

# The role of networks in transforming Australian agriculture

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**It has been argued that major, purposeful action often resulting in significant changes in structure or function, known as transformational adaptation, is required in some areas of the agricultural sector to adapt to climate change and other driving factors. Yet there is limited understanding of what factors instigate and facilitate this scale of change. From a social science perspective, one key question remains: to what extent do agribusinesses need social capital to plan and implement large-scale, transformational adaptation options, compared with incremental-scale adaptations? Data drawn from Australian primary industries found that those undertaking transformational change had more far-reaching information and knowledge network connections yet less extensive social links to family, friends and colleagues. These findings demonstrate that strong access to knowledge and weak social ties increases the ability to facilitate action that differs from established social norms, hence empowering transformational adaptors to plan and implement novel strategies and options.**

Action for climate change is not occurring as fast, widely or significantly as may be required to address major climate change impacts<sup>1,2</sup>. Recent reports<sup>3–6</sup> have the planet tracking above the Intergovernmental Panel on Climate Change's highest rate for emissions and a projected 4 °C global temperature rise is not out of the question if current rates continue<sup>7</sup>. The consequences of a 4 °C (or more) temperature rise over the next century will presumably affect ecosystem services so that the productivity of agricultural systems will be altered and dependent communities and industries will be significantly affected<sup>8,9</sup>. To adapt to this new world, multiple scales of action are required<sup>10</sup>. The focus of this Perspective is on adaptation that is occurring in the Australian agricultural sector due to climate change.

Research in the field of climate change adaptation has used various typologies to define adaptation. One approach is to define three levels of adaptation: (1) incremental — moderate changes are made to existing actions and behaviours; (2) systemic — changes are made at the system or structural level; (3) transformational — large scale, novel responses create a fundamentally new system or process<sup>11,12</sup>. So far, the adaptation programme has been dominated by incremental adaptation approaches — such as technological fixes, intensification of farming, improvements to crop varieties and breeds of livestock, or water and soil management practices — which can be seen as reactive responses to a variety of stressors including climate change impacts<sup>13</sup>. These approaches can be ineffective in the long term<sup>14,15</sup> and can even lead to adaptation that has harmful effects, known as maladaptation<sup>16,17</sup>. On the other hand, transformational adaptation is often (but not always) seen to be anticipatory and focused on the long term<sup>12</sup>. At the transformational scale, changes are defined as major shifts in goals and/or processes in response to risk and opportunities, for example, moving the location of production of specific commodities, making significant business structure

or operational changes, or even choosing to leave an enterprise or industry altogether<sup>12,18</sup>.

Investigating transformational adaptation is fairly new, compared with research conducted at the incremental level. Therefore, unlike incremental adaptation, there is far less understanding of what factors instigate and facilitate transformational climate adaptation. Researchers have suggested<sup>19–21</sup> that identifying the social mechanisms that can influence anticipatory adaptation could lead to a better understanding of the role these mechanisms play, which is of particular interest to this newly forming field due to the possibly significant impacts this adaptation approach can have.

For any agricultural system (regardless of the scale) to adjust to climate change, there needs to be a capacity for that system to do so. This 'adaptive capacity' is "a set of latent characteristics, or the potential, needed to adapt to climate change and the ability to be actively involved in the processes of change"<sup>22–26</sup>. Increasing the adaptive capacity of a system can improve its ability to manage change by making it more flexible and responsive to a variety of climate impacts<sup>21</sup>. Recent research<sup>26,27</sup> has raised the question of how social concepts, such as social capital, assist in assessing adaptive capacity. Therefore, the secondary aim of this Perspective is to report an investigation into adaptive capacity from a behavioural perspective, specifically in the context of transformational adaptation.

## Adaptive capacity and social capital

Many researchers are now calling for an extension of the traditional economic evaluation of adaptive capacity and advocating a more holistic scope of elements that form adaptation options, including social factors such as behaviour<sup>27–30</sup>. The inclusion of concepts such as social capital meets this call<sup>24,25</sup>. The level of social capital within a community (or organization) provides some indication of its

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**Table 1 | Ego-networks for social support ties.**

	Average number of direct supporters identified	Total number of ties in the network	Density
Incremental adaptors	10	136	14%
Transformational adaptors	3	43	3%

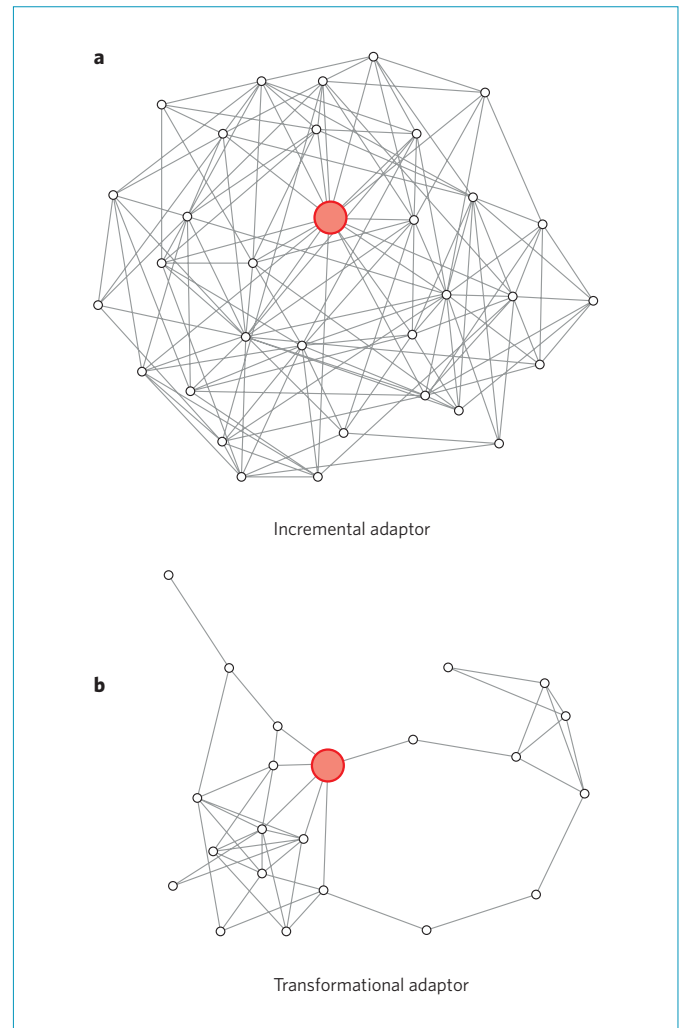
capacity to cope with change and adapt<sup>31–34</sup>, which helps to explain the ease with which ‘change events’ are accepted and incorporated into people’s lives. Individuals with stronger, more informed and more effective networks have been generally regarded as more resilient to generic change events than those with weaker ties<sup>35–37</sup>.

The large and growing body of literature surrounding social capital has created confusion over its meaning<sup>27</sup>. For the concept to be useful within an approach that seeks to understand and analyse climate change adaptation, it must be very specifically defined. Most definitions have grown out of the work by Putnam<sup>37</sup>, which included concepts such as norms, obligations, and trust with a focus on social capital being held within groups, communities or societies for collective action<sup>27</sup>. Therefore, a focus on social capital theory as a way to analyse the potential for transformational adaptation actions taken by individuals can be a powerful approach to assess the assets or capacity of individuals to transform and adapt.

Drawing on other approaches<sup>38,39</sup>, social capital is defined as the collective social resources available to individuals in the form of networks of relations or connections that may be used to access other resources, coping mechanisms and general livelihood strategies. Thus, ‘stocks’ of social capital reflect the level of social interaction, networks and relations that exist within a community<sup>37,40,41</sup>. Communities with increased stocks of social capital typically have reciprocal interactions and increased trust that are directed towards mutual benefit<sup>42–45</sup>. Social capital also includes knowledge and mutual obligation, and is developed through social learning<sup>46</sup>. Thus, social networks can be seen as the embodiment of social capital<sup>47</sup> and a loss of social capital can mean the decline of network connections, trust and skills. Many researchers have applied this approach to social capital in the field of adaptation relating to disaster recovery (for example, from floods and fires) and the role connections play in building resilience or restoring communities following a disaster<sup>48,49</sup>.

To focus exclusively on group membership as a measure of social capital at the macro-level would be to miss a potentially more detailed picture of an individual’s social relationships. Uncovering the social relationships that are crucial to climate change adaptation requires expanding our focus to include multiple types of networks (such as knowledge/information and social support ties). Accounting for formal structures and resource distribution is part of the decision making process when determining choices among adaptive strategies, but “a large part can be attributable to informal social relations and values — to social capital”<sup>27</sup>. Therefore, capturing multiple forms of structures and/or connections will provide a more comprehensive description than adopting an aggregated or consolidated view. In addition, past research has also demonstrated that effective social support and information networks are useful in framing adaptation<sup>30</sup>.

Finally, to investigate the roles adopted in network structures across incremental and transformational adaptors, we applied a synthesis framework<sup>50</sup> that measures social capital by examining levels of integration and linking<sup>51</sup>. ‘Integration’ refers to the number of social ties that exist within a network and ‘linking’ measures the ties between different networks at the micro-level. More recently, these terms have been referred to as bonding (ties shared within a network) and bridging and linking (ties that cross group boundaries to other networks to form alliances or that provide a connection to those with power and legitimacy)<sup>52,53</sup>.



**Figure 1 | Findings show that incremental adaptors have a greater social support network than transformational adaptors.** Total social support network ties for **a**, incremental and **b**, transformational adaptors.

### Comparing networks

The analysis we are reporting investigated participants’ networks (knowledge/information and social support) with a focus on the structural similarities and differences between transformational and incremental adaptors. The results of social network analysis reveal a difference between adaptor networks in relation to both social support (Table 1 and Fig. 1) and knowledge/information (Table 2 and Fig. 2) connections regarding effective assistance and encouragement for change. Overall, transformative adaptors had significantly less social support network ties (Fig. 1b) than incremental adaptors (Fig. 1a), yet had significantly more information ties (Fig. 2b). In other words, incremental adaptors establish strong social capital by creating bonding ties in their existing social support networks, but transformational adaptors build strong social capital in (bonding) and across (bridging and linking) their information and knowledge networks. These results were reflected in comments made in

**Table 2 | Ego-networks for information ties.**

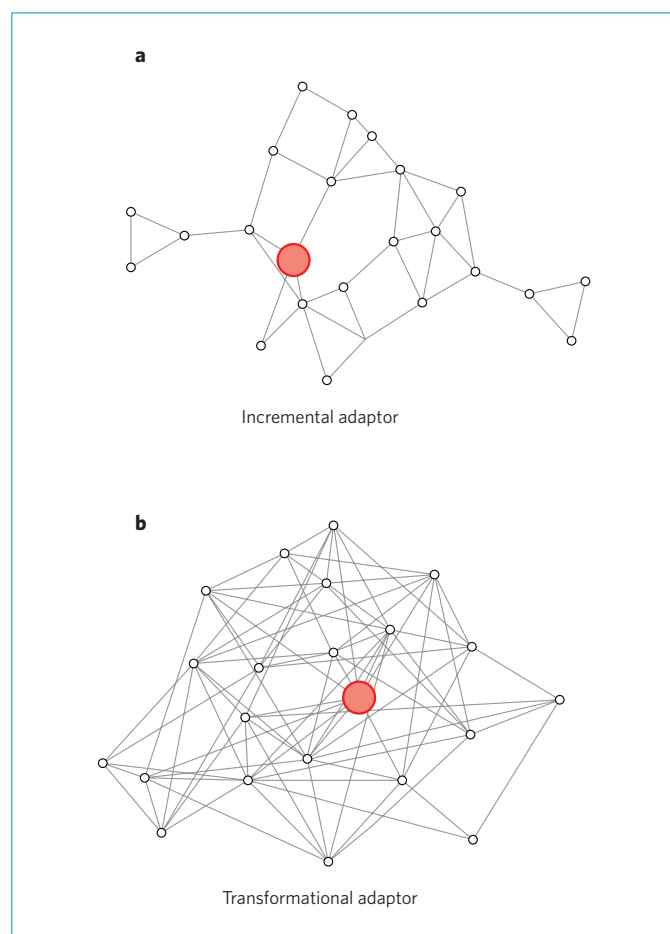
	Average number of direct sources identified	Total number of ties in the network	Density
Incremental adaptors	4	40	2%
Transformational adaptors	12	79	9%

interviews as well, where transformational adaptors expressed their effective and proactive ability to seek required information (that is, taking full advantage of existing network connections while also building new ties beyond geographic and industry boundaries) to make large-scale changes to their practices. However, they also remarked on the lack of social support from family, friends, neighbours and their colleagues within industry in the decisions and changes they were making; for example, they were told: “this is not the way this family does things”, “no one else is doing this, best we just follow the crowd” or “why do you always have to do things differently to everyone else”. Incremental adaptors reflected on the strong support they receive from peers and industry connections for the adaptation options they were implementing and stated that they were “content”, “happy” and “satisfied” with the level of information they received through their networks. A majority of incremental adaptors asserted that this came from a passive consumption of information (for example, receiving information from colleagues, neighbours, industry publications and natural resource management group sources) rather than the proactive seeking approach taken by the transformational adaptors (for example, going online to seek information or actively forming connections

through study tours and site visits outside their geographical location and industry).

The disparity between the numbers of ties (that is, bonding, bridging or linking) across the two scales of adaptors is an interesting finding. The critical difference in levels of tie-strength in a network arises because individuals that share strong and multiple ties tend to form close-knit groups that interact frequently and create shared norms and usually have common characteristics<sup>51,54–56</sup>. In addition, this is based on an expectation that social transitivity<sup>57</sup> will occur — where relationships between A and B and between B and C often lead to a relationship between A and C. Based on this premise, strong ties formed by A, B and C should also eventually be incorporated into the rest of the wider group. The implication of a strongly tied network is that information obtained should flow to other members of the network and contribute to shared knowledge, practices and norms<sup>58</sup>. Eventually each network member should hold the same information and enforce the group’s norms — a state known as redundancy<sup>59</sup>. Having redundant sources of information may be beneficial, to the extent that the transfer of information among group members is imperfect<sup>60</sup>. Even so, the dependence of information on strong ties reduces the likelihood of individuals receiving accurate and unique information<sup>54</sup>. From our findings, transformational adaptors have strong bonding connections within their information networks, but they circumvent the issue of redundancy by also actively seeking bridging and linking ties with individuals outside their peer groups, geographical locations and industry boundaries. By using this approach, the participants reflect an ability to not only share information locally but also go beyond the status quo understanding of current practices and seek broader sources of knowledge to feed into their decision making processes. From the perspective of developing transformational options in response to environmental changes, synthesizing and extending knowledge across a range of fields can be beneficial to the diversity of approaches that can be adopted as well as widening the opportunity to integrate actions<sup>61</sup>. Incremental adaptors, on the other hand, have a much smaller number of bridging network connections regarding information access, which limits their ability to share and obtain knowledge outside their bonded network and access a wider variety and scope of adaptation options.

Owing to the smaller number of network connections from a social support (encouragement) perspective, it could be concluded that transformational adaptors have a lower level of social capital and could face adaptation challenges compared with the stronger social capital possessed by incremental adaptors, but this is not necessarily the case. Borrowing once again from the notion of transitivity, it is less probable that weak ties will integrate into the core clique of individuals in the group<sup>51</sup>. In other words, if a strong tie exists between A and B and a weak tie exists between B and C, the probability of A and C forming a relationship is not enhanced. And although C may not join the clique that includes A and B, this is not to say that C will be isolated. Rather, C will probably seek to have their own set of strong-tie relationships that form into other distinct groups (once again, acting as a bridging and linking node to other networks and/or individuals with power and legitimacy)<sup>54</sup>. The benefit for C is that they can gain access to information disseminated between A and B (due to their weak tie with B) without being as bounded by the group’s social norms because of their weak tie to the group. Hence, the “strength of weak ties” refers to the relative advantage that weak-tie relationships provide through the development of



**Figure 2 | Findings show that transformational adaptors have greater information connections than incremental adaptors.** Total information network ties for **a**, incremental and **b**, transformational adaptors.

**Table 3 | Case study details.**

Case study	Summary	Participants	Measures
Wine	This case study tracks two South Australian wine companies that have taken the transformative step of purchasing vineyards in Tasmania to prepare for the likely impacts of climate change. This adaptation has occurred despite previously only sourcing grapes from a particular region because of heritage, place attachment and branding strategies.	<b>2011</b> — survey of 50 grape growers. <b>2012</b> — 19 face-to-face interviews with winery staff (winemakers, marketing directors, environment directors and so on).	<b>Demographics:</b> Age Gender Region Industry Farm size Income and source Length of time in the industry
Peanut	This case study consists of a large agricultural company deciding to expand its operations into Katherine, Northern Territory, Australia, after decades of below-average rainfall in their traditional peanut production region in southern Queensland.	<b>2009</b> — 28 face-to-face interviews with company, government and community representatives. <b>2010</b> — 9 face-to-face interviews with company, government and community representatives and 69 telephone survey responses.	<b>Attitude &amp; belief:</b> Climate change
Community	This case study focuses on the effects of individual farmer transformational decisions on community adaptation planning and responses. Growers in the region under investigation became interested in biodiesel as a value-added enterprise and possibly even diversification. They saw this as an opportunity to become a farmer of energy as well as a farmer of food and feed.	<b>2011</b> — 27 face-to-face interviews with representatives of farming enterprises, businesses, service providers and local councils in the region.	<b>Networks:</b> Information and knowledge Social support

new connections and access to additional resources. Regarding our research, transformational adaptors commented on the “freedom” they felt by not having to adhere to traditional practices, norms or ways of thinking imposed by their peer and industry connections. Being seen as an “outsider”, “someone that always does things differently” or “an early adopter”, provided an opportunity for transformational adaptors to find others “like them”, which once again allowed them to transcend peer groups, geographical locations and industry boundaries. From the other perspective, incremental adaptors stated that having strong peer and industry encouragement and social support (that is, a strong bonded social support network) was a key factor in being successful in their scale of adaptation.

Some researchers are starting to move away from delineating all bonding and bridging ties as being strong or weak connections, respectively. For example, Pelling and High<sup>27</sup> state:

“The language used to describe interpersonal relationships needs refining: not all bonding ties can be described as strong and neither are bridging ties necessarily weak. Moreover, the ability of individuals to change the orientation and character of their social ties gives social capital a dynamic and contextual quality through time and in response to external and internal stressors (Leonard and Onyx, 2003). This is an especially important concern for indicators of adaptive capacity that seek to measure generic social resources that could be the foundation of responding to future climate stressors.”

We agree that for an individual to have adaptive capacity their network ties need to be fluid enough to be responsive to stressors. In further supporting this perspective, labelling all bonding ties as strong and bridging ties as weak is not accurate, but understanding how adaptation decision-makers perceive the strength of ties is linked to the measurement of social capital and ultimately the assessment of their adaptive capacity.

## Conclusion

In this study, transformational adaptors were found to have far-reaching information and knowledge network connections, yet their social links to family, friends and local and industry colleagues were less extensive. Demonstrating the strength of weak ties, this finding indicates an ability to facilitate action that differs from established social norms, hence empowering transformational

adaptors to plan and implement novel strategies and options. By using a network-based definition of social capital at the individual level, and multiple types of network, we illustrate how specific dimensions of social capital played different but important roles in determining the structural differences between incremental and transformational adaptors.

Successful transformation processes need to have access to broader sources of knowledge to feed into decision-making processes. This knowledge can help to prepare for large-scale change and accept uncertainty. “Learning how to deal with uncertainty and adapt to changing conditions is becoming essential in a world where humanity plays a major role in shaping biospheric processes from genetic levels to global scales”<sup>62</sup>. To navigate through transformational processes, agricultural industries will need to consider how to access and develop a new range of collaborative networks so that long-term strategies that are anticipatory and flexible can be developed. Knowledge beyond the normal network sphere, for example, between industry and government, will presumably be particularly important for the adaptive capacity of Australian agricultural industries. The weak ties that form, and the ability to improvise strategies to meet changing conditions and maintain momentum will be essential in implementing large-scale planning events. Our findings begin to identify some of the key social factors and structures needed to plan and implement large-scale, transformational adaptation options, yet a lot more work is needed in this field.

## Methods

A multi-case study approach was adopted for this research, which used a self-nominating process for participation. The research focused on two sector-level cases (wine and peanuts) as well as a primary industry dependent community (Wimmera region, Victoria), within Australia. Each case study was undertaken to investigate the information and support sources used. Details of each case study site, coinciding participants and measures are provided in Table 3.

For the purpose of this research, a social network is defined as a series of direct ties from one actor to a collection of others, whether the central actor is an individual or an aggregation of individuals such as a group<sup>63</sup>. A network tie is defined as a relational or social bond between two interacting actors and is used to represent flows of resources, friendships, transfers or structural relationships between nodes<sup>64</sup>. Nodes can be individual people, households, groups, corporations or other collectives and sources<sup>64</sup>. In this research we focus on the individual level. Placing the individual at the centre of the defined network makes it an egocentric

network, which allows for easily identifiable boundaries for each participant and allows the use of each network to be representative of the social capital held by each individual<sup>65–69</sup>. Our aim was to delineate between information and social support networks and also categorize participants, based on their adaptation actions, as either incremental or transformational adaptors. To classify individuals into the two adaptation categories, participants were asked to indicate if they were implementing the following responses: (1) significantly changing the business structure and management of your operation; (2) changing your enterprise mix; (3) starting a new enterprise; (4) leasing or buying land to farm in other regions; (5) reducing the size of the farm; (6) exiting farming. If a participant ticked more than one of these options, they were classified as a transformational adaptor. All others were treated as incremental adaptors. Along with differences between network connections, demographics such as age, location, farm size, income source, as well as belief in climate change were also found to be distinguishing factors. Increasing age significantly reduces involvement in transformational action. Going from the youngest to the oldest farmer in the sample diminishes the likelihood of transformational action. Although the sample was not representative across all Australian regions, there was no distinguishing area that held significantly more transformational adaptors than the others. Regarding farm size, operating a farm under 1,000 hectares decreases transformational action and individuals whose income is based entirely on their farm engage in less transformational action than those who are not solely dependent on farming for a living. Finally, strong concern and belief in climate change increases the likelihood of transformational action compared with those who are not at all convinced of climate change.

Individual network matrices were created for each participant, generated from their interview transcripts and survey responses. The individual networks were then consolidated or collapsed into one network to represent the connectedness of the two types of adaptor. The results are provided in three ways: (1) the average number of direct people or sources identified across all the participants; (2) the total number of ties within the consolidated networks; (3) the density (group cohesion) measure for each network type.

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### Author contributions

A-M.D. and M.H. oversaw the project. A-M.D., N.M., A.F., E.J. and E.G. developed the design and collected the data. A-M.D. analysed the data, derived the general conclusion and wrote the paper. N.M., M.H. and A.F. contributed to the writing of the paper and assisted with editing.

### Additional information

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### Competing financial interests

The authors declare no competing financial interests.