Sustainable Intensification of Agriculture in Victoria's Food Bowl: Optimizing Productivity with the use of Decision-Support Tools

M. Johnson, R. Faggian, V. Sposito

***Abstract*—**A participatory and engaged approach is key in connecting agricultural managers to sustainable agricultural systems to support and optimize production in Victoria's food bowl. A sustainable intensification (SI) approach is well documented globally, but participation rates amongst Victorian farmers is fragmentary, and key outcomes and implementation strategies are poorly understood. Improvement in decision-support management tools and a greater understanding of the productivity gains available upon implementation of SI is necessary. This paper reviews the current understanding and uptake of SI practices amongst farmers in one of Victoria's premier food producing regions, the Goulburn Broken; and it spatially analyses the potential for this region to adapt to climate change and optimize food production. A Geographical Information Systems (GIS) approach is taken to develop an interactive decision-support tool that can be accessible to on-ground agricultural managers. The tool encompasses multiple criteria analysis (MCA) that identifies factors during the construction phase of the tool, using expert witnesses and regional knowledge, framed within an Analytical Hierarchy Process. Given the complexities of the interrelations between each of the key outcomes, this participatory approach, in which local realities and factors inform the key outcomes and help to strategies for a particular region, results in a robust strategy for sustainably intensifying production in key food producing regions. The creation of an interactive, locally embedded, decision-support management and education tool can help to close the gap between farmer knowledge and production, increase on-farm adoption of sustainable farming strategies and techniques, and optimize farm productivity.

***Keywords*—**Agriculture, decision-support management tools, GIS, sustainable intensification.

I. INTRODUCTION

AGRICULTURAL production is important to Australia's economic productivity and will likely be threatened by climatic changes in the future. In order to support farmer responses to these changes, decision-support tools are fundamental in knowledge transition and option analysis. This is particularly relevant in Victoria, which accounts for approximately 25% of the gross value of agricultural products generated in Australia, generating on average $123 billion annually (between 2011 and 2016) [1]. Of that, key food producing regions are situated primarily to the north of the state in the largely irrigated Goulburn Broken and Mallee regions, with high value dairy, wool and livestock producers in the South West and Gippsland.

The Goulburn Broken and Mallee region together account for 25% of the total value of Victoria's agricultural production [1], with the bulk of the Goulburn Broken region's contribution consisting of Pomme and Stone Fruits (68% and 96% respectively), and those two commodities alone worth $198 million to the Goulburn Broken economy in 2015-16. Similarly, tomato production, both fresh and processed was worth $62 million to the Goulburn Broken in 2015-16 contributing 67% of the total agricultural economy. In contrast, while milk production is important to the region's economy (17% of the total value), livestock in general is a small part of the region's economic value. This is despite being the bulk of the region's primary land use – 65% is primary production, with mixed farming and grazing making up the largest land use type (39%) within this [2]. Together, fruit, nut and vegetable productions account for less than 5% of the land area in the region [2] but contribute considerably more to the economy (22%).

Despite this high value and productive regional agricultural sector, the Goulburn Broken region is facing an uncertain future. Projected climatic changes are expected to have a significant impact on production across the region, with changes most evident in the north of the region, in the irrigated areas and along the Murray River. Projections show that conditions in the region will become increasingly hot and dry by 2050 with annual average maximum temperatures increasing by as much as 3 °C and annual average minimum temperatures increasing by between 1 °C and 2 °C. Average annual mean temperatures in the region are projected to rise from around 14 °C to over 15.5 °C, and average total precipitation is expected to decrease by between 100 and 150 mm per year. Importantly, seasonal changes are evident, with increases in average mean temperatures all year, but most noticeable in the warmer months with February's projected increase (2.6 °C in 2050) nearly 0.6 °C greater than that of July's (1.9 °C). The changes in seasonality expected across the region are even more evident in average rainfall projections, with historically wet months of May and August reducing in rainfalls and the emergence of June as the wettest month. August, historically the wettest month with 88 mm of rainfall, becomes significantly drier into the future and is expected to receive only 43 mm on average into 2050, while in 2050, June is the expected to be the wettest month, receiving 59 mm of

M. Johnson is with the Centre for Regional and Rural Futures, Deakin University, Burwood, AUS (phone: +61417519358; e-mail: madeleine.j@deakin.edu.au).

R. Faggian and V. Sposito are with the Centre for Regional and Rural Futures, Deakin University, Burwood, AUS (e-mail: r.faggian@deakin.edu.au, v.sposito@deakin.edu.au).

rainfall on average [3]. It is expected that such changes will have a significant impact on the agricultural sector, greatly reducing the capability of the region to support the current quality and volume of food systems [4].

Decision-support tools are commonly used to guide the decision making and strategy selection process for a wide range of sectors and industries. In the agricultural sector, they are important to assist people to understand and respond to both the challenges and opportunities that climate change is likely to bring. Importantly, decision-support tools are most effective when representing a local or regional system. Communities affected by climate change are likely to respond in different ways specific to their own experience. Decision-support tools can support users to adopt behaviour to maximise opportunities in perceived difficult decisions and offer strategies to mitigate or avoid serious challenges [5].

The development of decision-support tools that specifically cater to agricultural systems that facilitate adaptation and response to the challenges of climate change is particularly necessary. Improving knowledge around techniques from a SI of agriculture systems is once such way to facilitate the expansion of a climate smart agriculture sector.

The benefits of SI stem from increased input to output conversion efficiency [6]. This brings an economic benefit, with higher financial returns and a more sustainable product. The environmental benefits of healthy soils and ecosystems combined with viable agricultural systems are important for the future and sustainability of the entire food system, especially when confronted with a challenging and uncertain future. Critically, rationalising input use can help adaptation to climatic changes, in particular falling rainfall levels.

SI is key to increasing the resilience of farmers and encouraging adaptation to climate, with benefits such as the value-adds of waste minimization or diversification as a buffer against climate shocks [6]–[8]. The economic feasibility of SI can be a cause of concern for agricultural managers, as it can be a costly practice to initiate, with uncertain returns for agricultural managers unused to the practices. Uncertainty surrounding the exact revenue or yields obtained from these practices results in low uptake, that needs to be addressed though education and support. Agricultural managers will increasingly be called upon to make calls in trade-offs between land-use and environmental concerns and economical and sustainable development. These decisions will continue to be important in working with land-use planners and within the wider regional economies, to ensure farmers and their communities are supported in making viable financial returns, whilst protecting the environment and adapting to climate change in the near and distant future. Decision-support tools have an important role to play in this decision-making process, allowing farmers to be armed with current knowledge to be able to make informed and practical decisions regarding their farming choices.

II. Methods

A. Land Suitability Analysis

A Land Suitability Analysis (LSA) investigates the biophysical quality of a region for a particular land use. The mathematical model, developed within a GIS, uses climatic, soil and topographical inputs that determine the growth and production of the commodity of interest [9], [10]. Embedded within this process is a MCA applied with an Analytical Hierarchy Process (AHP) [11], in which experts participate in the modelling process, incorporating the knowledge of experts such as soil scientists, environmental scientists and agricultural managers, who have an in-depth understanding of one aspect of the specific system, for example optimum soil growth or temperature range. These specific factors influence growth, viability or suitability of the commodity of interest and are applied as criteria which are assigned numerical values (weight) [12]. These weights are placed on each criterion and indicate the relative importance to one another and to the overall output.

The LSA is run with historical climatic inputs and then again with forecasted climatic projections to obtain a predicted change in suitability due to climate changes. Climatic conditions are important factors for modelling plant growth and the timing of on-farm practices, such as sowing or harvesting times. A change in climatic conditions can thus have a significant impact on land suitability, and can identify areas where options for individual systems are changing from the historic norm, or might be expected to change in the future, and whether the region has any flexibility in potentially changing land-uses.

B. Spatial Decision-Support Tool

To frame the narrative of the complex mathematical modelling, and make it accessible to on-farm users and regional strategic planners, findings from the LSA were incorporated into an interactive decision-support tool. The tool was created using an online GIS feature for embedding spatial mapping into a website and then shared amongst regional planners and engaged agricultural managers or advisors. As such, the tool contains interactive mapping outputs, displaying the results of the LSA, in which users can locate their area and toggle between modelled commodities to identify farming systems most suitable to their location.

In the design of the decision-support tool, 14 key factors in [13] were applied. These included factors to maximize the uptake of the tool: 1) performance (provide a useful function), 2) ease of use, 3) cost, 4) scale of the business the tool is expected to be used in, 5) the relevance to the user and 6) farming type (is the tool usable for commodity specific on-farm decision making, or is it more broadly or regionally based).

In the construction of the tool key factors affecting the users of the tool were taken into account: 7) farmer habits (can the tool be integrated into their daily/monthly planning activities), 8) the age and 9) IT skills of the users (are the skills, abilities and inclinations of users going to match the tool) and 10) will the tool be supported by the majority of on-farm conditions (internet access, compatibility with existing tools).

Other considerations in the development of the tool were aspects to incentivize use and uptake of the tool, especially 11) the training and development in collaboration with agricultural advisors and planning professionals within local government to support roll out of the tool amongst their networks, as well as on-farm usage, 12) supporting the development of the tool with robust academic evidence to instill trust in users of the tool, 13) ensuring the tool met with all compliance requirements and 14) ensuring there were training and information sessions to spread awareness and understanding about both the tools existence and its usage.

C. Climate Smart Agriculture

To bolster the effectiveness of decision-support tools, an understanding of the region's capabilities in responding to climatic shocks is necessary. To determine the region's agricultural community's knowledge of alternative agricultural management systems and their attitudes to, and uptake of, both decision-support tools and broad scale climate smart agricultural strategies, a survey was conducted across the region. A key aspect of the survey was to determine the usage of decision-support tools, and the community's willingness to integrate the use of such tools into their everyday, on-farm management practices.

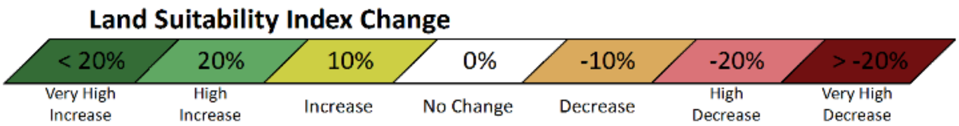
The survey was delivered electronically in June 2017 to the agricultural community in the Goulburn Broken Catchment Management region, with the assistance of the Goulburn Broken Catchment Management Authority and regional Landcare networks. The survey was self-administered, and a total of 55 complete responses were obtained, with representatives from each of the main commodity groupings: grazing, cropping, fruit and vegetable horticulture and forestry.

The potential for bias in the survey is acknowledged and may include unintentional bias in the design of the survey, self-reported and/or self-selection bias, non-response bias, and recall bias. Any of these may have an influence on the reliability of the results, however wherever possible, care was taken to avoid this.

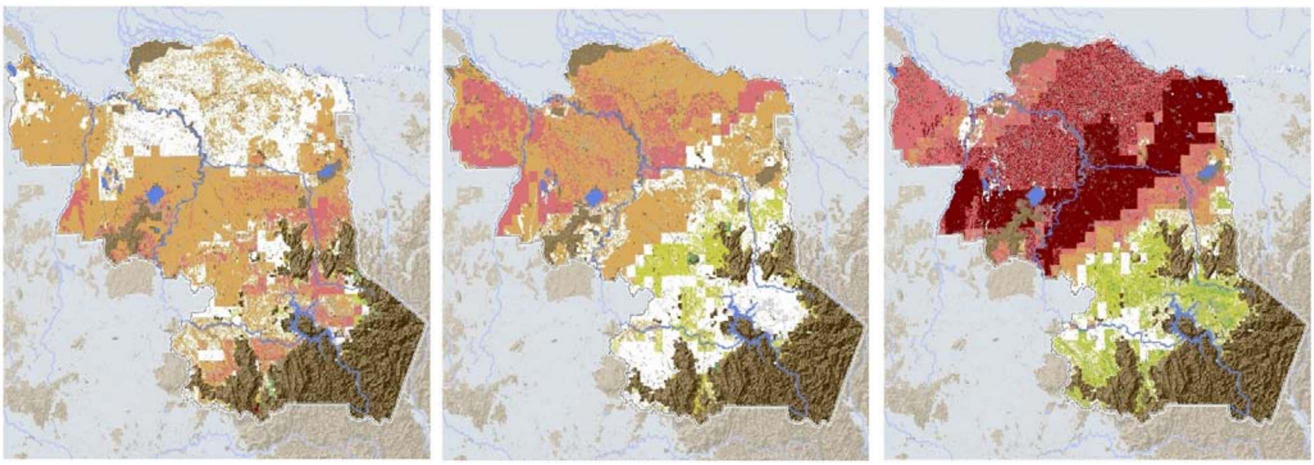
III. Results

A. Land Suitability Analysis

Reference [12] describes the LSA undertaken for the Goulburn Broken Region and shows categorically that production in the Goulburn Broken region of key commodities will be affected by projected climate changes, with an overall reduction in suitability, most noticeable in the north of the region along the Murray River. In particular, key, high value commodities in the Goulburn Broken region, apples, pears and tomatoes show declines in suitability out to 2050. Fig. 1 shows the reduction of suitability in the north of the Goulburn Broken region for apples, pears, and tomatoes. Apples show a moderate decrease in suitability (<10% change in suitability class) concentrated around the central west of the region.



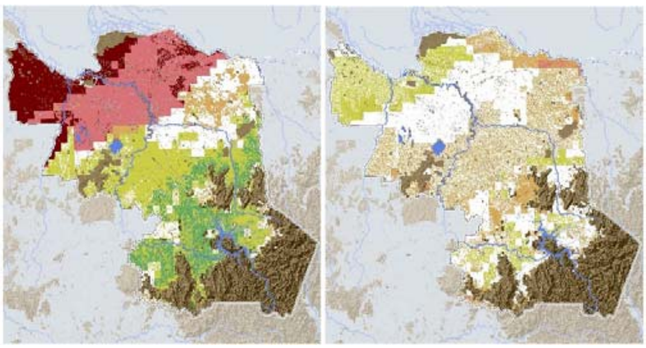
(a)



(b) (c) (d)

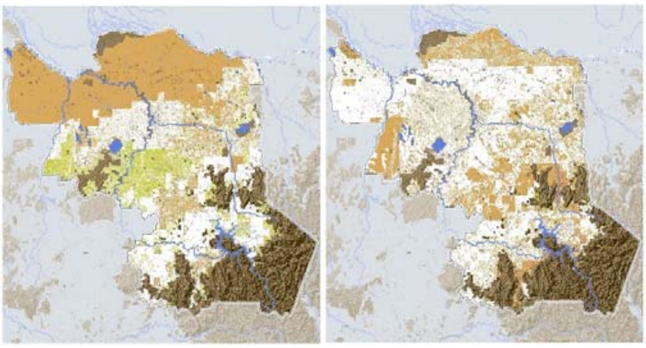
Fig. 1 Changes in suitability between historical climate (1961 – 1990) and projected climate (2050 (A1FI) with (a) Legend for change and (b) Apples, (c) Pears and (d) Tomatoes [14], [15]

Pears show a markedly larger decline, more spatially widespread, and with a high decrease (between a >10% and <20% change in suitability class) noticeable in the north east of the region running along the Murray River. There is a band of increase (<10 % change in suitability) in suitability however, across the center of the region. Of the three commodities in Fig. 1, tomatoes show the largest decline in suitability ranging from high to very high (>20% change in suitability class). This is concentrated in the north east of the region and extends southward to the central region. Similarly, there is reported to be a decline in suitability of pasture systems underpinning the dairy and livestock industries across the region (Fig. 2). Phalaris, in particular, shows very high decreases in suitability in the north west of the region; however, there are signs of opportunities in the center and south of the region, with increases and high increases (between a >10% and <20% change in suitability class) evident. The prospect for ryegrass is, however, less extreme, with moderate changes predicted to occur across the region, with no extremes or locations particularly vulnerable.



(a) (b)

Fig. 2 Changes in suitability between historical climate (1961 – 1990) and projected climate (2050 (A1FI) for (a) Phalaris and (b) Ryegrass [16]



(a) (b)

Fig. 3 Changes in suitability between historical climate (1961 – 1990) and projected climate (2050 (A1FI) for (a) Brassica and (b) Lettuce [15]

Despite the poor outlook for high value commodities for the region (apple, pear and tomato), there is a slightly more positive outlook for other vegetables. Fig. 3 shows the decline in suitability for brassica across the north of the region; however, the spatial distribution is relatively contained, and there are signs of increase in the center west of the region. The prediction for lettuce is more positive, with little to no decreases across the region.

B. Spatial Decision-Support Tool

A decision-support tool containing the results of the LSA modelling was developed for the Goulburn Broken region and was distributed amongst strategic planners, economic development and agricultural business officers in Local Government Authorities within the region and was very well received. The online, interactive tool displays commodity specific land suitability results with hyperlinks to strategy recommendations. Workshops were held for the collection of councils working for producers in the region to introduce these users to the tool and provide training on possible scenarios for usage options. Many of the discussions on tool practice, centered on its planning and economic development uses. This included the identification of highly suitable agricultural land, particularly land that purported to be highly suitable for multiple commodities into 2050, and areas that supported high value agricultural commodities. Protection strategies for these areas and planning for development on more marginal agricultural land was also discussed. Commodities that were situated within key strategic areas of interest, such as irrigation districts, close to processing and manufacturing centers or key distribution points were also highlighted as of importance.

C. Climate Smart Agriculture

Concurrently the survey of agricultural managers across the Goulburn Broken region obtained a profile of potential users of the Tool.

1. Summary Statistics

Over 60% of respondents to the survey were over 45 years old and mostly had some sort of agricultural training (approximately 75%), with a large proportion having undertaken further education in either the agricultural or other industry. This represents the understanding of the broader Australian agricultural community as obtained by analysis of ABS census and Farm Survey results [17].

2. Knowledge of Climate Smart Agriculture

The survey asked respondents if they were familiar with the term “Climate Smart Agriculture”. 50% of respondents reported they knew of the term, and 27% that they were unsure. The survey also asked if they were familiar with the term “Conservation Agriculture”. Over 75% of respondents were familiar with the term Conversation Agriculture, with less than 10% reporting they were not.

The survey allowed for a free text response to obtain respondents personal understanding of the terms. The responses largely did not distinguish between Climate Smart Agriculture (CSA) and Conservation Agriculture (CA) and mostly spoke of adaptation, resource conservation and sustainability. The two terms are inextricably linked, and can be used interchangeably in popular media, possibly explaining respondents overlapping understanding and responses. As illustrated in the free-text responses, there was a strong understanding amongst respondents that both terms are linked to sustainable agricultural systems, resource conservation and improving productivity.

The two terms were separated in the survey as generally; CA has stronger ties to soil amendment and improvement practices and the reduction of use of chemical insecticides, pesticides, fungicides and fertilizers, while CSA is found to have been not as palatable terminology, sometimes perceived to be overly political. The term CSA was also suspected to not be commonly used amongst industry communications. The results of nearly 25% greater knowledge of the term CA than CSA support these findings, however, the text responses, show a highly fragmented level of understanding of both terms and the impacts and practices they have on agriculture.

There were no specific mentions of SI of agriculture in any of the free text responses. There was some anecdotal evidence from the decision-support tool delivery workshops that there were likely to be negative connotations with the word intensification due to recent planning restrictions regarding livestock intensification in particular.

3. Climate Smart Agriculture Practices

Respondents were asked if they currently carried out, or would consider introducing (or would *not* consider introducing) CSA practices, including planting drought or other specific tolerant varieties, minimizing or eliminating tillage practices, cover cropping, crop rotations, water recycling, conservation and/or reuse, precision agriculture techniques, wildlife and biodiversity conservation or green energy production and use.

Over 50% of respondents reported they already carried out some form of CSA techniques, with a further 30% reporting they would consider introducing. Including respondents who said such techniques were not relevant to their situation, over 75% of respondents answered positively to implementing CSA techniques.

Of those respondents reporting to already carry out CSA practices, an even spread of techniques was reported, albeit in relatively low numbers. Biodiversity and/or wildlife conservation both targeted and on marginal land, including the planting of native grasses, crop and/or grazing rotations and soil improvements and amendments are all already carried out in over 15% of cases. Water conservation under various guises (often farming system specific) and a plan to reduce or eliminate the use of synthetic fertilizers and other chemicals were both also relatively highly reported at around 10%.

Generally, the practice of climate smart agricultural techniques is highly fragmented, and appears to be convenience based, with respondents largely reacting to external circumstances (drought, natural environment) or best practice (crop and grazing rotations).

4. Barriers to Climate Smart Agriculture

The survey asked respondents to think about the barriers to implementing CSA practices and techniques. Overwhelmingly respondents listed financial barriers, including costs of set-up, maintenance and access as the largest barriers. Personal decisions to not use IPM techniques, and the scale of farming systems also counted as factors. While knowledge was counted relatively low as a barrier (5%), this question was only asked to respondents who reported they knew of IPM techniques, so in reality knowledge as a barrier could be considered significantly higher than reported.

5. Usage of Decision-Tools

Respondents were also asked if they used Decision-Support Management Tools to support their agricultural activities, 64% of respondents reported they did use such tools. A cross-tabulation analysis of respondents reporting to use decision-support tools against those who self-reported to be resilient and satisfied was undertaken in SPSS. Respondents that were more likely to report themselves being more vulnerable and more dissatisfied were more likely to use tools, with 78% of respondents dissatisfied with their production levels reporting to use decision-support tools, and 80% of respondents reporting to be vulnerable to external shocks using decision–support tools. One explanation for this may be, that such respondents turn to tools to assist them in generating improvements in on-farm processes to improve resilience of the business or productivity.

IV. Discussion

With high value fruits and vegetables that are integral to the Goulburn Broken region’s economy under threat from climate change, and pasture systems that support the majority of the primary production across the region similarly in decline out to 2050, a change management and knowledge transfer system must be put in place, to ready the agricultural community for an uncertain future.

While lucrative historically, the pomme fruit and tomato industry in the Goulburn Broken, is likely to be less productive in the future, particularly under current irrigation and water trading conditions. This, combined with the reduction in suitability for grazing systems, may lead to agricultural managers experiencing economic hardships, particularly with limited understanding of the nature of climatic changes expected in their regions and fragmented implementation of climate smart agricultural techniques.

Access to decision-support tools containing up-to-date research and useful climate, soil and productivity data will give farmers the tools to plan adaptation strategies and capitalize on the opportunities climate change can bring. In particular, tools that are presented in an engaging and interactive way, help farmers to be more at ease in the decision making process.

For the Goulburn Broken region, the decision-support tools highlight the opportunities for key commodities, including vegetables like brassica and lettuce. Comparisons between varieties, broad scale mapping and intuitive features depict to users the trade-offs between farming systems proving them the knowledge to make informed decisions.

For instance, while tomatoes have historically been high value in the region (largely due to the volume produced, 173 million tonnes in 2015-16 [2]), a transition to other vegetable industries, such as brassica or lettuce, which remain highly suitable in the future, may be warranted. Brassica and lettuce production was less than 3 million tonnes in 2015-16 [2].

Transitioning to intensified farming systems (in particular vegetables and horticulture) from open grazing and cropping systems is significantly more profitable in Australia, with cropping systems garnering approximately $1,000 per hectare when comparing total production area (ha) with total value of goods produced in 2015-16 [1], [2]. Vegetables and fruits and nuts garner over $30,000 per hectare, with fruit and nuts making over $36,000 a hectare in the Goulburn Broken in 2015-26. Similarly, transitioning some of the large expanses of less suitable grazing lands to higher value, more intensified vegetable production systems, also results in higher employment. There is estimated to be a 4 times employment multiplier when transitioning from broad acre cropping or pastures systems to intensified horticulture. While financially these changes are practical options for increasing viability of local farming systems, such changes can also bolster regional communities, providing job opportunities and futures for underperforming and marginalized economies and populations.

Having access to such information allows farmers to identify the most productive, and economic efficient farming model that suit their systems. Of course, allowing for farmer values and potential outcomes if important to create community based decision-support systems, and by embedding a value matrix into interactive mapping is one way of achieving this. This way, farmers can specify their individual priorities, and strategies can be devised that specifically deliver on these priorities [18]. The ability to simplify the complex trade-offs in adaptation planning, and offer broad strategies for transitioning to climate smart agricultural farming that is system based – e.g. cropping, horticulture – is critical and should be based on user location, facilities, access and engagement.

The importance of decision-support tools in communicating new information and innovative farming techniques is fundamental in responding to new challenges facing farmers in a climate uncertain future. Alternative agricultural management systems are often overlooked by subsequent generation farmers, who may farm how they were taught as children, or how their parents farmed. Engaging, relevant and attractive decision-support tools can reach faltering farmers, for whom the old ways are becoming increasingly untenable. By engaging with decision-support tools, farmers may increase their willingness to consider alternative systems, and broaden their outlook on traditional techniques and methods. However, the uptake of decision-support tools is highly contingent on tool design and farmer demographic. When delivering tools, designers must be cognizant of the end user and prioritize both relevance and usability. Tools should be user input oriented, to provide individual user value, and they should be outcome based to provide strategies or recommendations to improve user knowledge base and options for implementation. Software for decision-support tools should be correlated with user IT literacy, with tools directed to younger farmers with greater IT skills likely to have higher levels of uptake [19]. Similarly, tools delivered electronically should be aware of the requirements of the system, with rural and regional areas in Australia often poorly supported by telecommunications infrastructure.

Regardless of design, decision-support tools are essential to providing change management strategies regarding climate smart agricultural systems and improving options for farmers facing climate change. Intensifying production in the Goulburn Broken region is a key way farmers can adapt to the challenges of climate change, particularly by transitioning traditional broad acre cropping and pasture systems to high value, intensified horticulture systems. The systems already in practice in the region are highly valuable and productive. There is strong evidence that a wider move to vegetables and some pomme and stone fruit, and the intensification of production in the region will results in both financial and productivity gains. The delivery of decision-support tools providing information about the opportunities available in the region was delivered effectively for the communities in the Goulburn Broken. The tool developed can reduce the fragmentation of knowledge and practices observed in farming systems in Victoria currently and increase knowledge and awareness of potential land use changes, SI systems and the greater benefits of both the ecological and economic efficiency gains that can be realized.

Acknowledgment

We would like to acknowledge the support of the Goulburn Broken Catchment Management Authority and the Goulburn Broken Regional Landcare Facilitator Steering Committee for their assistance in facilitating the CSAD Farmer survey through their regional Landcare network.

References

[1] ABS, *7503.0 - Value of Agricultural Commodities Produced, Australia, 2015-16*. Australian Bureau of Statistics, Australia, 2017.

[2] ABS, *7121.0 - Agricultural Commodities, Australia, 2015-16*. Australian Bureau of Statistics, Australia, 2017.

[3] CSIRO, *CMIP5 global climate model outputs and derived outputs*. CSIRO and Bureau of Meteorology, Australia, 2015.

[4] CSIRO, *Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report*. Australia, 2015.

[5] J. J. Nay, M. Abkowitz, E. Chu, D. Gallagher, and H. Wright, "A review of decision-support models for adaptation to climate change in the context of development," *Clim. Dev.*, vol. 6, no. 4, pp. 357–367, Oct. 2014.

[6] B. M. Campbell, P. Thornton, R. Zougmoré, P. van Asten, and L. Lipper, "Sustainable intensification: What is its role in climate smart agriculture," Curr. Opin. Environ. Sustain., vol. 8, pp. 39–42, 2014.

[7] Y. Gadanakis, R. Bennett, J. Park, and F. J. Areal, "Evaluating the Sustainable Intensifications of arable farms," *J. Environ. Manage.*, vol. 150, pp. 288–298, 2015.

[8] T. Garnett et al., "Sustainable Intensification in Agriculture: Premises and Policies," *Sci. Mag*, vol. 341, pp. 33–34, 2013.

[9] V. Ferretti and S. Pomarico, "Ecological land suitability analysis through spatial indicators: An application of the Analytic Network Process technique and Ordered Weighted Average approach," *Ecol. Indic.*, vol. 34, pp. 507–519, 2013.

[10] V. Sposito, R. Faggian, H. Romeijn, and M. Downey, "Expert Systems Modeling for Assessing Climate Change Impacts and Adaptation in Agricultural Systems at Regional Level," *Open J. Appl. Sci.*, vol. 3, pp. 369–380, 2013.

[11] R. W. Saaty, "The analytic hierarchy process—what it is and how it is used," *Math. Model.*, vol. 9, no. 3, pp. 161–176, 1987.

[12] H. Romeijn, R. Faggian, V. Diogo, and V. Sposito, "Evaluation of Deterministic and Complex Analytical Hierarchy Process Methods for Agricultural Land Suitability Analysis in a Changing Climate," *ISPRS International Journal of Geo-Information*, vol. 5, no. 6. 2016.

[13] D. C. Rose et al., "Decision support tools for agriculture: Towards effective design and delivery," Agric. Syst., vol. 149, pp. 165–174, Nov. 2016.

[14] R. Faggian, M. Johnson, V. Sposito, and H. Romeijn, *Climate Smart Agricultural development in the Goulburn Broken Region - Technical Report: Fruit Production.* Melbourne, 2016.

[15] R. Faggian, M. Johnson, V. Sposito, and H. Romeijn, *Climate Smart Agricultural development in the Goulburn Broken Region - Technical Report: Vegetable Production*. Melbourne, 2016.

[16] R. Faggian, M. Johnson, V. Sposito, and H. Romeijn, *Climate Smart Agricultural development in the Goulburn Broken Region - Technical Report: Pasture Production.* Melbourne, 2016.

[17] ABS, *7121.08 - Farm Management and Demographics, Australia - 2015-16.* Australian Bureau of Statistics, Australia, 2017.

[18] S. Anthony et al., *Landscape Typology - A Framework for Prioritisation of Sustainable Intensification Strategies.* Report for Defra project LM0302 Sustainable Intensification Research. UK, 2016.

[19] D. Rose, L. Dicks, W. Sutherland, C. Parker, M. Lobley, and S. Twining, *Identifying the characteristics of effective decision support and guidance systems in the context of integrated farm management.* UK, 2016.