Drought and climate adaptation program

DCAP3

CREATING ALTERNATE INCOME STREAMS TO INCREASE FARM PROFITABILITY AND BENEFIT THE ENVIRONMENT (UNISQ)

MILESTONE 9B REPORT

Developing downscaling approaches to provide farmer level decision making tools that assist them in assessing whether income diversification options are feasible and profitable on their land

Drought and climate adaptation program

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This report

Building on our earlier analyses and reports (Kath et al. 2023; Reardon-Smith et al., 2023; Thorpe et al., 2023; Kath et al., 2024a,b; Kath & Thorpe, 2024; Reardon-Smith & Mushtaq, 2024; Mushtaq & Reardon-Smith, 2024; Kath et al., 2024), this current Milestone 9b (MS9b) report develops a downscaled (farm level) prototype decision tree that will form the basis of a decision support framework to assist farmers in assessing and deciding whether income diversification options—specifically environmental (carbon, biodiversity) benefit payment schemes—are feasible and likely to be beneficial, financially and environmentally, on their land. This and subsequent work on this project relate to the final, yet vital, stage in the overall 'logic' that informs this project (Figure 1)—a package of works that will support farmers in making informed decisions around engaging in these income diversification opportunities. In this Milestone 9b report, we present this initial decision tree tool and briefly outline the subsequent development of the proposed interactive decision support tool.

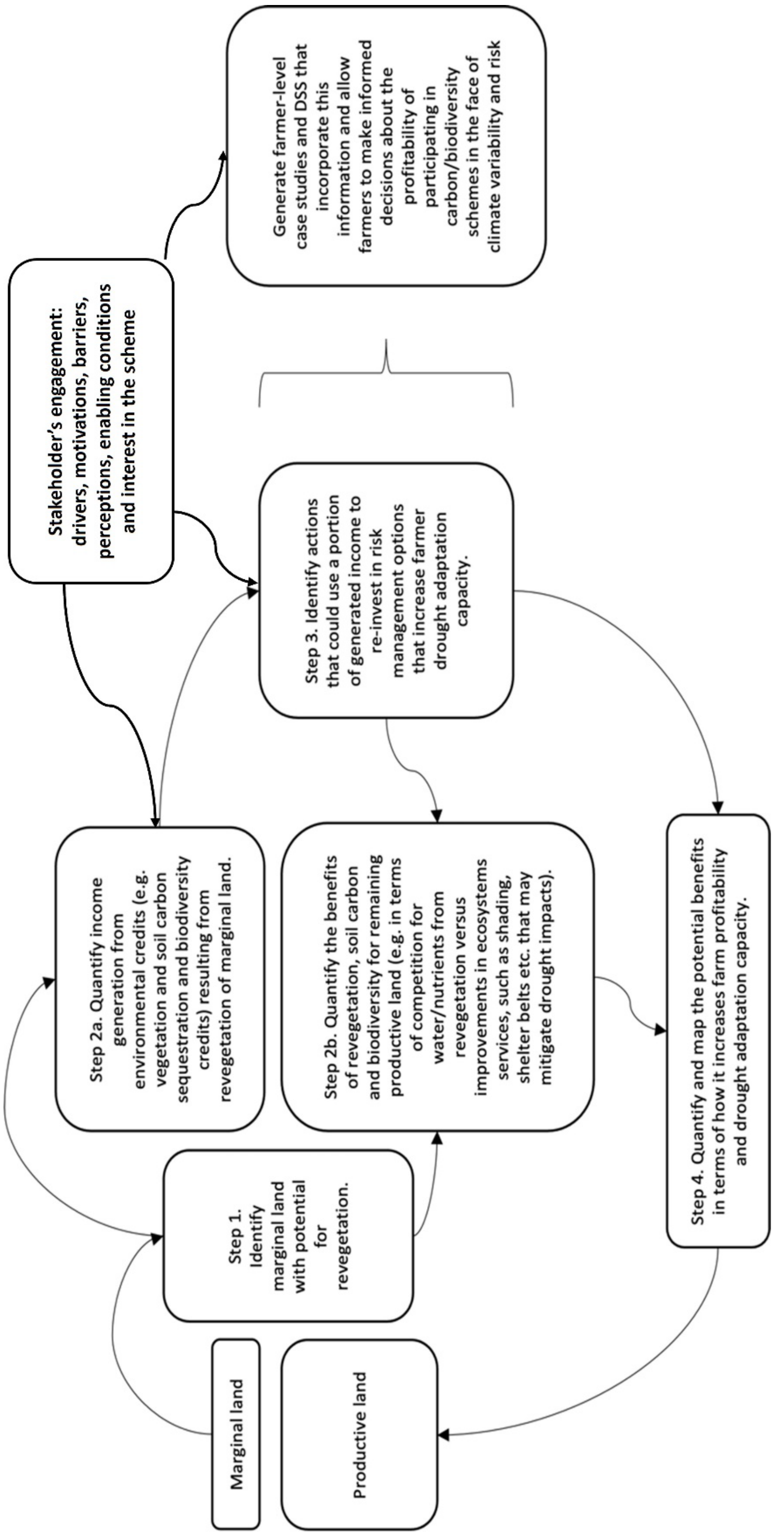

Figure 1. Schematic outlining the approaches and activities that are being undertaken in this project.

Decision-support & the need for user-verified tools

As indicated in earlier Milestone reports, environmental (carbon, biodiversity) benefit or ‘natural capital’ scheme investments are nominally expected to deliver improved financial gross margin outcomes for farming enterprises in Queensland’s climatically marginal cropping areas (Kath et al., 2023; Kath & Thorpe, 2024). However, significant challenges exist in knowing (i) which regions are effectively marginal (under both current and future levels of climate variability) in terms of long-term cropping productivity (i.e., which regions are potentially subject to ‘hard’ limits to adaptation where adoption of cropping practices and technologies may not adequately mitigate climate risk or enhance climate resilience); and, at a finer farm scale, (ii) what the ‘soft’ limits to adaptation are in terms of financial and personal capacity to change cropping practices to accommodate increased climate risk within a cropping enterprise.

Financial mechanisms such as markets for ecosystem services—e.g., Queensland’s Land Restoration Fund (LRF) and Reef Credits, and the Australian Government’s Emissions Reduction Fund (ERF)—aim to incentivise the adoption of sustainable on-farm practices that deliver enhanced environmental outcomes by offering an investment/income stream to participating agricultural producers (Thorpe et al., 2023). Such environmental benefit payment schemes sit alongside a range of investment options available to producers (Figure 2); hence, any decision to participate in a carbon or biodiversity benefits project is likely to be made in the context of other potentially relevant choices (including the decision to continue with the current land use), as discussed in our Milestone 5 report (Reardon-Smith and Mushtaq, 2024).

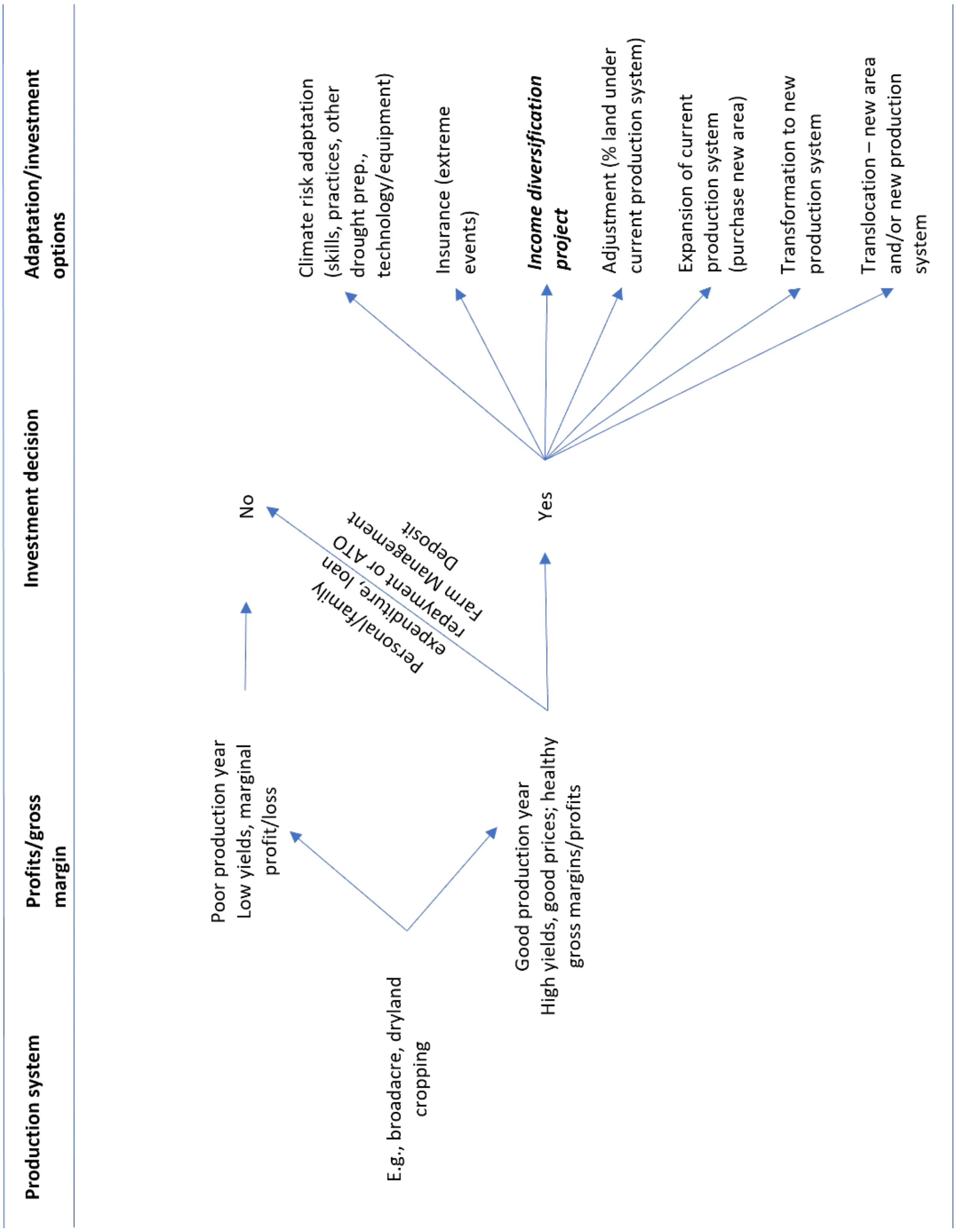

Figure 2 Potential investment options available for Australian broadacre crop production systems (Reardon-Smith et al., 2024).

As discussed in earlier reports (Kath et al., 2023; Thorpe et al., 2023; Kath et al., 2024; Kath & Thorpe, 2024), new environmental (carbon, biodiversity) income diversification projects offer additional options for consideration when making enterprise investment decisions. However, it is widely reported and understood that agricultural producers are often hesitant to adopt new practices, particularly where the financial implications are unclear and uncertainty exists in terms of policy and markets (Piñeiro et al., 2020; Rose et al., 2016); concerns around capacity and the legal and governance arrangements associated with novel schemes such as environmental payments also play a role (Reardon-Smith et al., 2024).

In addition to clear policy settings, market incentives, and access to technological resources, support for more informed decision-making about which investments might be beneficial in particular farming contexts is needed to facilitate the transition to a more diversified and sustainable farming system. This is particularly the case where uncertainties such as variable climatic conditions prevail. Developing improved regionally targeted support for decision-makers requires clear evidence of the (direct and indirect) benefits and costs involved in adopting income diversification options such as environmental benefit projects. We have attempted to analyse and provide such evidence in our earlier Milestone reports; however, there remains a clear lack of comprehensive data at farm scale.

While our earlier analyses have identified critical decision-points for diversification based on declining gross margins from crop production (Kath et al. 2024a; Kath & Thorpe, 2024), it should also be noted that such investment decisions are often not driven solely by financial considerations. Many producers might pre-emptively/proactively invest in environmental and income diversification projects and other strategic options that build the resilience of their production system/s and better ensure the sustainability of their livelihoods (e.g., Figure 3). However, knowing the financial implications of a decision is an important first step, especially where opportunity costs exist (e.g., when currently profitable farming land is taken out of production). Consideration of longer-term risks posed by climate change and increasing exposure to climate extremes may also be critical (Hughes and Gooday, 2021).

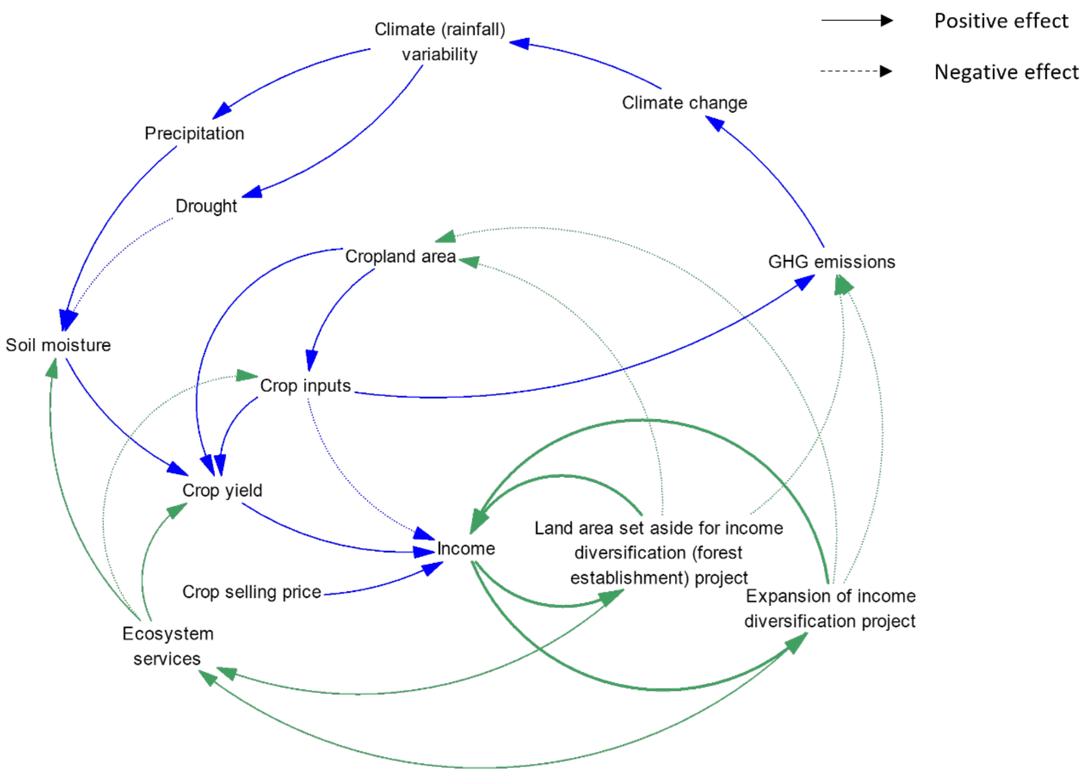

Figure 3. Influence diagram - Broadacre cropping system with income diversification – forestry establishment (ERF) project. Blue arrows indicate the relationships between variables or factors in the crop production enterprise; green arrows indicate the influence of the environmental benefits payment scheme (Reardon-Smith et al., 2024).

Informed decision-making

Good decision-making involves the integration of three key elements: choice, information and preference (Martin-Vegue, 2021), where the decision-maker:

- has multiple options (i.e., choice);
- has a desired outcome, such as increased profitability, financial security, climate resilience or combinations of these or similar; and
- has access to relevant information to be able to understand and assess any risk associated with the decision.

Risk assessment, in particular, helps identify potential hazards, evaluate their likelihood and impact, and determine appropriate mitigation measures, if needed. Improved understanding of the likelihood of risks associated with a particular decision means that the decision maker can enter into the decision with full knowledge of not only the potential benefits but also the potential costs of implementing the decision, including those of appropriate risk reduction strategies (Linkov et al., 2014). This process enables decision-makers to make more informed choices by understanding the potential consequences of different options and prioritizing actions based on risk levels.

Decision Support Tools (DST)

Decision support tools (DSTs) are resources that are designed to assist individuals in making informed choices, particularly in complex contexts such as healthcare and environmental (including agricultural) management. They do so by providing evidence-based information, outlining options, and helping individuals consider their preferences and values alongside potential benefits and risks. In agriculture, DSTs aim to help farmers make informed decisions by providing data analysis, insights, and recommendations. By integrating diverse information, often from technologies such as geographic information systems (GIS), remote sensing, and data analytics, they are often designed to enable farmers to optimize farming practices, enhance productivity, reduce risks, and improve profitability.

Key aspects of DSTs are/should be that they are evidence-based and user-friendly. In addition, they should help the decision-maker analyse risks and, as such, can be particularly useful for planning and managing potential impacts. They can also play a role in facilitating informed discussions between programs and participants, and in helping individuals consider what is important to them when making decisions.

However, in their broad review of DSTs developed for agriculture across multiple countries, Rose et al. (2016) report that, while DSTs are widely available in a wide range of formats, uptake is often low; for instance, McCown (2012) describes the problem of low uptake as an ‘enigma’. Building on work in Australia, which points to an ‘emerging consensus’ about the desirable characteristics of an effective decision support tool (Hochman and Carberry, 2011), Rose et al. (2016) identify fifteen factors that influence whether farmers and their advisers are likely to use decision support tools (Table 1). They advise that bearing these in mind when developing DSTs is likely to ensure both more cost-effective design and delivery of such tools and greater levels of acceptance and uptake by users.

Table 1. Checklist for the good design of DSTs (Rose et al., 2016)

1. Performance	Does the tool perform a useful function and work well?
2. Ease of use	Is the user interface easy to navigate?
3. Peer recommendation	Does it encourage peer-to-peer knowledge exchange?
4. Trust	Is the tool evidence-based and do we have the trust of users?
5. Cost	Is there a cost-benefit?
6. Habit	Does the tool match closely with existing habits of users?
7. Relevance to user	Can the tool say something useful about individual farms?
8. Farmer-advisor compatibility	Could the tool be targeted at advisors to encourage client uptake?
9. Age	Does the tool match the skills and habits of different age groups?
10. Scale of business	Is the tool applicable to different scales of farming?
11. Farming type	Is the tool applicable to different farming enterprises?
12. IT education	Does the tools require good IT skills to use?
13. Facilitating conditions	Can the tool be used effectively? Is there compatibility with existing devices? Is internet connectivity required?
14. Compliance	Does the tool help users satisfy legislative and compliance requirements?
15. Marketing	How do users find out about the tool?

Decision trees

Decision trees use a branching structure where each node represents a decision point or condition, and each branch reflects a possible outcome. This initial approach helps landholders systematically assess their options, clarify complex processes, and reach well informed conclusions. By using a series of “YES/NO” logic-based questions, the decision tree enables the decision-maker to step through the series of considerations leading to either an interim or final decision relevant to their specific context and situation.

A prototype decision tree for marginal cropping land

Our initial step in the process of developing a DST to support farm-level decisions around engagement in environmental benefit projects was to develop a decision tree to assist landholders involved in crop production in identifying whether an environmental benefit (e.g., carbon/biodiversity payment) project is likely to be beneficial to the long-term sustainability and climate resilience of their farming operation (Figure 4). As such, it clearly maps out choices, conditions, and outcomes, thereby providing clear guidance to assist the decision-making process by outlining the steps to be considered and information required to make an informed decision. It asks key questions that highlight the information that should be considered at each step and points to the need to access advice/guidance where needed before proceeding on to the next step. Working through this, the decision-maker can then make an informed decision about proceeding to engage in the specific program/project under consideration. Using this tool, land managers will be able to evaluate whether participation in an environmental benefits project is likely to be beneficial on their land and for their farming enterprise. They will also better understand the steps involved and further information/skills needed to implement a decision to undertake a registered environmental (carbon/biodiversity) benefits project.

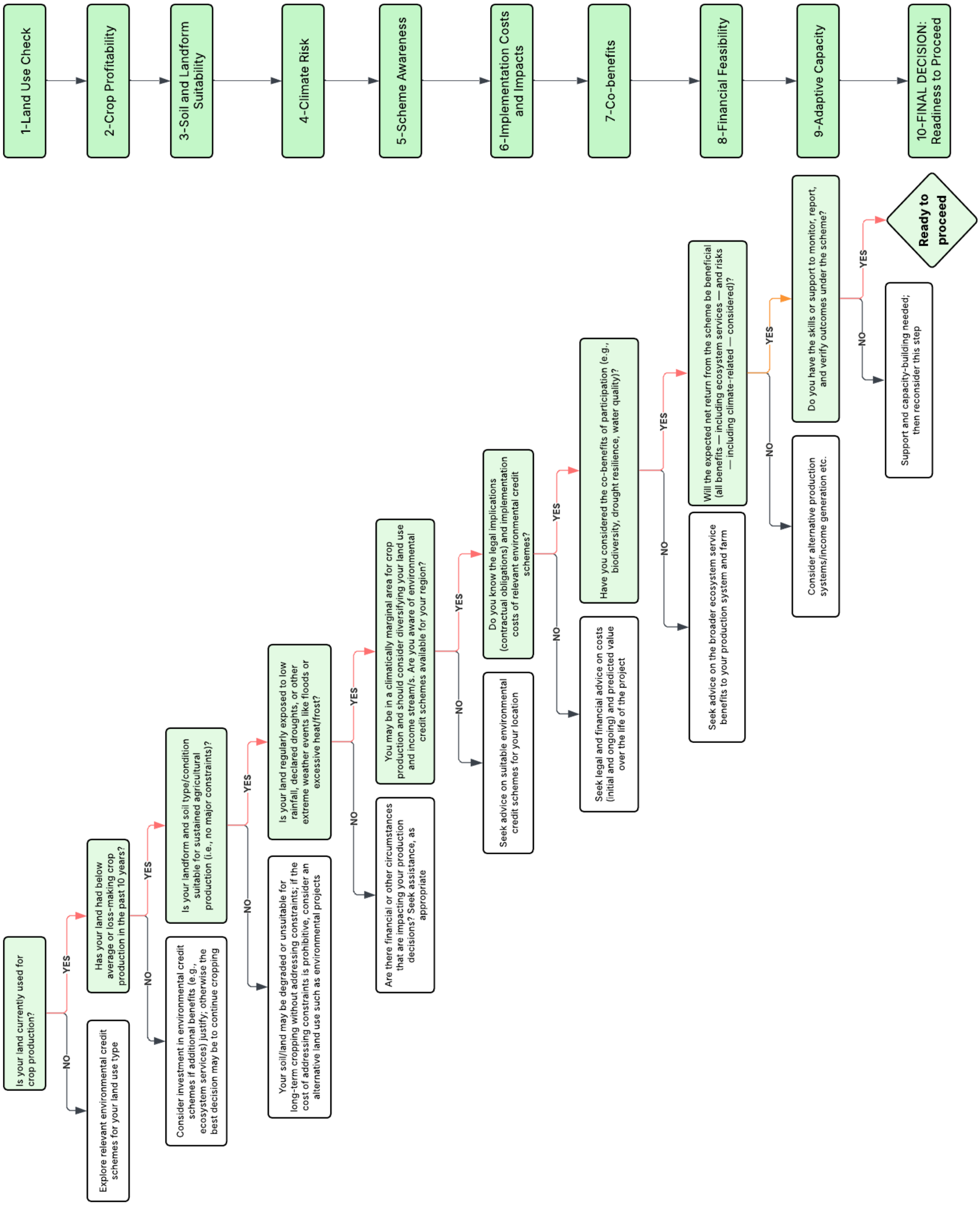

Figure 4. Prototype decision tree depicting the sequence of steps involved in identifying whether to invest in an environmental benefit (carbon/biodiversity) project on climatically-marginal cropping land.

The decision tree steps are detailed as the follow:

Step 1: Land use check

The process begins by determining the current land use. If the land is used for crop production, it qualifies for further assessment using this simple decision support tool. If the land is grazing land or under non-agricultural use (e.g., native forest), another decision tree relevant to the land use in question may be more applicable.

Step 2: Crop profitability

Here, the decision-maker is asked to evaluate whether their cropping enterprise has demonstrated below average or loss-making profitability over the past ten years. If so, they continue to the next step (Step 3). If not (i.e., the production system is currently profitable), further consideration depends on the likelihood that the environmental project will deliver significant ecosystem service benefits that contribute to reduced risk and/or input costs for the production system (as discussed in Kath and Thorpe, 2024 and Reardon-Smith and Mushtaq, 2024) and/or the scheme will deliver payments comparable to the returns from cropping; if neither applies, the best decision may be continue cropping.

Step 3: Soil and landform suitability

At this stage, the land manager/decision-maker is asked to consider whether the low profitability of their cropping enterprise is impacted by soil or landform constraints; if these can be readily and cost-effectively addressed, the best decision again may be to continue cropping (considering again the potential contributions of ecosystem services that might derive from an environmental project and the level of payments on offer).

Step 4: Climatic risk

In this step, the consideration is whether the cropping land is frequently exposed to climatic risk, such as low rainfall, declared droughts, or recurring extreme weather events (e.g., floods, excessive heat or frost). Cropping lands exposed to these conditions might be considered climatically marginal, especially if other constraints to crop production are not problematic. However, other personal or financial issues may also be in play and the decision-maker may at this stage wish to seek professional advice to assist with these.

Step 5: Scheme awareness

The decision-maker is then asked to consider whether he/she is aware of the environmental (carbon/biodiversity) credit schemes and registered methodologies that might suit his location, production system and aspirations. If additional information is required, they are advised to seek independent advice about what schemes are available before proceeding.

Step 6: Legal issues and implementation costs

This step checks if the decision-maker is aware of the legal implications associated with the scheme's contractual obligations and the costs of implementing a registered environmental (carbon/biodiversity) project. They are advised to seek independent advice before proceeding further.

Step 7: Co-benefits of environmental projects

This phase brings to the attention of the decision-maker the likelihood of benefits arising from environmental projects that are not directly financial in nature but may reduce the risks and costs of production and/or may align with their aspirations for the farming enterprise and landscape.

Step 8: Financial feasibility

This step considers the financial feasibility of foregoing (in total or in part) crop production and implementing a registered environmental project on climatically-marginal cropping land. At a minimum, the costs associated with establishing the baseline environmental condition of the project site, establishing the project and monitoring outcomes must be known and considered; in this regard, advice should be sought from a reputable source. In addition, there are many areas of uncertainty that may impact the financial feasibility of the project; this is an area where modelling may offer insight. Our next Milestone 10a activity is to develop an integrated data-informed predictive environmental (including projected climate) model to better inform such decisions (See Next steps, below).

Step 9: Adaptive capacity

Here the decision-maker is asked to consider their capacity to implement and manage the project. If this is currently lacking, they may wish to seek opportunities to engage in targeted capacity building or employ a project manager.

Step 10: Readiness to proceed

On reaching this step, the decision-maker should be equipped with the essential information needed to participate in a registered environmental (carbon and/or biodiversity) project as an alternative/additional income stream and be able to make an informed decision about whether and when to proceed.

In summary, we have developed a farm-level decision tree for land managers considering diversification of their farming enterprise to incorporate an environmental (carbon/biodiversity) benefits project under one of the incentive payment schemes currently available (e.g., ERF, LRF, Reef Credits etc.). This conceptual tool guides the decision-maker through a number of steps; asks key questions that highlight the information that needs to be considered at each step; and points to the need to access advice/guidance where needed before proceeding to the next step. Working through this, the decision-maker can then make an informed decision about proceeding to engage in the specific program/project under consideration.

Using this simple visual structure that captures the logic and sequence of the decision-making processes (without requiring immediate data input), the conceptual model provides end-users with a clear and consistent roadmap. This is an important step that will facilitate stakeholder engagement and lay the groundwork for a robust, data-driven decision-support system in the next phase of the project.

Next steps

Risk implies uncertainty, which is inherent in complex dynamic interactive (e.g., environmental) systems. This is particularly the case in instances where our understanding of an issue is still evolving. Environmental management is often termed a 'wicked problem' (Parrott, 2017) as it involves complex, interconnected challenges that lack clear-cut solutions, making it difficult to gauge the effectiveness of management decisions. Such situations require explicit consideration and quantification of uncertainties (Williams and Johnson, 2017).

The ability to model and predict risks in complex dynamic ecosystems was, until quite recently, limited due to difficulties in (i) quantifying the causal relationships between multiple interacting factors and outcomes, and (ii) capturing uncertainty. Bayesian network (BN) tools—based on Bayes' theorem, which describes the likelihood or probability of an event given prior knowledge of the conditions related to the event—are increasingly used to understand and manage such systems (Hart and Pollino, 2008; Merritt et al., 2010; Alvandi et al., 2023). This project will, in the next reporting periods, develop an interactive predictive data-informed decision support tool using a risk-based Bayesian network modelling approach. This tool will allow scenario testing against probable future climate and other (e.g., market) scenarios. It will be developed and tested during development in collaboration with industry and particularly land managers.

References

Alvandi, E., Sadoddin, A. and Sheikh, V. (2023). A web-based integrated Bayesian decision support system for rangeland management in semi-arid watersheds. *Environmental Science & Policy* 141, 80-96. https://doi.org/10.1016/j.envsci.2022.12.021

Hart. B. and Pollino, C.A. (2008). Increased use of Bayesian network models will improve ecological risk assessments. *Human and Ecological Risk Assessment* 14, 851–853. https://doi.org/10.1080/10807030802235037

Hochman, Z. and Carberry, P.S. (2011). Emerging consensus on desirable characteristics of tools to support farmer's management of climate risk in Australia. *Agricultural Systems* 104(6), 441-450. https://doi.org/10.1016/j.agsy.2011.03.001

Hughes, N. and Gooday, P. (2021). Analysis of climate change impacts and adaptation on Australian farms. *ABARES Insights.* https://doi.org/10.25814/589v-7662 CC BY 4.0.

Kath, J., Mushtaq, S. and Reardon-Smith, K. (2023). *Identifying Climatically Marginal Cropland*. Unpublished report (MS1, September 2023), DCAP3 Project 'Creating Alternative Income Streams to Increase Farm Profitability and Benefit the Environment (UniSQ)'. Drought and Climate Adaptation Program (DCAP): Queensland Government, Brisbane. 22 pp. Available at: https://cacs.unisq.edu.au/dcap3/dcap3-resources

Kath, J., Reardon-Smith, K. and Mushtaq, S. (2024b). *Assess How Targeted Decision Support Could Be Used to 'De-risk' Farmers' Concerns About Changing Management Practices to Reduce Climate Risk/Generate Alternate Income Streams*. Unpublished report (MS7, January 2025), DCAP3 Project 'Creating Alternative Income Streams to Increase Farm Profitability and Benefit the Environment (UniSQ)'. Drought and Climate Adaptation Program (DCAP): Queensland Government, Brisbane. 15 pp. Available at: https://cacs.unisq.edu.au/dcap3/dcap3-resources

Kath, J., Reardon-Smith, K., Thorpe, J. and Mushtaq, S. (2024a). *Mapping and Quantifying Environmental Credit Opportunities in Queensland Cropping Zones*. Unpublished report (MS3, January 2024), DCAP3 Project 'Creating Alternative Income Streams to Increase Farm Profitability and Benefit the Environment (UniSQ)'. Drought and Climate Adaptation Program (DCAP): Queensland Government, Brisbane. 34 pp. Available at: https://cacs.unisq.edu.au/dcap3/dcap3-resources

Kath, J. and Thorpe, J. (2024). *Assessing the Potential Ecosystem Service Effects of Natural Capital Schemes for Agriculture.* Unpublished report (MS4, March 2024), DCAP3 Project 'Creating Alternative Income Streams to Increase Farm Profitability and Benefit the Environment (UniSQ)'. Drought and Climate Adaptation Program (DCAP): Queensland Government, Brisbane. 26 pp. Available at: https://cacs.unisq.edu.au/dcap3/dcap3-resources

Linkov, I., Bridges, T., Creutzig, F. et al. (2014). Changing the resilience paradigm. *Nature Climate Change* 4, 407–409. https://doi.org/10.1038/nclimate222

Martin-Vegue, T, (2021), *Using Risk Assessment to Support Decision Making*. Available at: https://www.isaca.org/resources/news-and-trends/industry-news/2021/using-risk-assessment-to-support-decision-making (accessed July 2025).

McCown, R.L. (2012). A cognitive systems framework to inform delivery of analytic support for farmers' intuitive management under seasonal climate variability. Agricultural Systems 105, 7-20. https://doi.org/10.1016/j.agsy.2011.08.005

Merritt, W.S., Ticehurst, J., Pollino, C.A. and Fu, B. (2010). The value of using Bayesian networks in environmental decision support systems to support natural resource management. *International Congress on Environmental Modelling and Software* 236. https://scholarsarchive.byu.edu/iemssconference/2010/all/236

Mushtaq, S. and Reardon-Smith, K. (2024). *Preliminary Cost/Benefit Analysis of the Different Options Identified and How They Relate to Climate Risk*. Unpublished report (MS6a, September 2024), DCAP3 Project 'Creating Alternative Income Streams to Increase Farm Profitability and Benefit the Environment (UniSQ)'. Drought and Climate Adaptation Program (DCAP): Queensland Government, Brisbane. 42 pp. Available at: https://cacs.unisq.edu.au/dcap3/dcap3-resources

Parrott, L. (2017). The modelling spiral for solving 'wicked' environmental problems: guidance for stakeholder involvement and collaborative model development. Methods in Ecology and Evolution 8, 1005–1011. https://doi.org/10.1111/2041-210X.12757

Piñeiro, V., Arias, J., Dürr, J. et al. (2020). A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes. *Nature Sustainability* 3, 809–820. https://doi.org/10.1038/s41893-020-00617-y

Queensland Government (2024a). *The Land Restoration Fund*. Queensland Government, Brisbane QLD. Available at: https://www.qld.gov.au/environment/climate/climate-change/land-restoration-fund (accessed 27 June, 2024)

Queensland Government (2024b). *Reef Credit Scheme*. Queensland Government, Brisbane QLD. Available at: https://www.qld.gov.au/environment/coasts-waterways/reef/reef-credit-scheme (accessed 27 June, 2024)

Reardon-Smith, K. and Mushtaq, S. (2024). *Identifying Reinvestment Options from 'Natural Capital' Scheme Investments that Increase Farmer Drought Risk Mitigation and Adaptation Capacity*. Unpublished report (MS5, June 2024), DCAP3 Project 'Creating Alternative Income Streams to Increase Farm Profitability and Benefit the Environment (UniSQ)'. Drought and Climate Adaptation Program (DCAP): Queensland Government, Brisbane. 27 pp. Available at: https://cacs.unisq.edu.au/dcap3/dcap3-resources

Reardon-Smith, K., Mushtaq, S., Kath, J. and Thorpe, J. (2023). *Farmer Perceptions of Environmental Market Income Diversification Schemes*. Unpublished report (MS3A, January 2024), DCAP3 Project 'Creating Alternative Income Streams to Increase Farm Profitability and Benefit the Environment (UniSQ)'. Drought and Climate Adaptation Program (DCAP): Queensland Government, Brisbane. 29 pp. Available at: https://cacs.unisq.edu.au/dcap3/dcap3-resources

Rose, D.C., Sutherland, W.J., Parker, C., Lobley, M., Winter, M., Morris, C., Twining, S., Ffoulkes, C., Amano, T. and Dicks, L.V. (2016). Decision support tools for agriculture: Towards effective design and delivery. Agricultural Systems 149, 165-174. https://doi.org/10.1016/j.agsy.2016.09.009

Thorpe, J., Reardon-Smith, K., Mushtaq, S. and Kath, J. (2023). *Options and Cautions: Environmental Credits, Practice, and Payments for QLD Land Managers*. Unpublished report (MS2B, September 2023), DCAP3 Project 'Creating Alternative Income Streams to Increase Farm Profitability and Benefit the Environment (UniSQ)'. Drought and Climate Adaptation Program (DCAP): Queensland Government, Brisbane. 37 pp. Available at: https://cacs.unisq.edu.au/dcap3/dcap3-resources

Williams, B.K. and Johnson, F.A. (2017). Frequencies of decision making and monitoring in adaptive resources management. *PLoS One* 12, e0182934. https://doi.org/10.1371/journal.pone.0182934