans as a vehicle for supporting land use change on the highly erodible land within farms within each of the catchments. An important aspect in the exploration of solutions was identifying that targeting farm plans in priority catchments, and further targeting farms within each of the catchments with the most eroding land connected directly to water, would have a disproportionately large positive impact on reducing sources of sediment. Visual representation showing that targeting the 10% of farms with most eroding land in the region could reduce sediment loads by up to 50% was a powerful tool in convincing stakeholders of the value of prioritising the roll out of the farm plans. This prioritisation informed a report on the cost of SLUI and demonstrated the programme's feasibility to SLUG, Horizons and MAF. The SLUG set an agenda of "*a third, a third, a third*" from farmers, regional tax payers and central Government for SLUI to be affordable for all stakeholders.

The make-up of the TAG meant it had significant innovation capability for exploring solutions to achieve the SLUI agenda (Figure 12). Individuals on the TAG had long experience in research and activities in sustainable land management, working with land owners and industry, and were motivated to achieve the agenda. The ability of the TAG to put this capability to exploring solutions was supported by organisational-level changes in Horizons brought in by the new Chair and Chief Executive. This meant that Horizons recognised the complex changes needed to enhance sustainable land management and were willing to enact these changes, as described by a participant in SLUI; "*Horizons as an organisation went from the organisation that couldn't, to the little organisation that could*". This included Horizons developing stronger networks with science organisations, for example by paying scientists on a retainer, to be able to access the robust information needed to design SLUI. This change in Horizons' culture was tested at the AIS-level in following local elections with councillors campaigning on stopping SLUI to lower taxes being voted out.

At the project-level, the SLUG and TAG actively brought together a broad range of actors with knowledge, capabilities, resources and access to networks to develop solutions that balanced individual and collective agendas. This strengthened project innovation capacity to co-develop SLUI with a network of specialists. This enabled SLUI to select, combine and strengthen solutions that different actors in the network had been developing, as well as to mobilise collective capabilities to develop and implement these solutions.

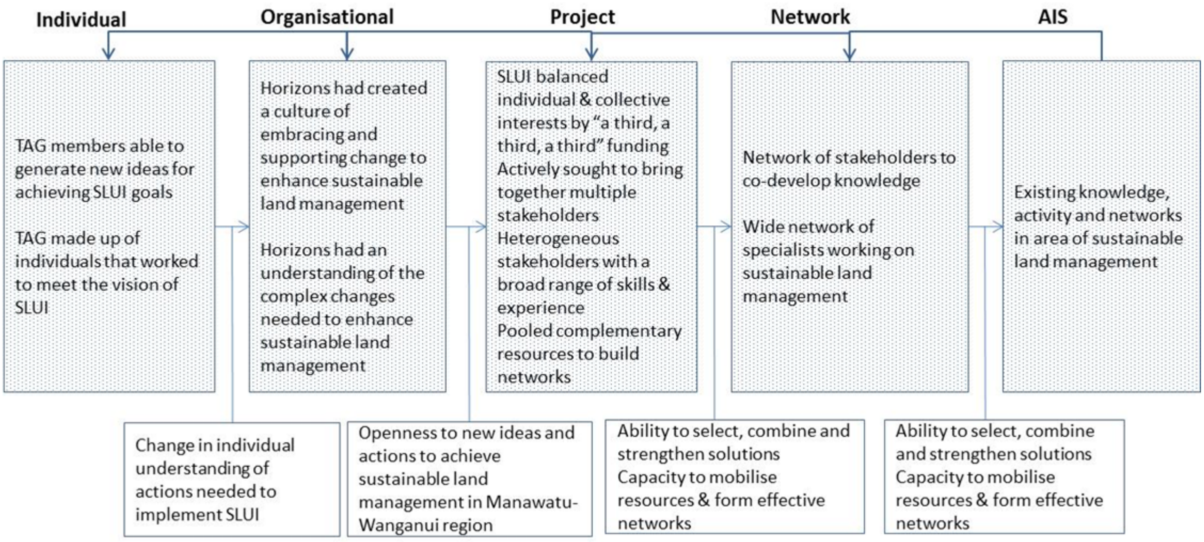

Figure 12: Capabilities and capacities used by SLUI to explore solutions

4.4.4 Solution design: SLUI Strategic Plan

A key aspect of the design of SLUI was the network for accessing support and then funding from central Government to resource the preparation of farm plans. The SLUG, and particularly the Chair, Chief Executive and management staff of Horizons utilised and developed strong networks with MAF and the Prime Minister's office (Figure 13). These networks led to the establishment of a central Government fund for local government agencies to resource erosion management. This was a contestable fund to ensure central Government was not favouring a particular region, however, Horizons, as well as other regional councils, had significant input to setting the fund criteria. Another example was Horizons input into design of the Afforestation Grant Scheme; this input arose due to the scheme being undersubscribed. SLUI utilised the scheme, along with the Emissions Trading Scheme, to resource production forestry as one of the options in the Whole Farm Plans for addressing erosion. The agenda of "*everyone contributes* [financially] *because everyone is a beneficiary*" and the way SLUI contributed to a change, as described by a participant in SLUI in "*the way most people now look at land use, not just the farmer, but all sectors of our communities look at it differently* also reduced free riding by any one actor.

At the project-level SLUG emphasised the need for advisors to be able to make decisions "in the field" without having to get approval from "head office". SLUI built capability to develop Whole Farm Plans by funding over twenty scholarships supporting undergraduate students in agriculture and offering summer internships to increase the pool of land managers. This support, along with funding of farm advisors and Horizons staff, focused on individual-level empowerment of advisors to establish effective working relationships with farmers. There was recognition of the capabilities all the advisors needed to understand the elements that made up a whole farm plan, have challenging conversations with farmers about their business, goals and current and future land use, and make a compelling case for the benefits from developing and implementing a Whole Farm Plan.

An institutional change proposed by Horizons at the AIS-level during the implementation of SLUI threatened to halt project progress. The One Plan, a regional plan for the management of land, water quantity and quality, and biodiversity, notified in 2007, on top of a tax on GHG emissions proposed by central government, created uncertainty and confusion amongst land owners in the region. Under the water quality component of One Plan over 500 landowners in targeted catchments would be required to each have a nutrient management plan to manage their nutrient losses as part of their consent conditions (Horizons Regional Council, 2014). The majority of these landowners were dairy farmers, as opposed to farmers with SLUI Whole Farm Plans, who were predominately sheep and beef farmers targeting soil erosion. Through miscommunication by some actors representing landowners who would be affected by the One Plan, the One Plan was linked to the activities of SLUI, a voluntary programme operating as a non-regulatory approach to erosion management. As one participant described it SLUI was perceived as "*the thin edge of the wedge, was going to be the forefront of…regulation in hill country*". The actor networks developed through SLUG were able to address these AIS-level changes; "*To offset risks you constantly maintain connections with your major supporters*."

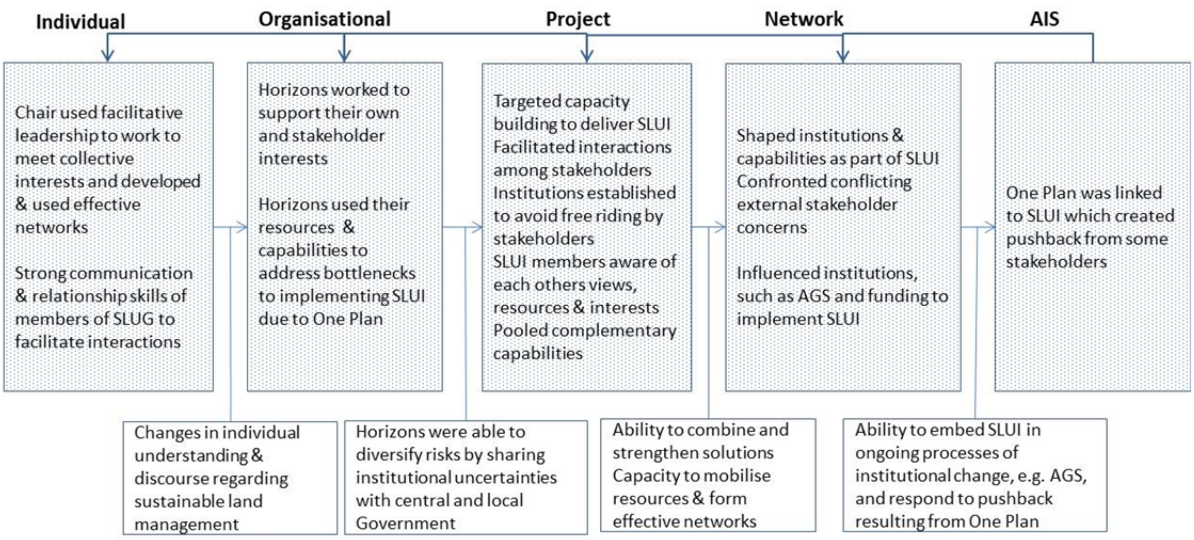

Figure 13: Capabilities and capacities used to design SLUI

4.4.5 Implementation and monitoring: 513 Whole Farm Plans completed by 2014

Implementation of SLUI first focused on working with six leading farmers to develop Whole Farm Plans, which were also used as case studies in workshops, presentations and one-on-one conversations with farmers. These farmers were recognised as not necessarily all needing a Whole Farm Plan, but by being willing to share information with other farmers on the financial and environmental benefits of implementing farm plans, they contributed to SLUI going from actively seeking farmers, to having a waiting list within a year.

One individual in SLUI was identified as a project champion; "*a force of nature and incredible enthusiasm, and doesn't respond well to 'no'*". This project champion formed relationships, challenged perceptions and misbeliefs about sustainable land management, and created enthusiasm for the programme, especially within Horizons, which brought people on board to deliver SLUI.

At the project-level, monitoring of completed Whole Farm Plans, and how these plans could contribute to reduced erosion and sediment loss, was an important activity at the end of SLUI's first phase and during the second phase (Figure 14). This was driven by the need to demonstrate to MAF, rate payers and stakeholders that funding was meeting the targets set and was effecting meaningful land use change. An important aspect of monitoring was modelling of erosion and sediment loss, which showed the magnitude of SLUIs impact on sediment loading into rivers, along with a farm advisor's analysis of the economic benefits to the region. Another aspect of monitoring was State of the Environment reporting, which was used by Horizons to convey the benefits of SLUI to tax payers in urban areas, in terms of reduced costs of flood protection. This information demonstrated the AIS-level benefits of SLUI to network actors.

The network connected to SLUI was important for the project to be able to respond to AIS-level changes, such as the Afforestation Grant Scheme ending in mid-2013. SLUI continued by negotiating changes in programme targets with MAF to reflect the loss of this funding and land use change option. The response of SLUI to these changes also reflected the capability of individuals in the project to recognise possibilities in emerging problems; a "*glass-half-full*" attitude.

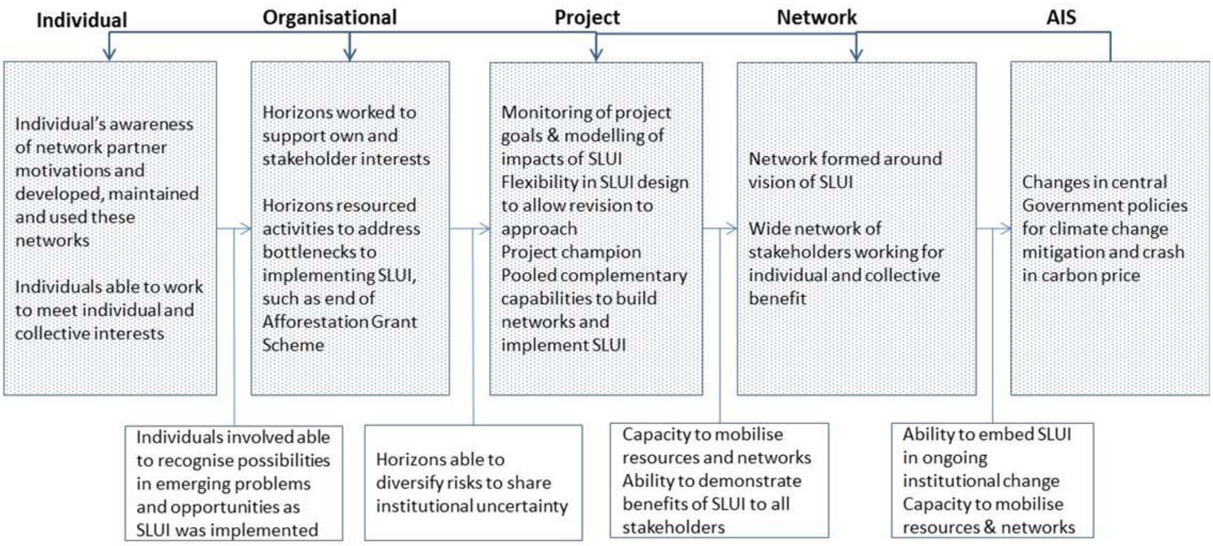

Figure 14: Capabilities and capacities used to implement and monitor SLUI

5 Analysis and discussion

5.1 Successful innovation involves coordination of capabilities at multiple-levels

From the above results, it is observed that particular capabilities at particular levels alone are neither necessary nor sufficient for building innovation capacity. For example, a crisis was important for setting a new agenda for sustainable land management and building a network of stakeholders to support this agenda (e.g. Boin et al. (2009) and Verduijn et al. (2012)). A crisis was, however, not necessary to set an agenda and build a network for improving lamb survival. In this case a window of opportunity was created by framing (Brusoni and Prencipe, 2013) poor lamb survival as a "lost opportunity". Also, a crisis was not sufficient for successful innovation in the sustainable land management case, as additional capabilities were needed to build innovation capacity. At the individual-level these included an innovation broker to frame the crisis and policy response in a way that brought together a wide network of actors to design and implement solutions and access financial resources.

The case studies highlight the need to combine and reconfigure capabilities from the individual to network-level to adapt to internal project and external AIS changes and build innovation capacity as projects proceed. In both cases particular individuals brought critical boundary spanning, mediating and brokerage capabilities (Klerkx et al., 2009; Westley et al., 2013) enabling continuity of innovation, by building networks of actors aligned to an opportunity and facilitating the meeting of their individual and collective needs (Nettle et al., 2013). This built project- and network-level capacities for accessing on-going resourcing (e.g. funding of the lamb survival project) and implementing solutions (e.g. institutional elements of SLUI to resource Whole Farm Plan implementation).

Organisational-level capacities can enable (or hinder) individual-level capabilities to develop project-level capacities. In the sustainable land management case at the individual-level the Chair strengthened Horizons' capacity to implement SLUI by creating a culture for change and engaging with technical experts. In contrast, in the lamb survival project there was a misalignment between the organisation-level capacity to support demand-driven science and network interactions in the lamb survival project. A couple of strategies were observed in the lamb survival case as a way to strengthen project-level capabilities in this situation: (i) create a research team focused on demand-driven innovation within the wider organisational culture of science-led innovation, and (ii) individuals utilised their individual capabilities to deliver project- and network-level agendas, rather than organisational-level agendas.

Building project-level innovation capacity was observed as important for both cases to progress innovation while working in complex systems with low decidability. For the lower decidability of the sustainable land management case an important project-level capacity was network connections to reconfigure parts of the solution. The network formed as part of the lamb survival case was predominantly for knowledge sharing and accessing on-going resourcing to progress to solution design and implementation.

5.2 Different capabilities are needed to build innovation capacities through the innovation process

Both cases highlighted that different capabilities are needed at different phases of innovation, and that capacities built in earlier phases are critically important in later phases.

Innovation capabilities, such as knowledge co-development with technical experts, were especially important in the problem explanation and solution exploration phases to provide legitimacy for the problem explanation and solutions identified and confidence to network stakeholders that solutions were feasible. During the implementation phase, the absorptive capability of networks is more important. Again both cases demonstrate that it is important to coordinate capabilities to build this absorptive capacity during earlier innovation phases, and explicitly including resources in solution design to build this capacity, such as institutions to support implementation of Whole Farm Plans. Finally, monitoring capabilities are especially important in the implementation phase to demonstrate benefits of solutions, and includes monitoring of multiple outcomes that align with the different interests of stakeholders.

Setting agendas for innovation requires individuals with the capability to identify and seize windows of opportunity that emerge in the AIS. Innovation agendas in both cases were driven by individuals who were able to frame the issue in a way that connected the agenda for change to the interests of a wider network needed to support and implement the agenda. The networks that were formed and reconfigured around both projects were essential to assemble supporters for an innovation agenda (Beers and Geerling-Eiff, 2013; Douthwaite et al., 2009; Giller et al., 2008; Rohrbeck et al., 2009) and become an important capacity in later innovation phases by providing access to new network partners to understand the causes of the problem and design and implement solutions. These networks also increased capacity to share risk, e.g. by being able to undertake risky solution design, as in Landcorp's ewe feeding trials in the lamb survival case, and mitigate misinformation as in SLUI.

6 Conclusion

The cases analysed in this paper provide two key insights on how innovation projects can effectively configure capabilities at different levels of the AIS to successfully build innovation capacity. Firstly, individuals with facilitative leadership capability and networks of actors with strong external connections, organised around a collective agenda, formed in the problem description and explanation phases became important capacities for solution design and implementation phases. Secondly, institutional support is needed to enable projects to explicitly build innovation capacity as part of project outcomes. Both cases studied utilised resources and capabilities in the early phases of the innovation process and at multiple-levels, particularly the individual- and project-level, to build innovation capacity (Hall et al., 2003) and increase the likelihood of successful innovation.

This paper provides a framework for evaluating the configurations among project capabilities at multiple-levels to understand how these interact with individual, organisational and external capabilities to successfully build innovation capacity and create impact. Our findings also provide guidance on the capabilities that projects may need to coordinate to achieve this, with a particular emphasis on individual and network-level capabilities.

Acknowledgements

We would like to acknowledge the Ministry of Business, Innovation and Employment for funding the Primary Innovation project (CONT-30071-BITR-AGR) through a Biological Industries Targeted Research grant and the Adoption and Practice Change Roadmap Implementation through Core Funding. We also acknowledge funding by New Zealand dairy farmers through the DairyNZ Co-innovation project (HC1302). The paper greatly benefited from suggestions made by Helen Percy and Bruce Small. Most importantly, a special thank you goes to the interview and workshop participants who kindly made themselves available to participate in the study.

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