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WATER SCARCITY RISK FOR AUSTRALIAN FARMS & THE IMPLICATIONS FOR THE FINANCIAL SECTOR

UTS Institute for Sustainable Futures

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ABOUT THE AUTHORS

The Institute for Sustainable Futures (ISF) was established by the University of Technology, Sydney in 1996 to work with industry, government and the community to develop sustainable futures through research and consultancy. Our mission is to create change toward sustainable futures that protect and enhance the environment, human wellbeing and social equity.

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CITATION

Kelly, S., R. Cunningham, R., Plant, Maras K., (2019) Water Scarcity Risk for Australian Farms and the Implications for the Financial Sector. Institute for Sustainable Futures, UTS.

ACKNOWLEDGEMENTS

This research was a partnership between the Institute for Sustainable Futures (ISF), The Yield and National Australia Bank.

Special thanks to James Bentley, Brett Pringle and Stephanie Russo for their helpful comments and advice throughout the project. We would also like to thank the agribusiness bankers and Australian farmers who participated in this study.

DISCLAIMER

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EXECUTIVE **SUMMARY**

Water scarcity is a persistent and growing issue for farms across Australia. Access to affordable water is necessary for farms to remain competitive in an increasingly globalised food and commodity market.

Recent droughts have heavily reduced dryland farming production and the overall volume of water that can be allocated to irrigation. The future impacts of climate change will also increasingly contribute and exacerbate the effects of water scarcity. Despite the underlying influences of El Niño and La Niña Australia is experiencing long-term trends of increasing water scarcity over the period 1996 to 2015 as shown in Figure 1.

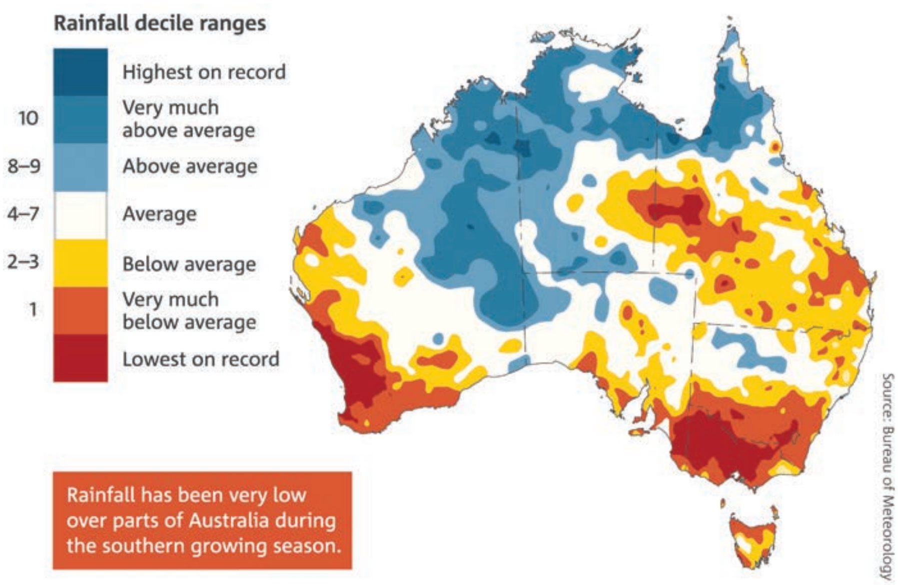


Figure 1: Changes in rainfall patterns across Australia over the period 1996 to 2015 compared to the entire record period.

Water scarcity therefore represents a material risk factor for farms across Australia with the potential for a reduction in yields and increasing the costs of farm production. The volatility of water price ultimately dictates the risk level of an asset and its usefulness as collateral against a loan. For example, during a drought water prices are high but this coincides when most farmers want to increase their borrowing capacity in order to purchase water from the market.

**Source: Bureau of Meteorology. Southern growing season (April - October rainfall deciles for the last 20 years (1996 - 2015). This map shows where rainfall for the period 1996-2015 is either above average or below average in comparison with rainfall for the entire record period from 1900.*

While using water rights as collateral may seem reasonable but could lead to trouble when water prices drop and water price volatility significantly reduce the value of the collateral against the loan increasing risks for the bank.

At present, the materiality of water risk is not fully incorporated into the assessment of farm loan applications. Introducing water risk assessment processes into farm loan applications has the potential to reduce financial risks for farms and financial institutions as well as improving the long term viability and sustainability of farming in Australia.

This report develops a new method to calculate the water risk exposure for farms.

This report develops a new method to calculate the water risk exposure for a farm and therefore estimates the materiality of water risk for finance in the Australian agribusiness sector. This research project assesses the current approach undertaken by financial officers (in the Agribusiness sector) and farmers in Australia when assessing water risk, and from this seeks to identify opportunities to improve the associated financial decision-making processes. Building on the phone interviews and literature review, a brand new water risk assessment framework was developed from the ground-up. The new on-farm water risk calculation methodology estimates 'Water Value at Risk', or wVaR for short. This metric affords farmers and bankers a new way to incorporate water risk exposure into the financial decision-making processes.

To complete this research three different research methods were undertaken:

1. Comprehensive literature review on the implications of water risk in the agribusiness sector in Australia.

2. Semi-structured interviews with farmers and agribusiness bankers, to identify and understand on-the-ground decision-making processes.

3. Data-analytic modelling to analyse published data and construct risk assessment frameworks and procedures to assist front-line agribusiness bankers.

In summary, this research presents a new approach to asses and optimise the decision-making processes for both financial advisers and farmers. Outputs from this research provide a sound theoretical basis for the assessment of on-farm water risk.

This research was completed in partnership between The Institute for Sustainable Futures, The Yield and the National Australia Bank (NAB).

DR SCOTT KELLY

Research Director, ISF

1.1 HIGH-LEVEL FINDINGS FROM THE LITERATURE REVIEW

The main conclusion from the literature review was that very little existing research has been carried out in Australia (or internationally) on how water risk can influence finance serviceability requirements. Whilst the number of published studies pertaining to on-farm decision-making around water risks was far smaller than anticipated, several relevant studies were identified, including two from Australia.

None of this research developed a model for linking on-farm water risk to financial decision-making processes. The current literature review found four relevant studies: Jackson et al. (2011); Schenk et al. (2014); Fernandez et al. (2016) and Ng et al. (2011). The latter two studies are relevant with respect to linking the farm scale with catchment and river basin scales. From the parallel stream of grey literature, ABARES represented an important source of information and historical data that contributed to this research.

1.2 HIGH-LEVEL FINDINGS FROM INTERVIEWS

The focus of the phone interviews was to understand how farmers currently manage water risk on farms and how agribusiness bankers incorporate water risk factors into their financial decision-making processes (e.g. the assessment of loan applications).

The existing NAB agribusiness loan application processes were also reviewed and confirmed our finding that while financial institutions do take water risk into consideration, formal on-farm water risk assessments do not take place during the loan application process.

A typical loan application will primarily consider the financial performance of a farm on the basis that it is able to service its debt obligations. Agribusiness bankers also place significant weight on the character of the applicant in making their assessments. The only time that water risk may become a material factor is either during or immediately preceding a drought as this would have an impact on the recent financial performance of the farm.

It was considered standard practice for front-line bankers to inquire about any water licences (allocation rights) or entitlements including any government concessions. However, without a formal on-farm water risk assessment, these are not usually included within the overall assessment of assets and don't appear to be included in an assessment of assets of on-farm water risk. This represents a significant gap in the existing processes and leaves the bank vulnerable to farm business default and accumulation risk.

For clarity, 'grey literature' are materials and research produced by organisations outside of the traditional commercial or academic publishing and distribution channels.

MITIGATING WATER SCARCITY RISK

A key recommendation from this research is that on-farm water risk is considered as a formal part of every agribusiness loan application process. In undertaking this assessment it is important to distinguish between baseline water risks (i.e. risks outside a farmer's control) and on-farm water risk management (i.e. on-farm risks and mitigation strategies that impact overall risks). Therefore, a final water risk assessment needs to incorporate two components: (i) baseline water risk and, (ii) adjusted on-farm water risk.

Bankers see themselves as connected to the community and often come from an agricultural background themselves.

Baseline water risks are important as they contribute to a farms overall water risk profile. For example, a farm located in an area that is prone to droughts will have a higher level of water risk then a farm located in an area with consistent rainfall. Baseline risks are defined as any risks that go beyond the scope of the farm and which a farm does not have any direct control or influence over. All farms that operate within a particular basin, region or district - depending on the resolution of the model - will have the same baseline water risk profile.

BASELINE WATER RISKS	ON-FARM ADJUSTED WATER RISK
Cimate Change	On-Farm Water Storage Capacity
Historical Rainfall Patterns	Farm Allocated Water Permits
Water Basin Storage Capacity	Irrigation Systems Employed
Historical Water Spot Price	Crop Choice
Water Basin Topology	Time of Seasonal Planting
Total Quantity of Allocated Water Permits	Time of Irrigation
Regulatory & Legal Risk	Access to Financial Capital (Cash)
Competition for Scarce Water Resources	On-Farm Technology & Information Systems

Figure 2: Baseline Water Risks and On-Farm Adjusted Water Risks.

A farm is then able to a adjust their baseline water risk through effective water risk reduction strategies. Figure 1 provides some examples for the different types of water risks under each category.

Baseline water risk is an objective water risk assessment for a particular area based on historical information. The Baseline Water Risk is then adjusted by On-Farm Water Risk which either offsets or contributes to the farms overall Risk Profile Score.

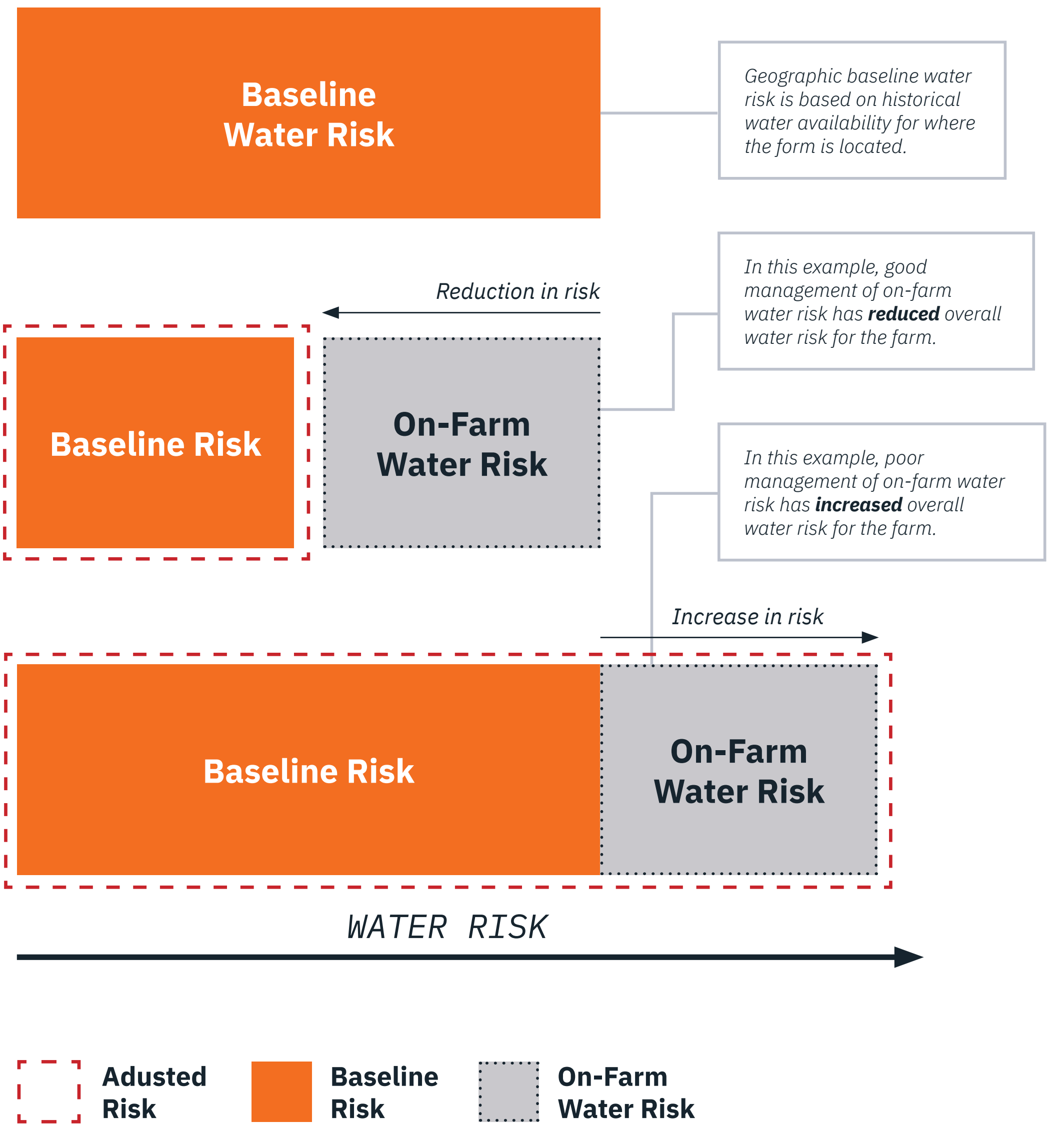


Figure 3: Baseline water risk and adjusted water risk

1.2.1 AGRIBUSINESS FINANCE SECTOR

- The majority of information required for loan applications is supplied by the loan applicant. The banker will then use their own experience and knowledge to decide on the loan.

- Water risk does not form part of the formal loan application process.

- The most important information used by a banker in making a decision on a loan application is the previous financial history of the applicant and income forecasts into the future (approx. 12 – 24 months).

- Many agribusiness business bankers draw on their own professional experience and rely heavily on the reputation and personal relationship with customers before deciding to provide a loan.

- Bankers see themselves as connected to the community and often come from an agricultural background themselves.

- Information regarding water risk is presently highly fragmented, and use of this information varies significantly between different bankers and different regions.

- There is no special allowance within the existing loan application process to assess a farms exposure to water risk and assign a water risk rating. Therefore, the relative importance given to water risk in making final financial assessments remains opaque and is not treated consistently across loan applications.

- All water basins across Australia operate under different markets and legal requirements, and thus bespoke solutions must be sought per basin, farm and crop type. Naturally, this leads to specialist knowledge within a particular area.

- Water risk is perceived as just one risk factor within a suite of other risk factors within the broader loan assessment process.

- Water mitigation strategies such as the purchase of equipment for above surface infrastructure can be funded using existing financial instruments. However, this is only in cases where the infrastructure asset can be sold and transported off the farm in the event of a default. The bank will not provide loans for infrastructure that is difficult to remove from the farm (e.g. underground irrigation equipment) even though this equipment may reduce on-farm risk.

- The future market price of water is predicted using historical prices and conditions rather than future conditions that are expected to arise due to climate change. This has the effect of underestimating future water risk and therefore the future market price of water, future crop yields and global commodity prices.

1.2.2 FARMERS

- Water was considered a significant risk for all farmers interviewed.
- When undertaking credit risk and due diligence processes as part of reviewing applications for finance, banks consider a range of factors, including a potential borrower's capacity to repay and the materiality of environmental, social and governance (ESG) factors.
- Almost all the information provided to a bank for making a loan application is related to the financial position of the farm. However it does not involve a rigorous or robust formal consideration of water risk.
- Water accessibility and availability is linked directly to water basin market policies and the on-farm availability of water resources and irrigation systems.
- The timing for accessing water from the system through allocation rights or spot market purchases was fundamental to successful on-farm water management.
- Farmers are much more likely to purchase water than sell water. Anecdotally it was thought the source of water permits on the open market generally came from farmers who had kept their water allocations after selling their property.
- Farmers who had been living in the region for decades (if not generations) tended to employ embodied tacit knowledge rather than smart technology and sensors to enhance their decision making.
- Few farms are using advanced smart technologies and sensors to improve their on-farm decision-making. Most farms still prefer traditional methods (e.g. shovel, soil moisture sensors, rain gauge or weather station) for decision-making. Particularly those who have been in the industry over many years. New farmers may find smart technologies and sensors as being more beneficial.

1.3

HIGH-LEVEL FINDINGS FROM THE QUANTITATIVE ASSESSMENT

This section of the research aimed to identify how bank professionals and farmers can make better decisions to mitigate financial risks resulting from water scarcity.

A quantitative assessment of water risk across different Australian basins was undertaken, providing a summary of the various sources of water risk faced by farmers. An appraisal of price risk and quantity risk is presented with a detailed assessment of the relationship between water availability (quantity risk) and market (price) risk.

Finally, we derive a novel formula for estimating a farms exposure to water risk. In this ground-breaking approach, we define a farms risk exposure to water risk as Water Value at Risk or wVaR. The estimation wVaR can be used for different water scarcity probabilities, but for this research, we recommend the 10th percentile or a water scarcity event that would occur with a 1 in 10 chance.

Given the flexibility of this calculation methodology, the estimation of a farm's financial exposure can be measured under a range of water scarcity conditions. Another advantage of this method is that it allows for the calculation of the probability of when a farm will default on its loan obligations and the setting of specific thresholds.

For example, if a farm's wVaR at the 10th percentile is higher than its gross profit margin, then it will also be under financial stress and at risk of defaulting on its loan repayments with a 10% chance. Or put another way, if the wVaR exceeds the gross profit margin for a farm at the 10th percentile, the farm will likely default on its loan at least once over a ten year period. Moreover, the calculation procedure can provide advice to the farmer and banker on the primary source of water risk for a farm and how water risk can be ameliorated.

1.4

REDUCING WATER RISK WITH AGTECH

Our research has shown that there is a vast scope and potential for the development of new and emerging technology to support the agriculture sector in Australia.

With data-analytics taking centre stage in the agtech revolution, precision agriculture is allowing farmers to make real-time decisions and develop long term strategies that save time, money and reduce risk. New challenges such as population growth, resource scarcity and climate change are going to continue to increase the risks that are borne by the agriculture sector. New technologies such as the use of satellites, drones, robots and sensors will provide more granular information about crops, soil, and the environment to optimise overall farm productivity. As new farm technology is increasingly integrated and connected through the 'internet of things (IoT)' large volumes of real-time data will be used to support improved on-farm decision making processes that provide advanced warnings, real-time alerts and suggest courses of action that will improve overall farm productivity.

Farms may need to adapt to this new technology and be run very differently to remain competitive. New data streams will allow better decision making - not just on the farm – but also to support robust decision making processes in other supporting sectors such as logistics, trade and the financial sector. New agtech companies are increasingly being established to support Growers as they start incorporating digital technologies into their operations. One such company is "The Yield Technology Solutions"whose products marry microclimate sensors that are installed on the farm with data intelligence to provide accurate insights into what's happening in the crops. By providing real-time information on growing conditions this technology helps growers make faster, more accurate decisions by backing up gut feel with hard evidence. The Yield is focused on continuous improvement of its product offering and will look to include additional functionality to further support growers by reducing water risk and making more informed decisions (for irrigation and other factors), this will further promote the grower's ability to improve productivity.

STRUCTURE OF THIS REPORT

THE STRUCTURE OF THE REPORT IS AS FOLLOWS

- **Section 2** provides a description of the methodology and the methods used in this research.
- **Section 3** provides a review of the literature on managing water risk.
- **Section 4** presents the findings from the interviews with bank professionals and farmers.
- **Section 5** introduces findings from the quantitative assessment of water risk in Australia.
- **Section 6** presents the preliminary conclusions of this research.
- **Section 7** is the bibliography.
- **Appendix A** provides a summary of papers considered for the literature review.
- **Appendix B** is the interview summary sheet used for banking professionals.
- **Appendix C** is the interview summary sheet for farmers.

A study that covers the hardship of water scarcity for farms & the ground-breaking approach that affords farmers due credit for managing on-farm water risk.

2
LITERATURE REVIEW

In December 2017, ISF conducted a targeted study of academic literature to identify modelling techniques and concepts with relevance to the current project's decisions and risk management strategies.

LITERATURE REVIEW CONCLUSIONS

It was hoped that the literature review would provide a solid grounding on the best methods for developing a risk assessment framework for this research.

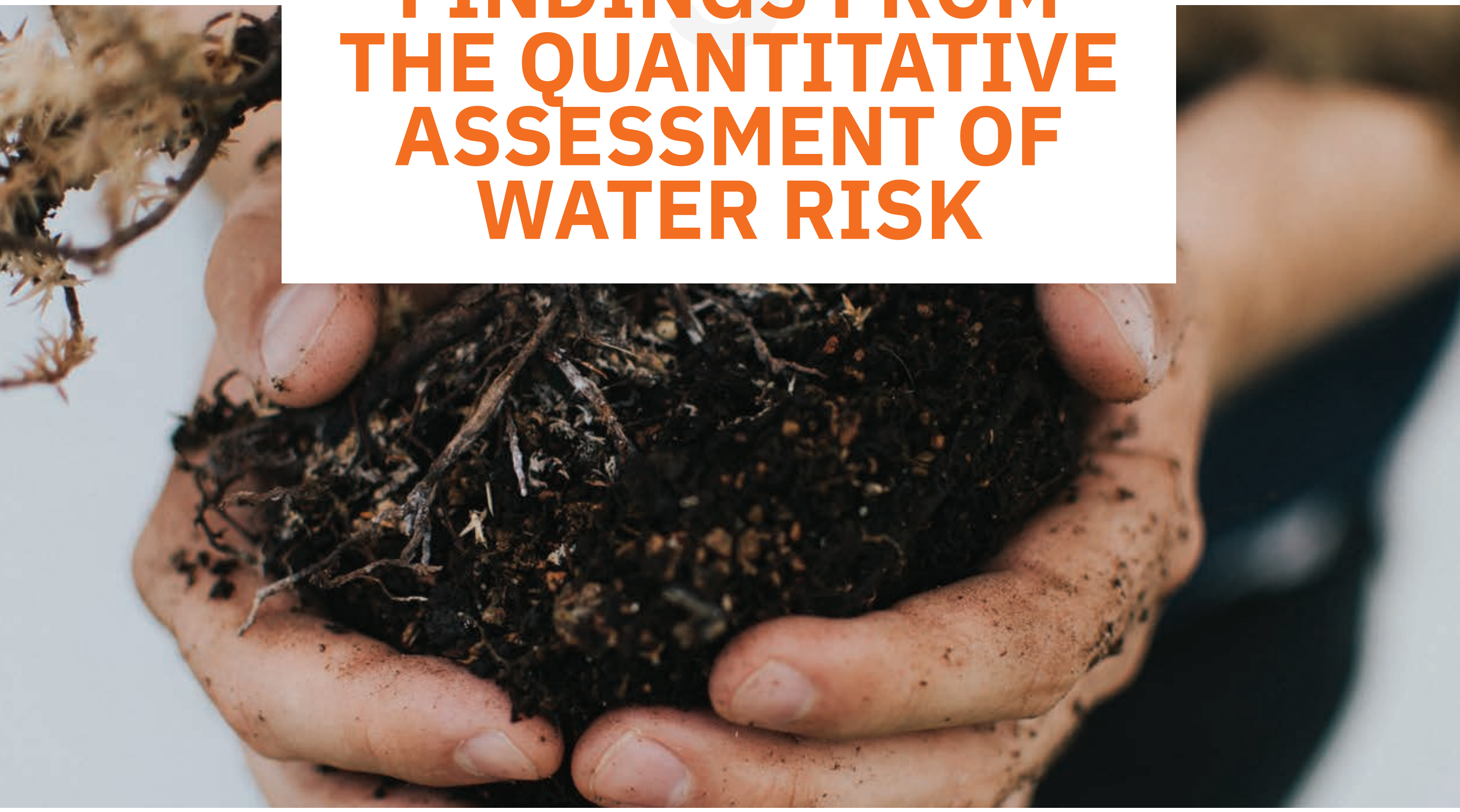
However, it became clear through the process of completing this literature review that there are presently no formal methods for estimating the impact of water risk on a farms ability to service a loan.

While the number of published studies on farmer decision-making and water risks was far smaller than anticipated, several relevant studies discuss water risks in general, including two from Australia.

The current literature review recommends four studies, in particular, to inform the project's modelling approach: Jackson et al. (2011); Schenk et al. (2014); Fernandez et al. (2016) and Ng et al. (2011).

The latter two studies are relevant to linking the farm scale with catchment and river basin scales. For more detail on the literature that was reviewed as part of this study please consult Appendix A.

3 FINDINGS FROM THE QUANTITATIVE ASSESSMENT OF WATER RISK



3.1 WATER TRADE IN AUSTRALIA

Water markets in Australia have developed significantly over the past two decades.

Water markets are used to balance competing demands for scarce water resources and aim to deliver more efficient investment, allocation and use. Within this section, we outline the environmental and economic decision-making processes for assessing water risk.

This is achieved by making recommendations on the data and methods that can be employed to appropriately price risk for existing financial and insurance products in the industry.

The Australian Bureau of Agriculture and Resource Economics (ABARES) is responsible for producing the annual 'Water Markets Report for Australia' (ABARES 2017).

The report covers climatic factors, water availability, environmental water and irrigated agricultural activity, as well as traded products, trading activity, prices and relevant changes in water market structures. The 2016-17 edition of the report represents the 10th annual statement of water trading activity across Australia. The report highlights trends and market activity during the year.

The report incorporates and combines data from several government departments and presents this information via an online dashboard that can be accessed from the ABARES website: http://www.bom.gov.au/water/dashboards/.

Water trading activity occurs across 60 separate Trading Zones in Australia with Agriculture accounting for around 70% of water extractions, followed by urban use (20%) and other industries (10%). Within the agriculture sector 92% of water consumed is through irrigation and the Murray Darling Basin (MDB) accounted for 66% of irrigated water use in Australia.

Figure 4, on the following page, shows the amount of irrigation water use in 2015-16 by natural resource management region.

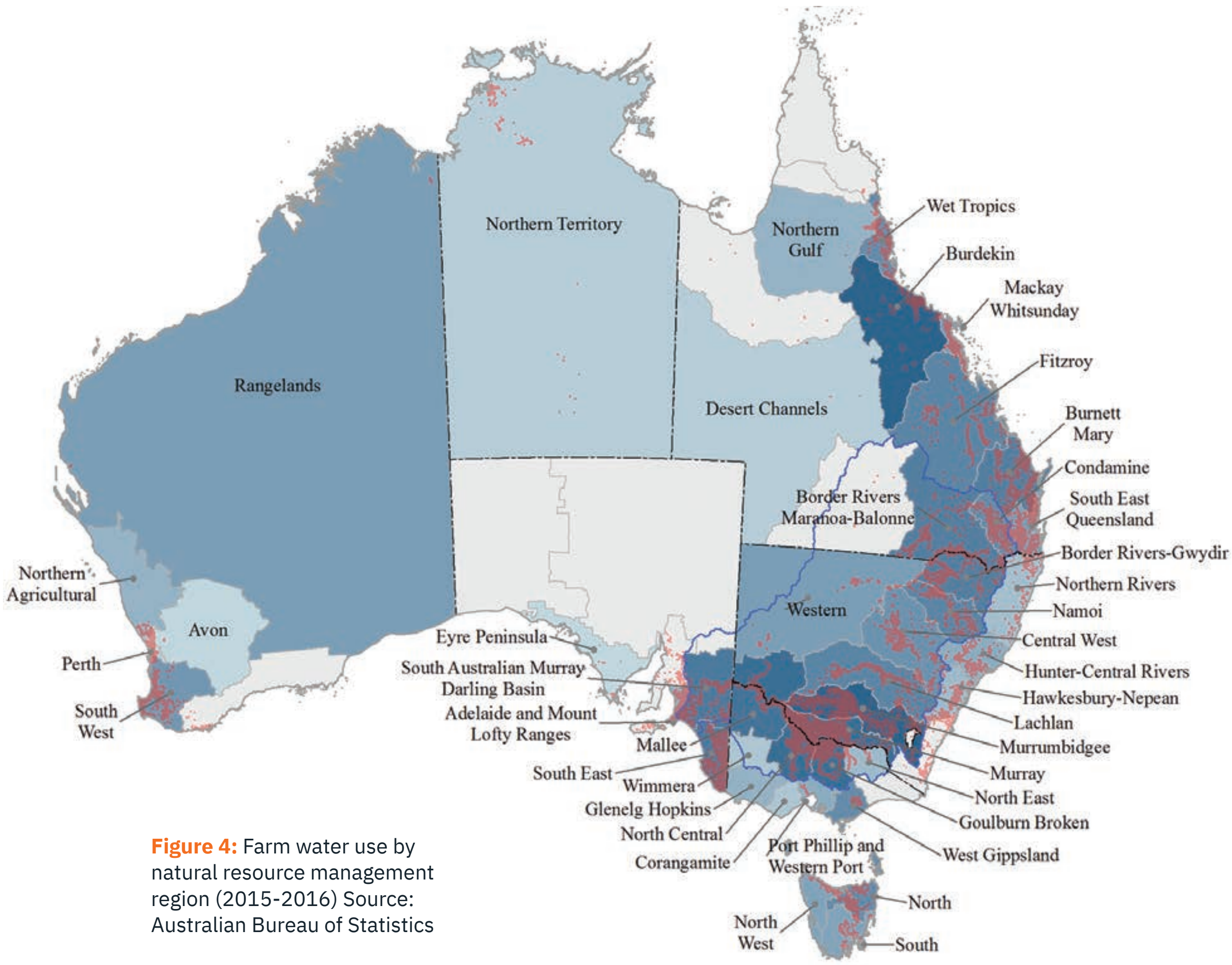
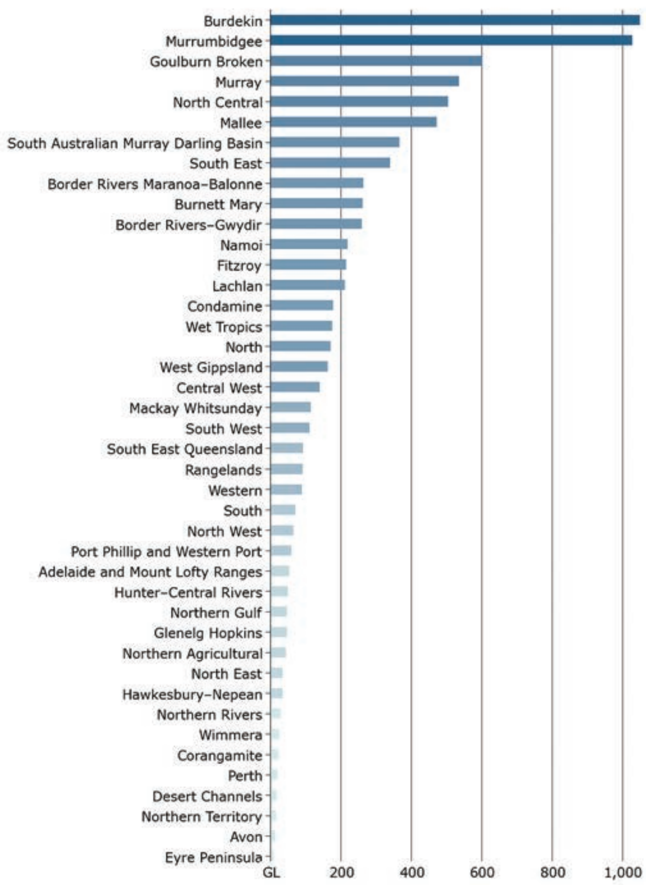


Figure 4: Farm water use by natural resource management region (2015-2016) Source: Australian Bureau of Statistics



The total volume of water sold in the water allocation and entitlement markets varies from year to year, with the vast majority of water trade occurring between agricultural users.

AVERAGE ANNUAL VOLUME OF TRADED WATER ON THE ALLOCATION MARKETS (2011— 2016)

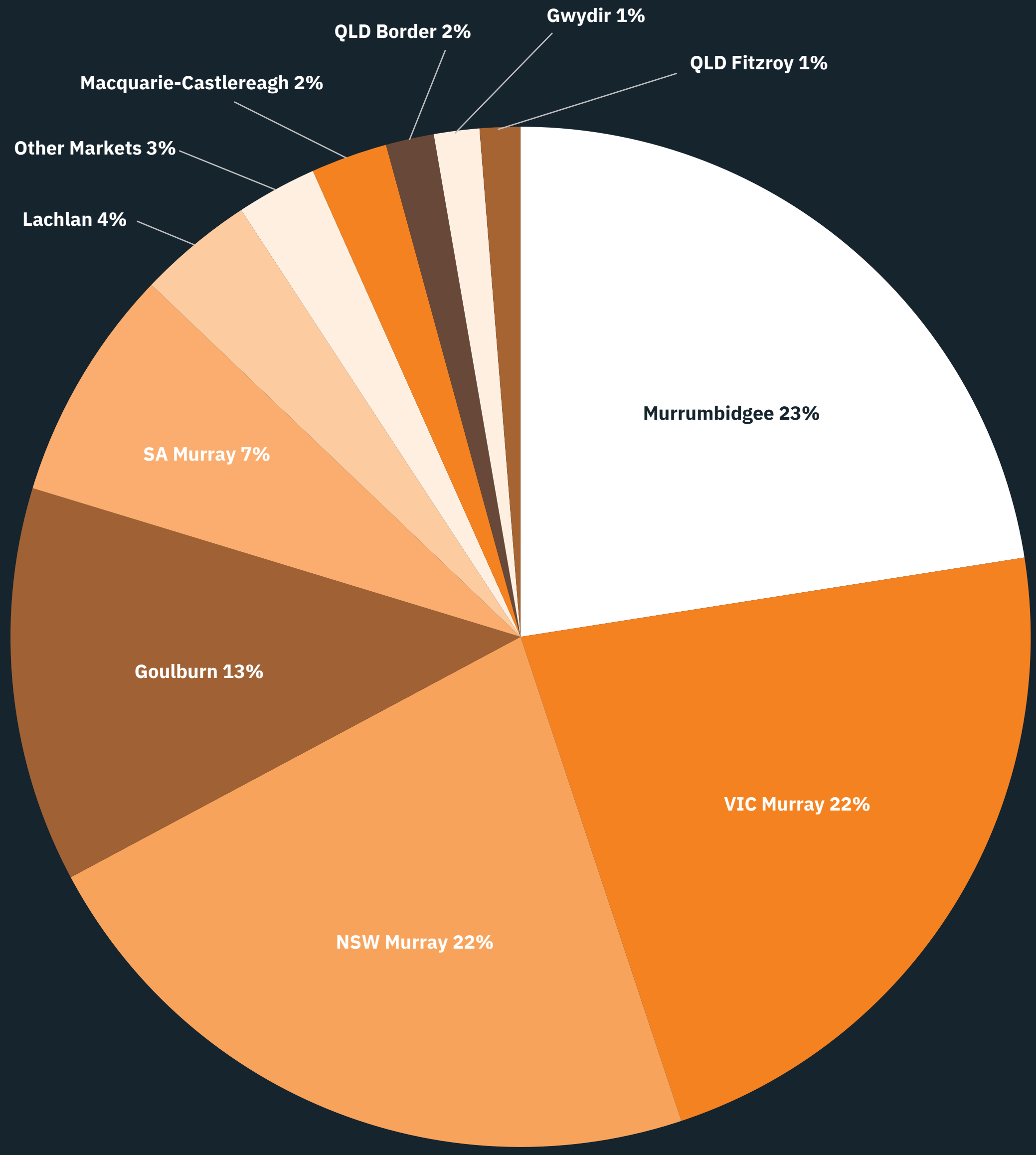


Figure 5 : Traded water allocations for the largest trading zones

AVERAGE VOLUME OF TRADED WATER ON THE ENTITLEMENT MARKETS (2011-2016)

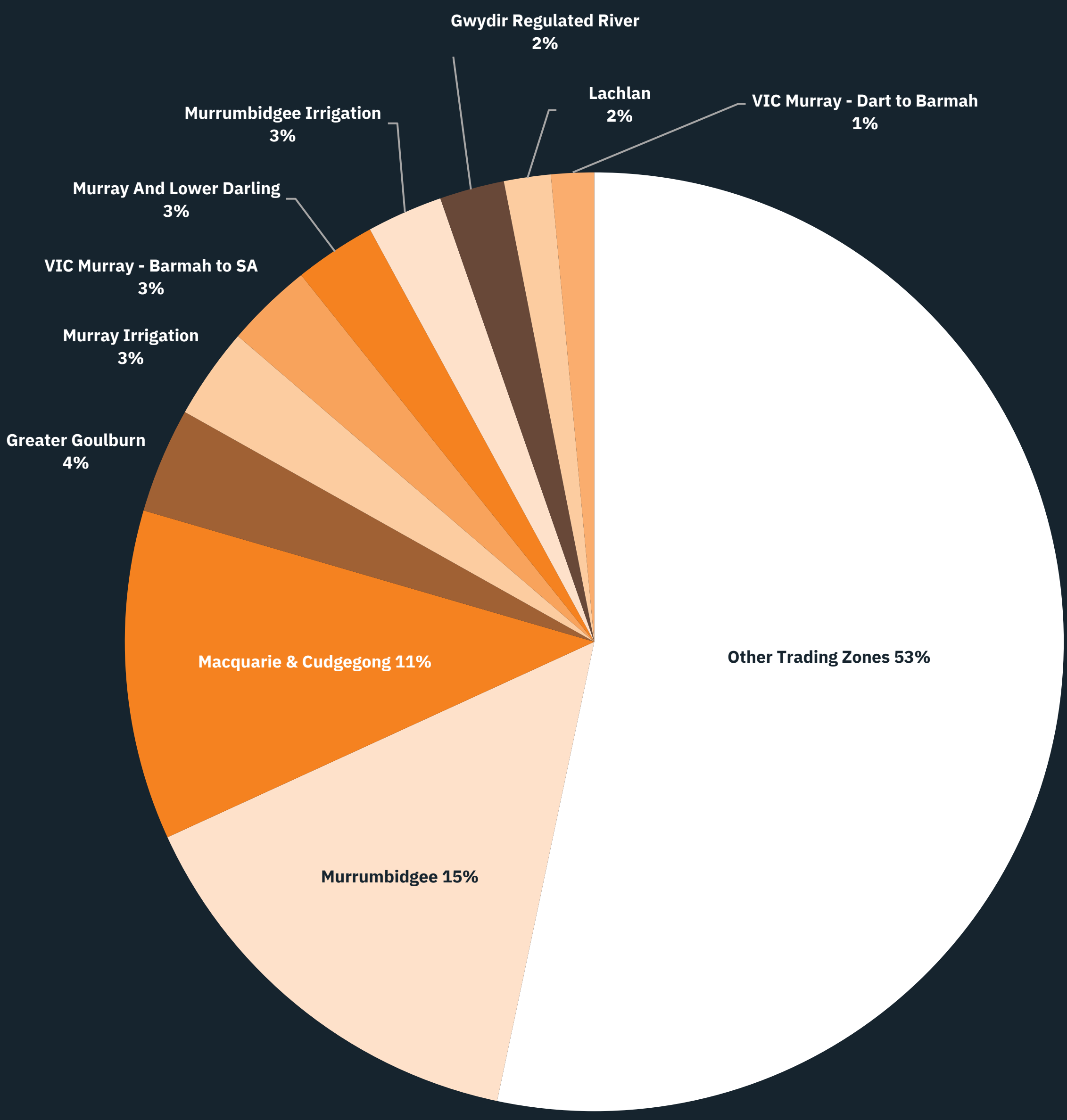


Figure 6: Traded water entitlement rights for largest trading zones.

3.2

UNDERSTANDING THE AUSTRALIAN WATER MARKETS

Murray-Darling Basin, water entitlements are purchased from irrigators, which can then be used to improve the health of the basin's rivers, wetlands and floodplains.

Programmes like this are part of a long-term strategy to provide a permanent rebalancing between consumptive water use and the environment.

Water markets in Australia are based on a 'cap and trade' system where the cap represents the total pool of water available for consumptive use. Non-consumptive uses include water that must remain in the system for environmental and other uses. Available or consumptive water is distributed to users who own 'entitlements' or 'water rights' providing an annual share of the water that is made available in any given year. Water entitlements are administered by the basin states. An owner of a water entitlement has the right to sell their entitlements. Water entitlements are a permanent trade and are equivalent to selling ownership rights in a capital asset.

- Trading water entitlements is a permanent trade in the right to future water allocations.
- Trade in water allocations is a temporary trade in the actual water that has been allocated in any given season.

A water 'allocation' is the actual amount of water made available to the owners of water entitlements in any given season. During the year, water is allocated against the share entitlements by state governments in response to factors such as changes in rainfall and storage. This is equivalent to the yield a piece of land may produce over a year.

Thus the owner of an entitlement share can trade their annual water allocation on the water market each year. Trade in water allocation is therefore a temporary trade. Figure 7 on the following page shows the quantity of water available compared to the amount of water that has been allocated.

ALLOCATION TRADE VOLUME (MEGA LITRES)

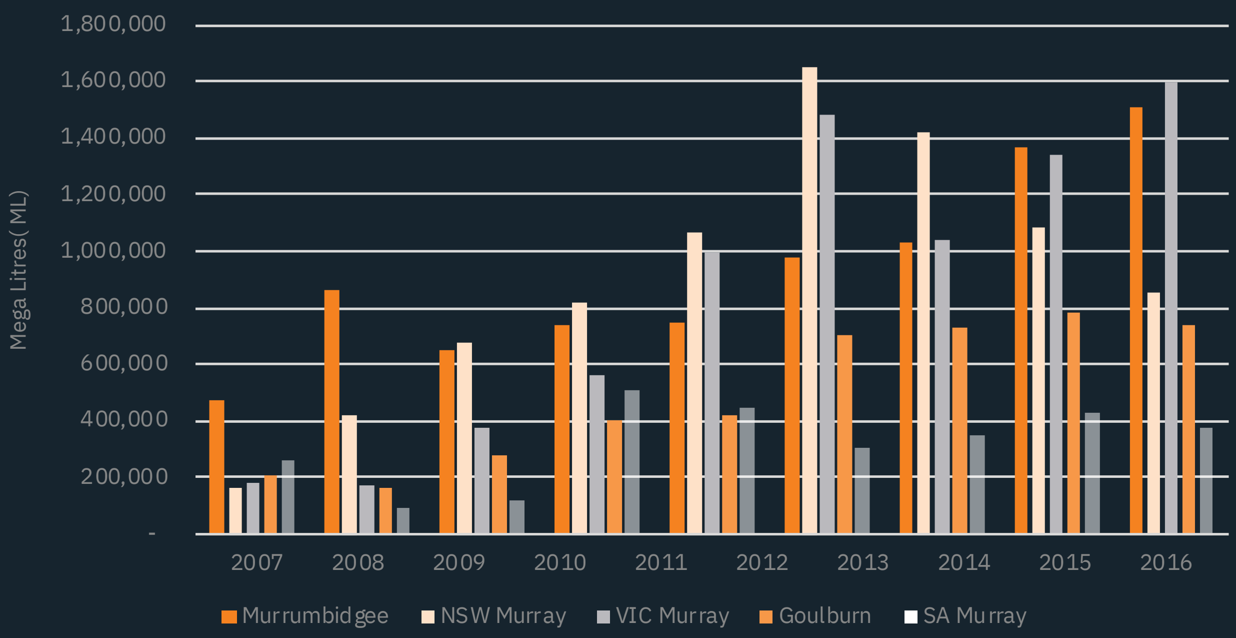


Figure 7: Water allocation trade volume for five of the largest water trading zones.

MAXIMUM MONTHLY WATER PRICE BY STATE

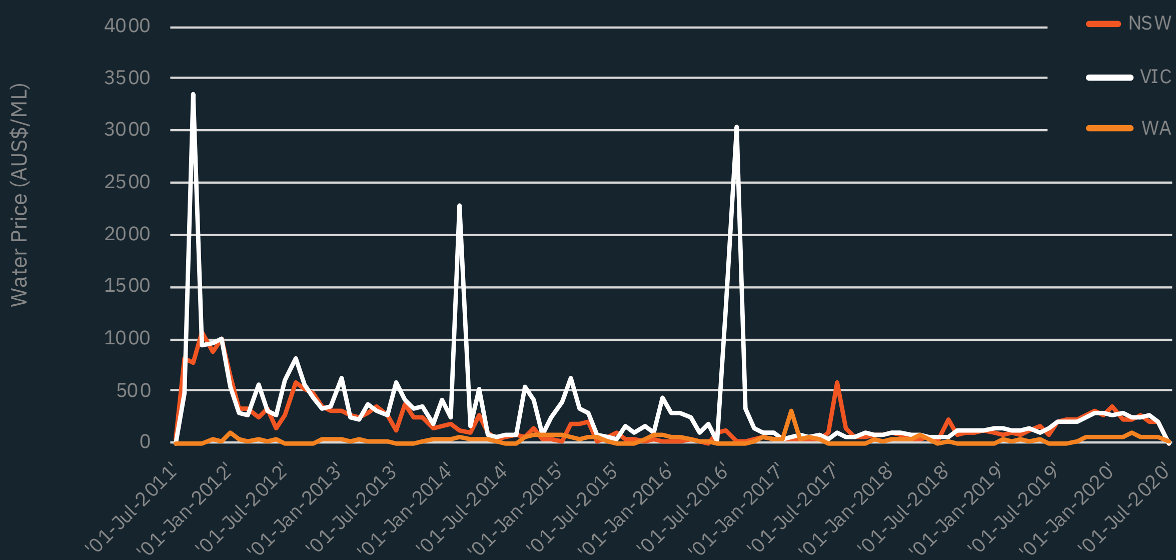


Figure 8: Maximum monthly water price by state.

Figure 8 shows the volatility in prices experienced across three states.

TOTAL VALUE OF TRADED WATER ALLOCATIONS ($) MILLIONS

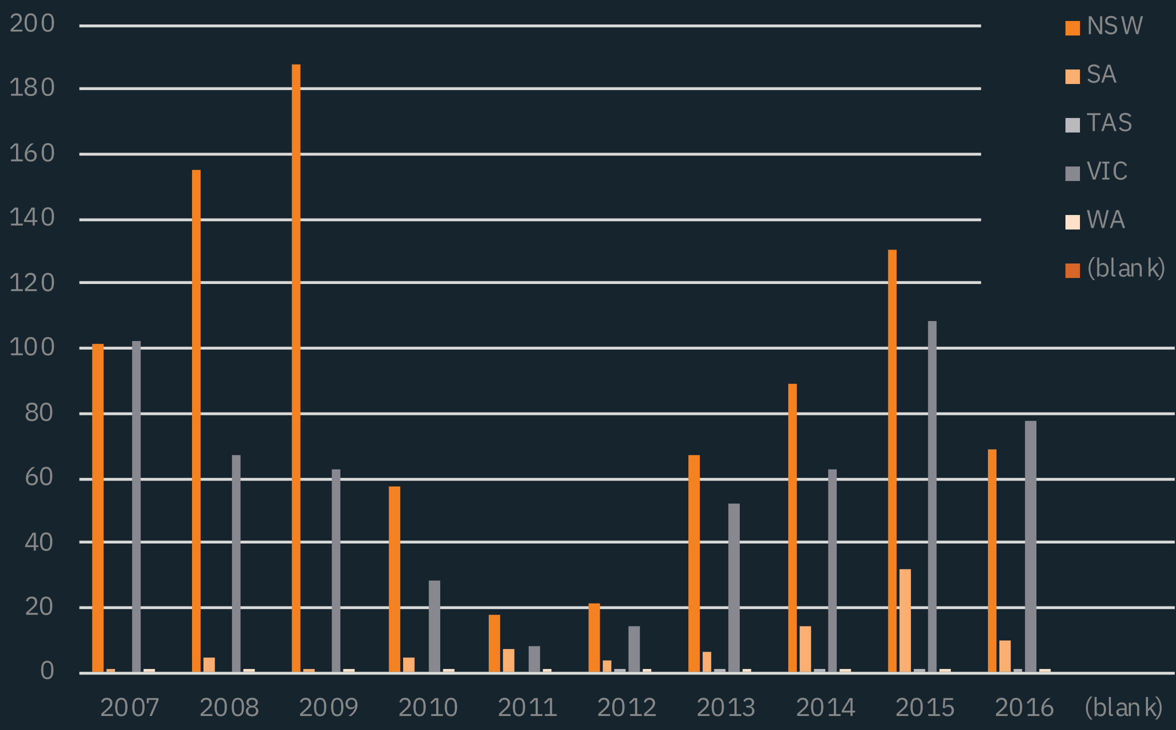


Figure 9: Total value of water traded annually on the allocation markets

QUANTITY OF WATER (MEGA LITRES)

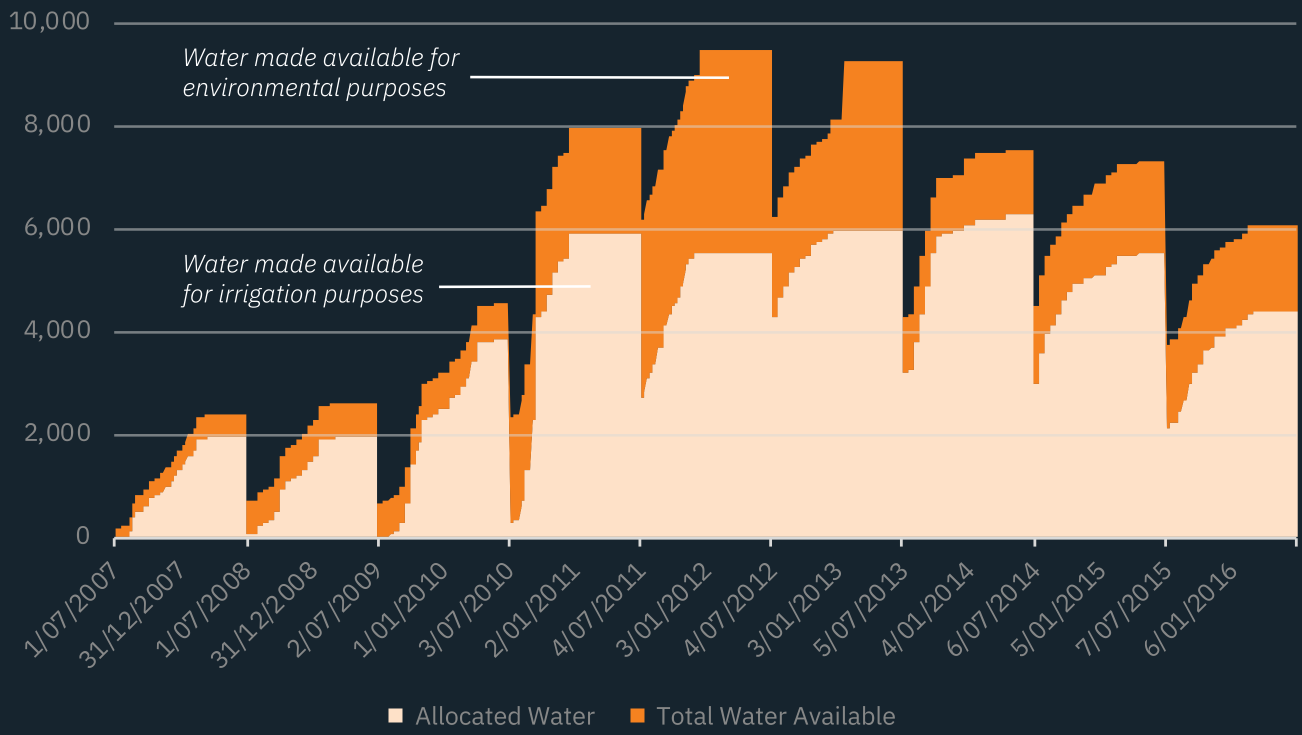


Figure 10: Water available and water allocated for the Southern Murray Darling Basin

4

REDUCING WATER RISK WITH AGTECH

Globally, the agricultural sector is experiencing a technological revolution and Australia remains a leader in the invention and adoption of agtech.

New challenges such as population growth, resource scarcity and climate change are continuing to increase the risks borne by the agriculture sector.

New solutions to these growing concerns are therefore required. For Australia to remain competive in a world that is increasingly globalised, the agriculture sector must embrace the expanding and promising role that agtech will play in the future success of this sector. New technologies such as the use of satellites, drones, robots and sensors will provide more granular information about crops, soil, and the environment to optimise overall farm productivity (Kristhna 2016).

As new farm technology is increasingly integrated and connected through the 'internet of things' (IoT) large volumes of real-time data will be used to support and improve on-farm decision making processes that provide advanced warnings, real-time alerts and suggest courses of action leading to improved overall farm productivity (Vasisht, Kapetanovic et al. 2017).

The Agricultural sector in Australia is embracing digital technology through the incorporation of a variety of sensors that generate large data sets changing the way livestock and paddocks are managed (Keogh and Henry 2016). There are a range of examples in Australia where digitisation has transformed on farm practices. From wireless sensor networks that provide farmers with information regarding crop health and animal movement in real time (Corke 2005); robotic technologies allowing dairy cows to decide when they want to be milked (Lyons, Kerrisk et al. 2013); airbone drones aiming to improve the understanding of crop cycles (CSIRO 2016); and imagery from space to estimate pastural growth rates, improve stock management and optimise on-farm decision making (Landgate, 2018). Other advances are directly related to the challenge of climate change, for example farm equipment that can run on renewable electricity rather than fossil fuels, such as the John Deere “gator” traditional utility vehicle (Deere 2018).

Our research has shown that there is significant scope and potential for the development of new and emerging technology to support the agriculture sector in Australia. These complex new technologies will collect and share greater volumes of data and will allow the integration of this information up and down supply chains and to the final consumer. However, these new technologies will bring their own challenges to farm based businesses.

Farms will need to adapt to this new technology and be run very differently to remain competitive. New data streams may allow for better decision making - not just on the farm – but also to support robust decision making processes in other supporting sectors such as logistics, trade and the financial sector.

For example, between 2012 and 2015 global investments in agtech soared by 600% increasing from 0.5 Billion to 3.0 Billion (De Clercq, 2018). This has transformed both the quantity and the quality of data that is being collected at a farm level. Such historical information is invaluable for assessing and managing the the long-term ecological sustainability and economic viability of a farm over the long term.

With data-analytics taking centre stage in the agtech revolution, precision agriculture is allowing farmers to make real-time decisions and develop long term strategies that save time, money and reduce risk. New research conducted by IBM Research (2016) showed that 90% of all crop losses were weather related and these losses could be reduced by up to 25% through the use of digital technology and precision agriculture techniques.

By connecting physical devices such as computers, sensors and mobile phones over a network (e.g the cloud) farmers are able to optimise and prioritse their decision making processes.

New agtech companies are increasingly being established to support Growers as they start incorporating digital technologies into their operations. One such company is “The Yield Technology Solutions”whose products marry microclimate sensors that are installed on the farm with data intelligence to provide accurate insights into what is happening in the crops.

By providing real-time information on actual growing conditions, this technology helps growers make faster, more accurate decisions by backing up gut feel with hard evidence. The primary technology is called “Sensing+” which employs the use of onfarm sensors (that can be installed at the farm, crop or block level) to measure microclimate conditions. When this rich data source is combined with local weather data it provides farmers with new information and reduces uncertainty about what course of action needs to be taken. The sensors that are currently available measure:

- Photosynthetic Active Radiation
- Relative humidity
- Barometric pressure
- Total Solar Radiation
- Rainfall
- Air Temperature
- Wind Speed and Direction
- Leaf wetness
- Soil Moisture
- Soil Temperature

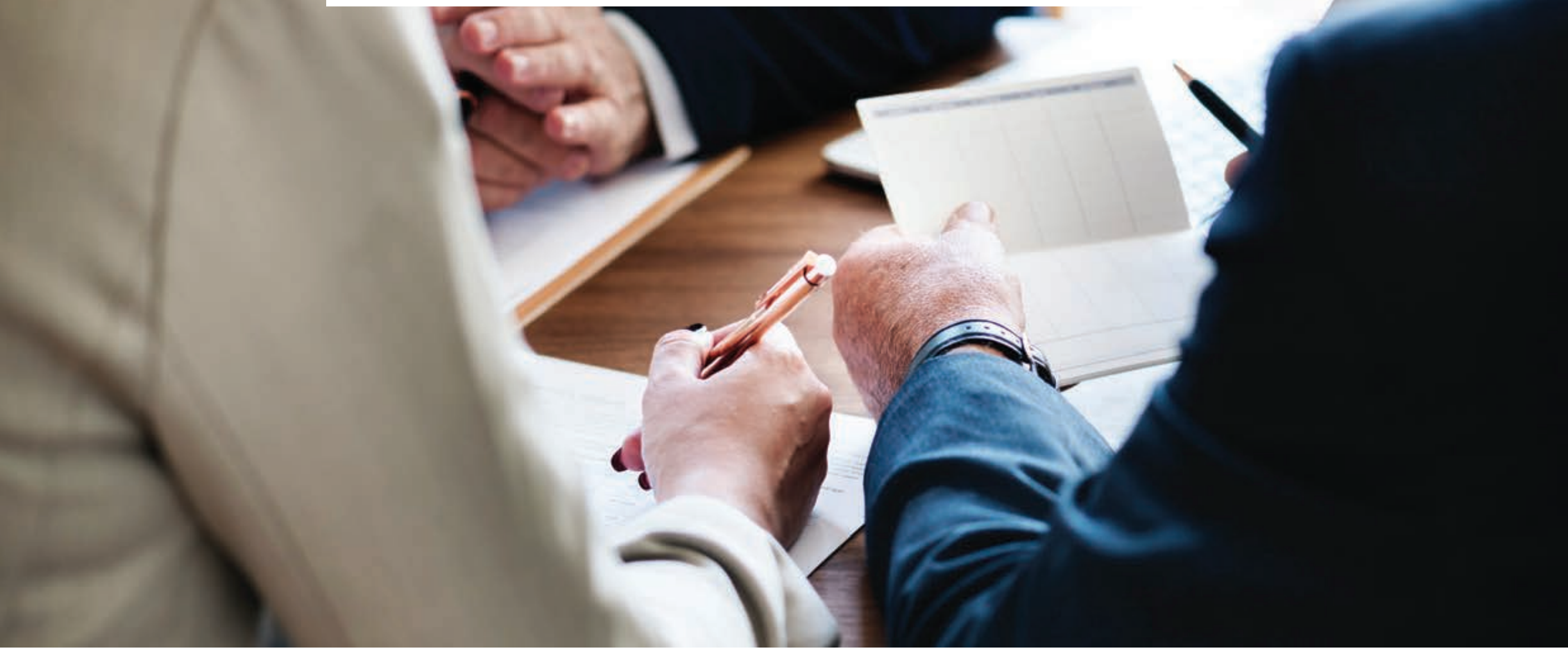
With relevance to this report, The Yield’s app supports growers with making decisions about how to effectively use their irrigation resources by providing insight into crop watering needs.

The product functionality uses data collected from dedicated onfarm sensors which when integrated with readily available weather information can calculate (based on evapotranspiration, irrigation and rainfall) what water is and will be available to the crop. This information supports growers when making the “how much and when” to irrigate decisions.

The App functionality includes current, historic (last 7 days) and predicited (next 7 days) information on a range of climatic conditions being measured, and also on the availability of water to the crops. As an example, in the Sensing+ application a simple indicator shows a deficit or surplus of water available to the crop and graphs show the soil moisture at a various depths for each site or crop type providing growers access to critical information at their fingertips (24/7) reducing the need to unnecessarily water crops, or alternatively by improving the effectiveness of of irrigation applications by ensuring the right amount of water is applied at critical stages throughout the growth cycle minimising wastage.

The Yield is also focused on continuous improvement of its product offering and will look to include additional functionality to further support growers to reduce water risk by making more informed decisions (for the irrigation regime and other factors), that will further promote the growers ability to improve farm productivity.

5 INTERVIEWS WITH BANKERS & FARMERS



5.1 INTERVIEWS WITH THE FINANCIAL SECTOR

This section provides an overview of the main findings from the interviews with front-line bankers and farmers.

Between August and September 2017, ISF researchers undertook interviews with agribusiness bankers located in New South Wales, Victoria and Tasmania. The majority of these bankers were frontline staff with a range of different responsibilities and portfolios.

Semi-structured interviews were conducted by telephone and lasted approximately 40 minutes in length.

Participants provided their consent before being interviewed. Conversations were recorded and transcribed according to the ISF ethics protocol. The qualitative thematic analysis was completed using the software package NVIVO to draw out the key themes from the interviews.

Questions asked during the interview focused on the following three themes[1]:

1. The internal bank processes for assessing loan applications;
2. The type of information and resources required for the assessment of on-farm loans;
3. Water inaccessibility as a risk factor for agribusiness customers.

In addition to the domains of process, information and risk, questions on additional information about the local area demographics and the duration of time a family had spent in the area were also asked.

The interviews used a semi-structured format to allow for developing themes during the interview that could be discussed. Some of the topics exposed during this process include the banker / farmer relationship, policy shifts and the role of water as a financial risk driver.

The content analysis undertaken from these interviews highlighted the following six themes: portfolios and connection to place; processes for assessing loans; water scarcity as a risk factor; changes in client base; policy shifts and the associated impacts on customers; and, the role of water in providing security for a farm. Each of these themes is discussed further.

5.1.1 PORTFOLIOS AND CONNECTION TO PLACE

Agribusiness bankers often noted their portfolio of customers came from a variety of different farm types including broadacre farming, dryland cropping including rice and cotton, citrus, grapes, livestock, dairy, cereal, and aquaculture.

Most participants had been working within the region for more than three years, and could therefore broadly relate to their customer base with regards to local climate and cropping patterns.

5.1.2 PROCESSES FOR ASSESSING LOANS

When prompted all interviewees referred to the NAB online assessment process during the interview. They described the process as being rigorous while still allowing the NAB agribusiness banker and the customer to discuss the specific needs of the farmer and the type of loan that was required.

The agribusiness bankers interviewed needed the following types of information: a statement of future cash flows (minimum of 12 months but up to 2 years); an income assessment; evidence that the customer kept records and understood the financial performance of the farm; information showing both historical and projected financial performance of the farm.

1 For full list of questions, see interview guide Appendix B

As well as information about the farm, the majority of agribusiness bankers also collected evidence on the character of the client, which included factors such as the client's track record of meeting commitments and farm management practices.

"...I would say character would probably be paramount."

This finding supports the hypothesis that financial lending to farm businesses is highly dependent on a relationship banking model, in which local knowledge and community relationships are important considerations.

5.1.3 INFORMATION NEEDED WHEN ASSESSING LOANS

Most agribusiness bankers discussed the different types of information required for determining and processing loan applications; however, within this line of questioning, the agribusiness bankers were asked where they sought this information. Almost unanimously, participants noted that the customer was required to provide the majority if not all of the information that was needed to assess a loan application. In some instances, supplemented financial data came from an accountant, financial planner or professional accounting software.

The participants did note that on most occasions other information was also taken into consideration including information that was already known by the banker (e.g., they had grown up in the region and remembered the water requirement per ton per crop) or they independently sought out additional information (e.g., water price)[2].

"[As a] matter of fact, the one thing I would say that we have in common with our leading farmers is their use of technology. More and more of our leading farmers either have an ag degree or someone in the family or someone they've employed has that. They use expertise and they marry that with ag data."

Agribusiness bankers also appreciated that some farmers had a higher risk tolerance than others. In most loan applications there was always a discussion about a farmer's access to water and said water's source (e.g. whether water came from on-farm dams and rivers, water allocation rights or the ability to purchase water when required and the potential of future El Niño / La Niña predictions on water availability)

One significant finding was that every water basin market in Australia operates differently. Each basin has its own set of market

2 In a typical case a farmer would come to a bank and asked for x money for y land to grow z crop. The farmer would then provide evidence showing they have access to p water, and q projects and giving a total of r yield. The farmer would then expect the banker to know how much water was required for each type of crop to meet the projected yields. If this information was not known at the outset of the application, the banker would ensure the farmer could provide that information prior to approving the finance rules and regulations stipulating who can access water and when. In any water market, many players have an impact on the dynamics of the market, including government, water companies, irrigation operators, corporate enterprise and farmers.

The publicly available information about water price is considered to be significantly fragmented, with no single centralised resource. Several essential information sources were brought up during these interviews (e.g. ABARES, Murray Goulburn water, and so on). However, there was no pre-specified list of information that an agribusiness banker was required to check before authorising a loan application.

5.1.4 WATER SCARCITY AS A RISK FACTOR FOR FARMS

In all locations (except for Tasmania), bankers reported that lack of access to sufficient water was s a considerable risk factor for farms. If farmers had over promised the output yield for a particular crop when they did not have adequate access to water to meet the water demand requirements for the crop, the loan would generally not be approved.

"Environmental factors don't come into loan application assessments as much as the probability of risks and the assessment of risks"

However, our findings suggest that formal on-farm water risk assessments are rarely carried out in practice. Bankers were found to rely on the farmers expertise and financial statements than conducting their own water risk assessments.

Such processes do not adequately allow for the risk of future water scarcity. Therefore, including water scarcity risk in such assessments is critical for multi-year loans where droughts are likely to occur.

Some interviewees noted that they had long-term clients, some of whom had been through the ten-year drought, and it was in no one's interest to see a farm go under in this scenario. As such, when things were tough, there was a desire to see the farm succeed through these times.

One banker commented:

"When the customer is happy and successful, so is the bank."

For example, in July 2018 NAB announced a Drought Assistance Package for customers affected by prolonged drought conditions. The Assistance Package offers eligible customers extensions on loan terms and suspensions on home loan repayments among other offerings.

If more rigorous procedures around the assessment of water risk were in place, the need for the banks to make such allowances would be reduced with a corresponding reduction in default rates.

5.1.5 CUSTOMERS ACTIVELY IMPROVING WATER EFFICIENCY

Most agribusiness bankers recognised that many farmers were actively looking to improve their water efficiency. Some farmers had also started using a range of on-farm technology to strengthen on-farm decision making, such as soil moisture monitors. Others were beginning to consider mitigation strategies, such as switching to more efficient centre pivot irrigation systems for broad acre farming or installing solar photovoltaics on the roofs of pumping stations.

In some cases, farmers located at the end of irrigation channels were forging contractual arrangements with water suppliers to take the wastewater, clean it and put it back onto the crops.

One water efficiency strategy popular for the irrigation of perennial crops is the installation of a sub-surface drip irrigation system. This efficiency strategy is one that an agribusiness banker cannot currently fund. The stated reason for this is due to the limitation that a bank cannot lend money for infrastructure that cannot be stripped down and sold as collateral in the event of foreclosure. Any subsurface elements would also require a considerable amount of labour to recoup the investment.

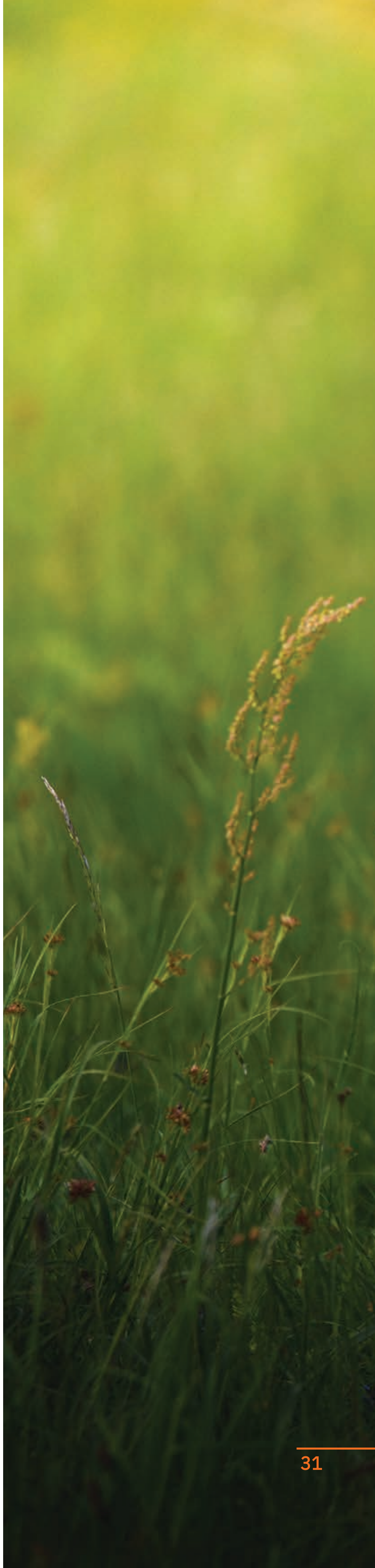
5.1.6 CHANGES IN CLIENT BASE

In some regions, in particular, the Griffith Region (Goulburn-Murray basin) some agribusiness managers have noticed a change in clients from “mum and dad” farmers to larger corporate farms, with corporates based in China and the USA who typically grow nut crops. Anecdotally this has been thought to have an impact on the market price of water in these regions, as no matter what the price of the water, the corporate farmers will pay the going rate. Further, as the nut trees are perennials, these require a constant stream of water (similar to citrus or grapes) whereas rice or cotton crops are an annual crop with different water demands.

5.1.7 POLICY SHIFTS & IMPACT ON CUSTOMERS

Another important player operating within the water market is Government. Not only does the Government purchase water, but they also control the rules of operation for the water markets and create the policy framework that impacts water use requirements.

To improve on-farm irrigation effectiveness, a customer may want to improve their irrigation infrastructure. However, the farmer can only influence a small pathway of the irrigation infrastructure, the rest (lining of channels, removal of old channels, piping, and so



on) is owned and operated by either Government or by private enterprises; this limits the types of water efficiency investments that a farmer can make.

The age and efficiency of irrigation systems can have a substantial impact on water demand. Different farms may be connected to various forms of irrigation infrastructure with considerable variation in age and overall efficiency. One particular agribusiness banker mentioned they had one client who benefited from an irrigation upgrade and it took up to five years for another client in the same region to benefit from the same upgrades to their farm.

5.1.8 THE ROLE OF WATER ALLOCATION RIGHTS AS SECURITY AGAINST A LOAN

If a standard policy is not in place there can be inconsistency in decisions as to whether water allocation rights can be used as security against a loan.

Ultimately, the volatility of the water price dictates the risk level of the asset and its usefulness as collateral against a loan. In most situations, the water markets may tend to hide the risks associated with the use of water allocation rights as security against a loan. For example, during a drought, water prices are high, putting a premium on allocated water rights; this coincides with the time when most farmers want to increase their borrowing capacity in order to purchase water from the market and meet their water demand requirements.

In this example, using the value of water allocation rights as collateral against a loan might seem like a reasonable idea, but such a strategy fails to consider the volatility of water prices and the natural downward pressure on water prices when the drought breaks. This volatility significantly reduces the collateral against the loan and increases the risk for the bank.

Since the introduction of water allocation rights, many farms have started to put in place long-term strategies to secure future access to water. For example within the Griffith Region, where there is a significant amount of agricultural output, there is an extremely high demand for water. In this market, many farmers buy their water in advance to secure their access to water over the growing season.

Some farmers even buy, lend and lease their water allocation rights. Most farmers have a mixture of permanent water licenses, temporary water licenses (e.g. leasing licences from someone else) or finally purchase water directly from the spot market. Some customers had previously bought water when the price was high, and now they are still sitting on those water credits, even when the price of water has reduced substantially.

5.2 INTERVIEWS WITH FARMERS

This section provides an overview of the main findings from the interviews with front-line bankers and farmers.

Between October to November 2017, three in-depth interviews with farmers were conducted. Two of whom had farms in New South Wales (Hume and Dartmouth & Goulburn Murray basins), and the third had a farm in Tasmania (Clyde River). Semi-structured interviews were undertaken over the telephone and lasted approximately 40 minutes in duration. Participants provided their consent before being interviewed.

All conversations were recorded and transcribed according to the ISF ethics protocol. Qualitative thematic analysis was completed using the software package NVIVO which was used to draw out the key themes from the interviews.

Questions asked during the interview focused on the following topics[3]:

1. Information about on-farm activities
2. Processes related to water risk undertaken on the farm
3. Information used when assessing water risk
4. Water scarcity as a risk factor

Semi-structured interviews allow for emergent themes during the interviews. The content analysis undertaken highlighted the following six themes: the definition of water risk to farmers; information about finance; irrigation; sensors; and, the financial value of water. Each of these is discussed in detail as follows.

3 For full list of questions, see interview guide Appendix C

5.2.1 WATER RISK

Water was considered to be a considerable risk for all participants, as, without water, there could be no farm.

5.2.2 THE INFORMATION REQUIRED FOR FINANCE

Various types of information are requested and provided to banks during a loan application. The information most frequently supplied by farmers includes financial information, crop types, expected dividends, historical financial information and forecasted income (1-2 years).

Farmers noted that the information requested by the financial sector did not change due to environmental conditions, however, sometimes the conversation regarding seasonal expectations arose informally.

5.2.3 IRRIGATION SYSTEMS AND METHODS

During the interview, farmers discussed the main types of irrigation systems they used on their farm. It was identified that many farms were constrained by the basin and the topography of their farm. For example, one farmer had planned to install a sizeable underground irrigation system consisting of piping between dams and channel irrigation; however, the farmer was constrained due to lack of funds.

For the farmers who participated in this research, the primary factor affecting irrigation were crop type, the timing of planting and the timing of watering.

5.2.4 ON-FARM SENSORS

Farmers were asked if they currently used sensors and if not what the barriers were to using sensors in the future.

Some reported using soil moisture sensors; another had access to information from their neighbour's weather station. All participants reported using multiple weather apps on their mobile phones and computers with data collected from nearby weather stations.

However, in addition to this information, there was a significant amount of embodied knowledge that had accrued through living in the region for decades if not generations.

This understanding was reflected in the response of one grower when asked if they used sensors, they responded:

"A shovel works fine."

5.2.4 THE FISCAL VALUE OF WATER

All farmers noted that water was critical to their success. Several farmers conceded that any water they had access to on the farm, had no overall benefit to their financial standing.

One grower outlined this:

"...we've had trouble attaching to the capital value of the water, so this water we've just bought is only really valid by the increasing land value whereas really it should be valid as a separate asset class, so that's really one issue that doesn't increase the land value by that much so we struggled to get the loan."

"The cost of water is massive. It is a cost to our business that directly affects our profit."

TOWARDS DEVELOPING A MODEL OF WATER RISK FOR FARMS

During a loan application process, multiple risk factors need to be considered before offering the loan.

From the interviews with farmers, it was clear that water risk was a primary concern and could have a large impact on both the short and long-term profitability of a farm. Water risk was seen as something that could be managed with an appropriate level of planning, but in general, when farms were presented with the prospect of limited water availability over extended periods, it often resulted in very tough decisions needing to be made.

An end result of this, is the risk of defaulting on any agribusiness loans that a farm may be servicing.

The water that is available for farming varies from basin to basin, and this is due to a multitude of different factors such as:

- rainfall
- on and off-farm storage capacity;
- water allocation rights;
- the number and size of farms in the basin;
- the type of irrigation systems being used;
- major crop types in the basin;
- seasonal demand for water; and
- the amount of evaporation and leakage that occurs across the basin.

Timing also plays a vital role in proper water management over both the short-term and the long-term. For example, different crop types have different water demands over the year. Simple changes to irrigation times, such as irrigating in the evening when it tends to be cooler can improve water efficiency because less water is lost to evaporation.

Other factors that have an influence over the longer term include; carryover water storage capacity and water rights from previous years; changes to the amount of annual environmental allocations which take priority; and, the long-term effects of El-Nino and La-Nina. Therefore both short-term and long-term factors have a meaningful impact on the availability of water for the farmer.

Faced with complex factors, the farmer then needs to make choices to maximise the farm's total return. The ability of a farmer to successfully manage their water resources, therefore, has a direct impact on the prosperity of the farm which directly impacts performance and thus the ability for a farmer to payback any given loan.

As the turnover for a farm is seasonal and linked to the sale of crops, there can also be long delays of up to 18 months for the effects poor water management to appear on a farms balance sheet. Thus effective farm management requires good forward planning and management to ensure sufficient funds are available to purchase water when required.

6.1 APPROPRIATELY PRICING WATER RISK WITHIN THE FINANCIAL SECTOR

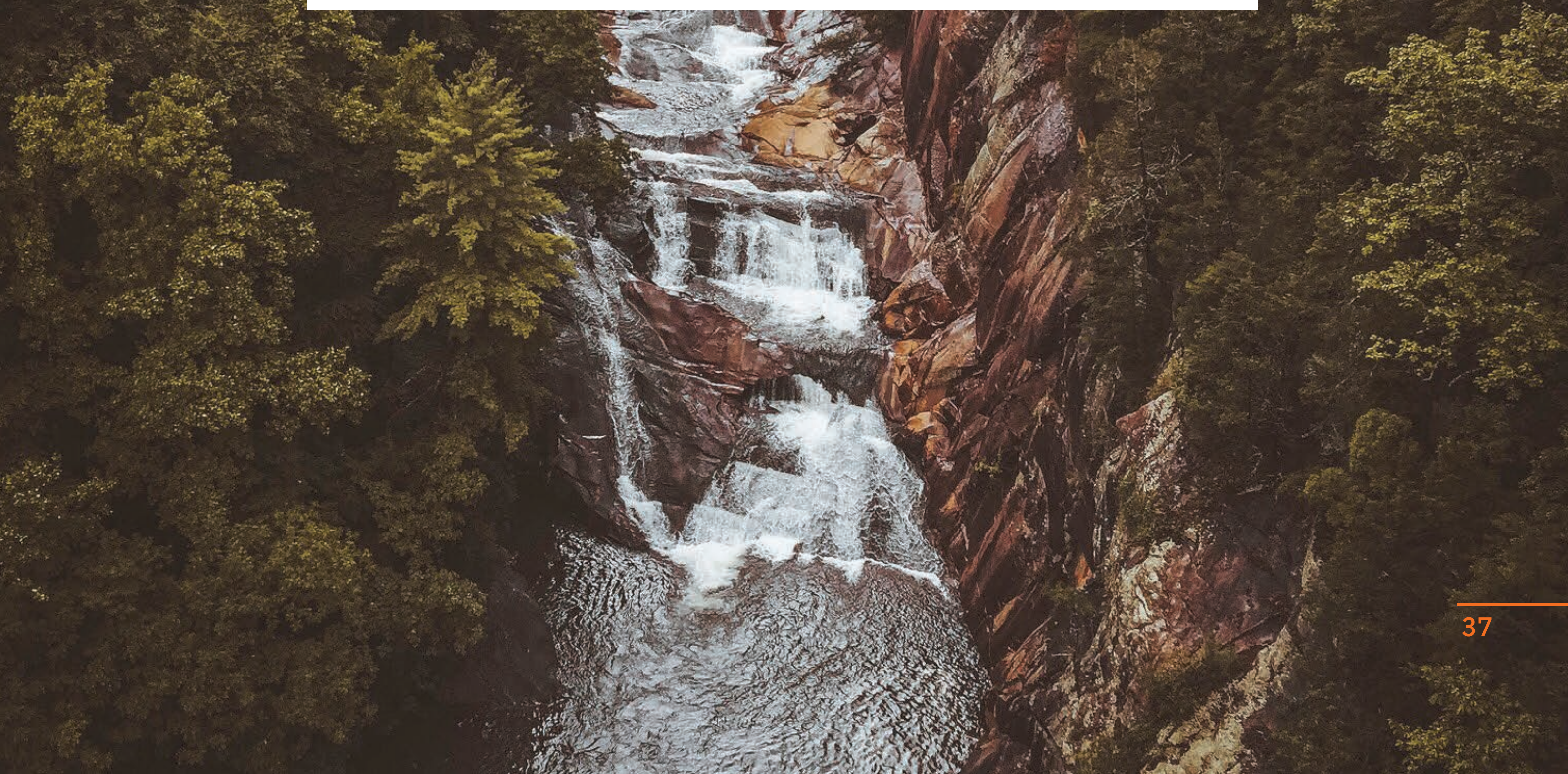
A variety of factors contribute to water risk across regions and across time. Seasonal rainfall patterns can have a cumulative impact on dam levels across multiple years.

Dam levels are therefore impacted by longer-term weather fluctuations such as El Niño & La Niña cycles and prolonged droughts.

Short-term factors include seasonal weather conditions such as average rainfall, irrigation choice, evaporation, and crop water requirements.

Medium-term factors include on-farm storage levels which provide a buffer to short-term inflow and outflow differences and commodity prices that offer economic signals to produce certain crops with different water requirements. A recent example where commodity prices have influenced the quantity of irrigation being demanded from the system has been the recent decline in both milk and grape prices causing a shift to water-intensive fruit and nut production.

Long-term factors that drive supply include longer-term weather patterns such as El Niño & La Niña cycles and climate risk from CO2. Long-term demand comprises farm productivity and structural changes to global agriculture markets that impact exports and domestic food requirements.



Individual farms operating within a market context are also exposed to a set of on-farm water-related factors.

Such factors include crop choice and the corresponding water intensity of those crops; the source of supply water and the respective reliability and cost of each source of water; the type of irrigation systems and farming equipment being deployed and the relative efficiency and impact of water prices on the timing of water purchases. Water risk can, therefore, be bucketed into the following three categories, namely: on-farm operation risk; weather and climate-related risk; and market-based risk.

Figure 1 below illustrates on-farm water risks within the context of broader environmental and economic factors. These risks are represented on a continuum from long term risks to short term risks.

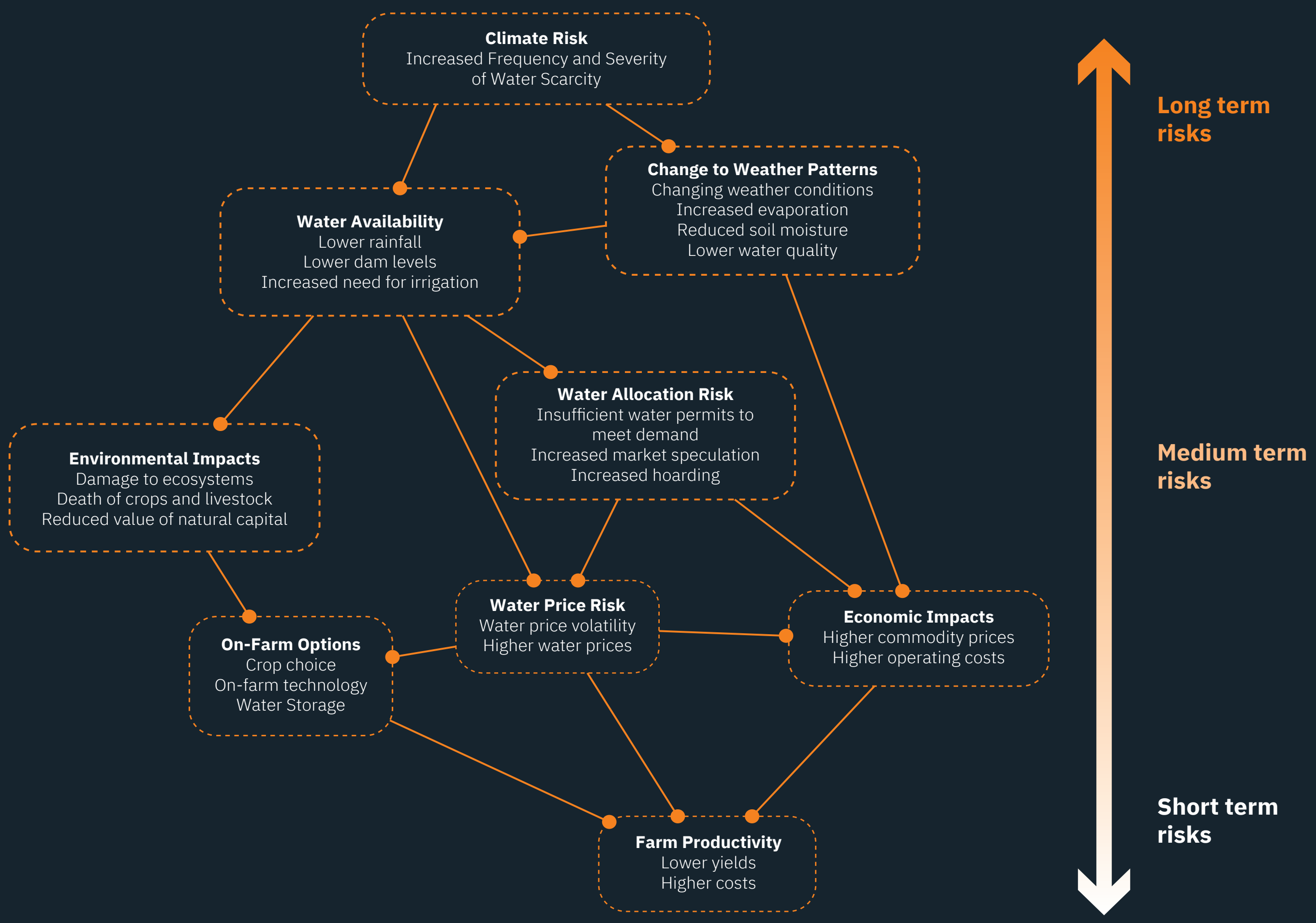


Figure 11: On Farm Water Risk and Water Market Factors

Time Horizon	Context	Risk	Cause	Mitigation
Short Term	Weather	Production variability	Weather fluctuation effect on production	Site monitoring, regional weather indicators
Short Term	Operations	Production choice	Crop choice impacts water use and profit	Crop cycling, profit margin signals, market research, understand water needs
Short Term	Market Prices	Water purchase timing	Timing and irrigation needs given local weather and water price	Local weather monitoring (evap,temp), soil probes, optimised water given crop type and maturity, water market forecasts
Short Term	Weather	Climate Forecast inaccuracies	Model Error	More timely forecasts, more regional forecasts, early warning systems/communication
Medium Term	Market Prices	Commodity price fluctuation	Effect Revenue and incentive to produce certain crops	Monitor and financial hedging, co-operatives, multiple sales channels, sales agreements, customer research and vertical integration
Medium Term	Operations	Water Source diversity	Supply risk	On farm storage investment, high reliability water purchasing given risk appetite
Medium Term	Operations	Water Quality (Salinity)	Evaporation increases salt concentration	Electrical conductivity monitoring of water
Long Term	Operations	Water efficiency	Rroductivity decline leading to sub-optimal methods	Water use tracking and trend analysis, infrastructure investments, for example: underground irrigation investments
Long Term	Climate	Drought	Sustained unfavourable weather	Long term tracking of indicies (Souther Oscillation Index and El-Nino event indicators), dam levels

6.2

PRICE RISK

In the Australian water market, prices have been shown to increase by more than a factor of ten during periods of water scarcity.

From an economic standpoint, such increases show that the market is working effectively because the price of water increases when water is scarce and decreases when water is abundant. However, the significant fluctuations in price makes it difficult for farmers to plan adequately for the future.

Although prices are set within water basins, a moderate degree of connectivity between basins does exists through regional trading and shared environmental drivers.

Moreover, when a drought strikes, it tends to affect multiple water basins across Australia this causes a relatively high degree of regional correlation particularly in dry periods. Where regional price differences do occur, these spreads are due to via regional climate variations and to the propensity for farms in a particular basin to favour certain crops which have different water requirements.

For instance, during the 2008 drought, NSW rice farmers were net sellers of water allocations to Victorian grape and fruit producers. Regional weather patterns and the availability of supporting infrastructure are also factors that influence regional price spreads.

6.3 ALLOCATION (QUANTITY) RISK

The amount of water available each year varies depending on seasonal inflows and storage management.

For each season, each basin declares the amount of water that will be allocated to the environment and how much will go to agriculture. This is generally based on the basins predicted annual seasonal water availability from rainfall.

Water entitlements are the rights to future water allocations. Having water entitlements, therefore, does not guarantee a set amount of water each year, but rather a percentage of the water that has been allocated to farmers consumptive use in that year.

Actual allocations for the owners of water entitlements can, therefore, vary significantly from year to year. A farm with water entitlement rights is consequently exposed to being under-allocated in the event of a drought.

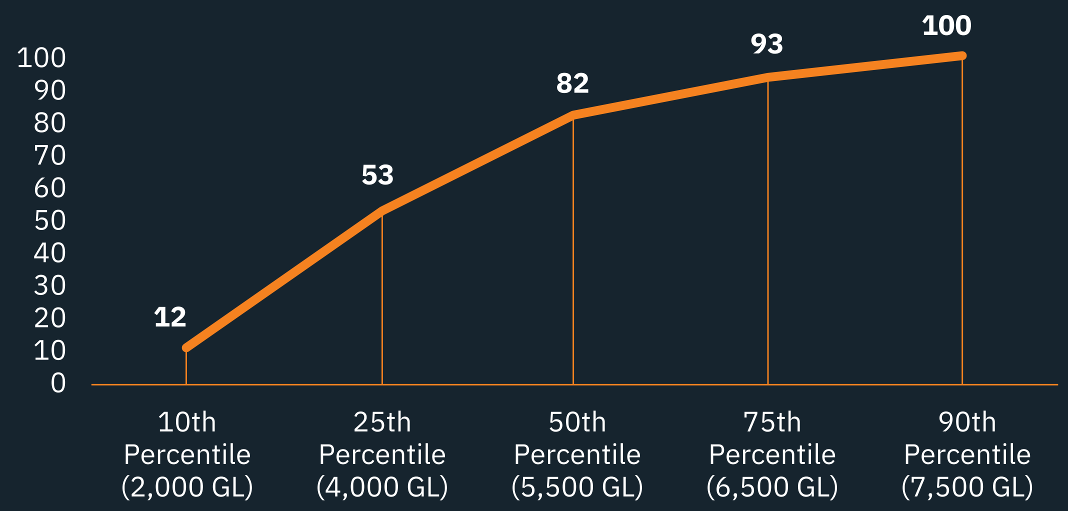
Figure 12 shows the incidence of under-allocation based on the level of entitlements given. For example, if allocation levels are consistent with the historical average (50th Percentile), then the percentage of allocation for high-reliability water is on average 82% (e.g. 50% of the time a farmer can rely on receiving at least 82% of their full entitlement).

The same chart also shows that there is a 10% chance of being allocated the full entitlement and a 10% chance of being allocated just 12% of their entitlement.

The shape of this graph is concave down and monotonically decreasing which shows that the percentage of water allocated to farms drops sharply for below the 50th percentile.

PERCENTILES OF YEARLY ALLOCATION AND ALLOCATION

Figure 12: Percentiles of Yearly Allocation and Allocation Percentage



6.4 RELATIONSHIP BETWEEN QUANTITY RISK & PRICE RISK

Water allocations and rainfall provide the most reliable signal for determining water price.

ABARES have conducted a series of econometric models where rain and yearly allocation levels are shown to be the primary determinants for estimating price. The models use historical data from 2001 to 2016 and illustrate how price can vary in each region given specific allocation and rainfall levels. The charts below are an extract of this relationship and reveal exposure to price risk for different environmental conditions in the Murray Region. While regional prices are highly correlated, during times of shortage, this correlation reduces and regions further along the Murray River (VIC Goulburn and SA Murray) have higher propensities for price increases.

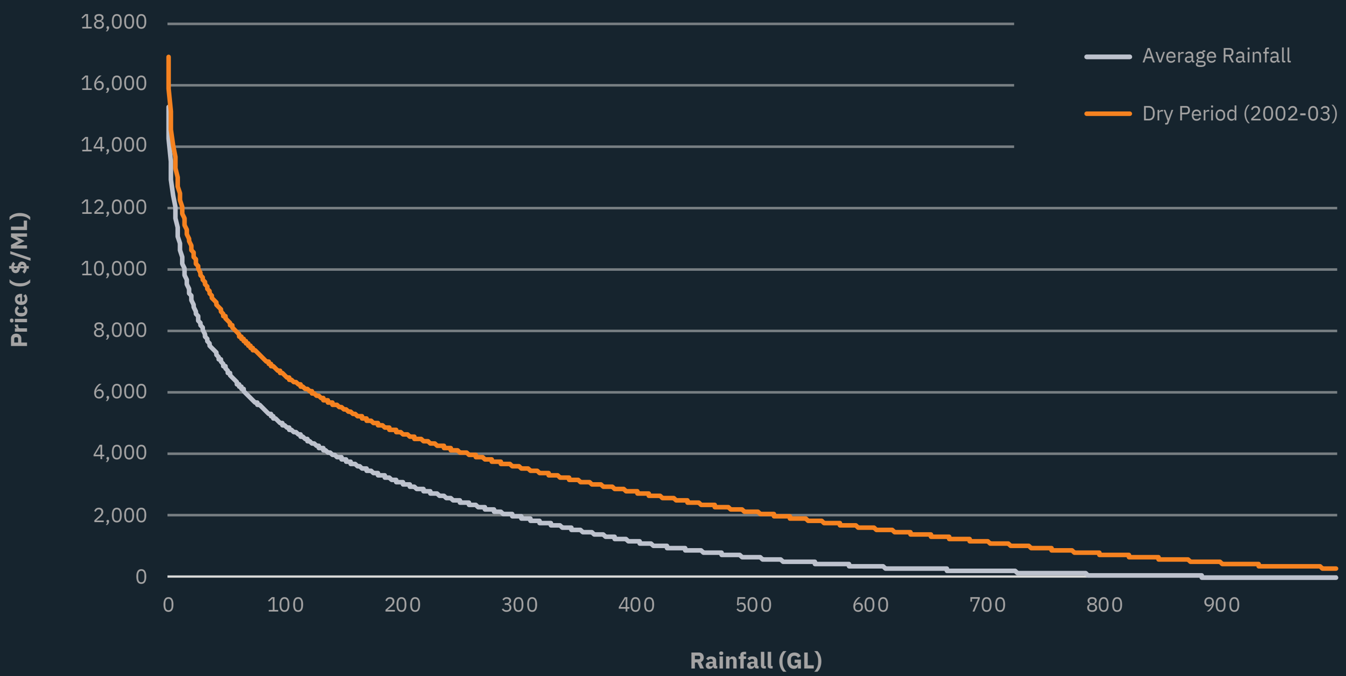


Figure 13: ABARES estimated price for water based on the predicted volume of rainfall across all regions

Data source: "Lessons from the water market the Southern Murray–Darling Basin water allocation market 2000–01 to 2015–16," by Neal Hughes, Mihir Gupta, Keerthanan Rathakumar, pg 57. 2016 Australian Government Department of Agriculture and Water Resources ABARES.

Figure 13 shows the modelled effect of rainfall on the price of water. As show, their is a significant premium paid for the price of water during dry periods.

Using ABARE’s econometrics model we further highlight the linkage between price and quantity risk by region.

The chart below uses the ABARE's econometric model but applies varying amounts of yearly allocation levels (percentiles from historical bands) to illustrate the impact of allocation and rainfall on average water price.

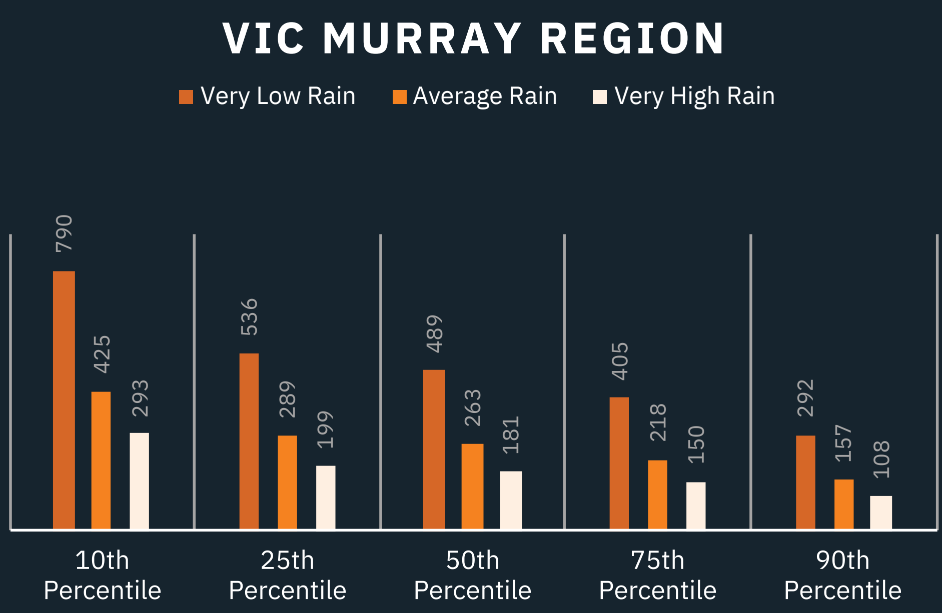


Figure 14: Expected water prices across basins in the Victoria Murray Region

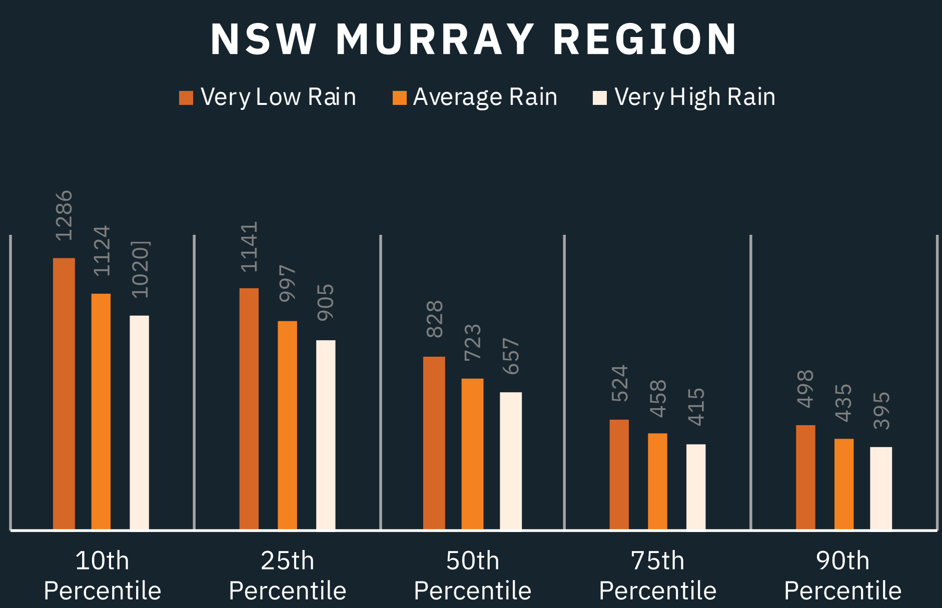


Figure 15: Expected water prices across basins in the NSW Murray Region

INTRODUCING THE CONCEPT OF WATER VALUE AT RISK (wVaR)

The waterfall chart shown in Figure 16 measures the exposure to water price risk for a hypothetical farm.

The demand for water from specific crop choices can be compared to the supply of water – each with varying costs.

If a farm has a shortage of water that is not met by rain, on-farm supply, or from its water entitlement allocation, the difference in water supply must be sourced directly from water market purchases. To meet on-farm water demand, the farm is exposed to both allocation risk (due to being allocated less than its entitlement) and price risk from having to go to the market to purchase water at a time of water scarcity.

The data shown in Figure 16 and Table 1 illustrates this with a real example. The table below shows a hypothetical example of the total amount of water supply available to a farm from allocation permits, on-farm resources and rain which in total is equal to 66 ML. It also shows the total water demand for the farm is 88 ML suggesting a shortfall in water supply of 22 ML.

ON FARM WATER QUANTITY (MEGA LITRES)

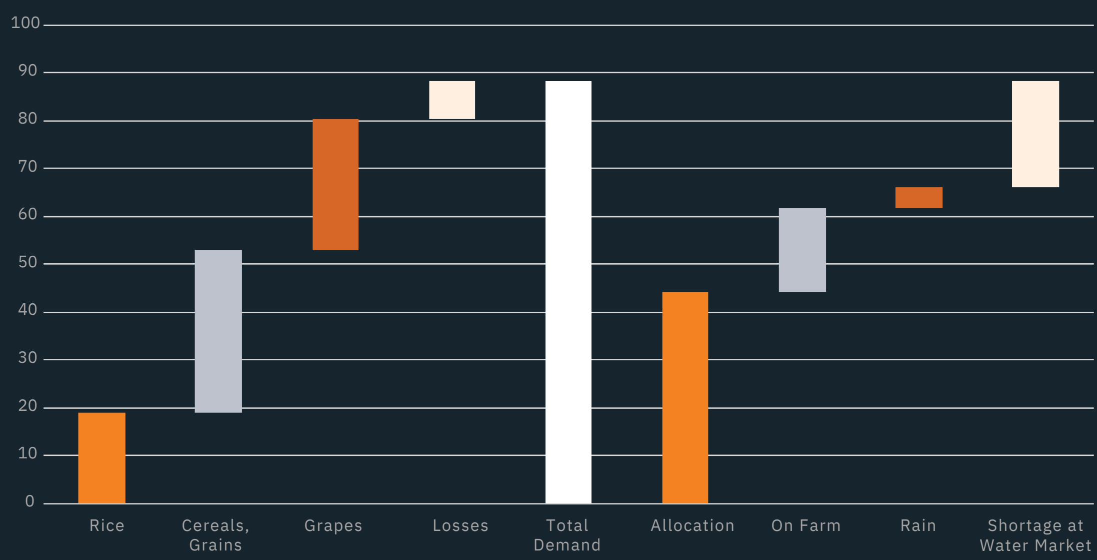


Figure 16: Water fall chart showing the demand (left) and supply (right) for water

In this model the shortfall has to be met through the purchase of water from the open spot market. From these tables two prices are given, one is the current spot price at the 50th percentile and the other is the spot price at the 10th percentile. If we assume that our water supply shortage remains constant at 22 ML, then the farm's exposure to water prices at the 10th percentile can be estimated. The second table estimates the total revenue required from the farm to meet the exposure from water risk based on the revenue generated from different crop types.

The following tables assume that on-farm water capacity and actual water allocation entitlements remain constant and the farmer seeks only to purchase the same quantity at an increased price. However, under conditions of water scarcity the water available to a farm from rain, on-farm capacity and water allocation entitlements may also reduce, requiring the farmer to purchase even more water from the market. As this is also during a period of water scarcity, the market spot price for water will also be much higher. In this situation, a farmer will, therefore, need to access an increased quantity of water from the market at an increased price. The combined effects of both quantity risk and price risk could consequently place the farm under financial stress and at risk of default.

If the farmer cannot afford to purchase the water to grow the crops, then they will have no income to make payments on their loan obligations.

TABLE 1: WATER RISK FOR DEMAND AND SUPPLY

	ML	ML	Price
Allocation	44		
On-Farm	18		
Rain	4		
Total Supply	**66**		
Total Demand		88	
Shortage		22	
Current Price			$297
Possible High Price (10th)			$414
Exposure to Water Risk			**$6,534 - $9,108**

Table 2 below highlights crop choice and the corresponding water requirements for different crops.

Crop Type (Application rate (ML/ha)	**ML/ha**
Fruit trees, nut trees, plantation or berry fruits	9.0
Cotton	8.0
Grapevines	5.4
Other crops n.e.c.	3.6
Average	3.5
Vegetables for human consumption	3.4
Nurseries, cut flowers and cultivated turf	3.1
Pastures (including lucerne) and cereal crops cut for silage	2.1
Other cereals for grain or seed (e.g. wheat, oats, maize)	1.7
Other broadacre crops	1.7
Rice	1.3

Table 2: Annual water requirements for different crop types. Water use on Australian Farms–2015-16.

6.6 ESTIMATING wVaR

Estimating the exposure of the farm to water price risk is provided using a hypothetical example below.

In this example, the ABARES econometric model was used to simulate prices from historical data. The 10th percentile from the forecast distribution was used to estimate equivalent price levels. The interpretation of the 10th percentile is that there is a 1 in 10 chance that prices will increase above this value given the variation in historical prices will continue into the future. The cost of water at the 10th percentile is then multiplied by the quantity of water shortage to estimate the on-farm water value at risk (wVaR).

This estimate returns the exposure of the farm with a 10% probability. When the wVaR exceeds the expected revenue margin for a farm, this signals a red flag and the need for on-farm risk reduction strategies.

A farm with a wVaR that exceeds the revenue margin for a farm will be at risk of defaulting at least once due to water scarcity risk over a ten year period.

We will now illustrate how the wVaR for a farm can be estimated to determine the level of water risk exposure for a farm. In this assessment we assume that when a farm has a water shortage, it can always purchase sufficient water from the spot market to meet its own demand at the going market rate. In this particular example, we assume that even under wet conditions the farm will need to purchase some of its water from the open market (i.e. 40% of water supply comes from water rights entitlements, 30% comes from rain, 20% comes from on-farm storage, and 10% is purchased on the temporary allocation market. These values will vary from farm to farm). We will now estimate wVaR under three separate conditions, namely:

- Wet conditions (90th percentile and no water stress)
- Average conditions (50th percentile normal conditions)
- Dry conditions (10th percentile water stress)

Under the first condition, we assume the farm is operating under wet conditions and will receive its full allocation from its water rights entitlement (see Figure 12). Under this scenario $wVaR_{90}$ will take the following form:

$$\textbf{Eq 1.}\ wVaR_{90} = M^{sh} \times P^{90}$$

Where **wVaR** is the water value at risk, M^{sh} is the quantity of water to be purchased from the market in Mega Litres and P^{90} is the price of water at the 90th percentile. M^{sh} can be calculated from the shortfall in supply to meet demand requirements (e.g. M^{sh} = Water Demand - Water Availability).

Under the second scenario at the 50th percentile, the amount of water the farm receives from allocations will decrease because the farm will not receive all water allocation entitlements. At the 50th percentile, the amount of water allocated to the farm will be 82%, leaving a shortfall of 18% of the farm's total expected allocations.

The decrease in the amount of water allocated will mean the farmer needs to purchase this additional water from the temporary allocation market. The price of water, P^{50}, will also increase because water is now more scarce. The relationship described in Equation (1) is still valid, but the total water shortage experienced by a farm will now take the following form:

$$\textbf{Eq 2.}\ T^{sh}{}_{50} = M^{sh} + (A^{sh} + R^{sh} + D^{sh})_{50}$$

Where T^{sh} is the total quantity of water to be purchased from the spot market and consists of M^{sh} which is the original water shortage to be purchased from the market (this is the same amount of water to be purchased under wet conditions). However, we need to add to this value the following additional shortages: A^{sh} is the allocation shortage, R^{sh} is the expected shortfall in rain and D^{sh} is the expected shortfall from on farm storage (e.g. dams and reservoirs). From this new definition the following relationship emerges for wVaR:

$$\textbf{Eq 3.}\ wVaR_{50} = [M^{sh} + (A^{sh} + R^{sh} + D^{sh})_{50}] \times P^{50}$$

where P^{50} is the price of water at the 50th percentile. The actual allocation Ash can be estimated using Figure 12. The estimated shortfall from rainfall, R^{sh} can be estimated from weather forecasts (e.g. The Yield technology) and D^{sh} is estimated as a function of predicted rainfall and previous years drawdown from on farm water resources and is farm specific.

From the above definition describing the estimation of **wVaR** we are able to determine the exposure of a farm to water risk under different scenarios. If, for example, the **wVaR** for a farm at say, the 10th percentile, exceeded the marginal revenue for that farm in any given year then the farm would also be in financial stress and would find it difficult to pay back a loan.

Estimating the **wVaR** at the 10th percentile takes the same form as Equation 3 but the quantity of water shortage values for A^{sh}, R^{sh} and D^{sh} will be much larger owing to the fact that it represents a one in ten dry year.

This is graphically depicted in Figure 17 below which shows a frequency histogram of the monthly maximum price for water on the allocation markets for NSW over the last 10 years. The mean monthly maximum price is \$193. The monthly maximum price at the 10th percentile is \$400, at the 5th percentile it is \$653 and at the 1st percentile it is \$1,280. Thus to determine the **wVaR** for a farm at the 10th percentile, a price of \$400 / ML needs to be used for the value of P10 in the equations outlined above. The monthly maximum median is \$193 which says that 50% of the time, a farm would expect to pay a maximum price of \$193 per month.

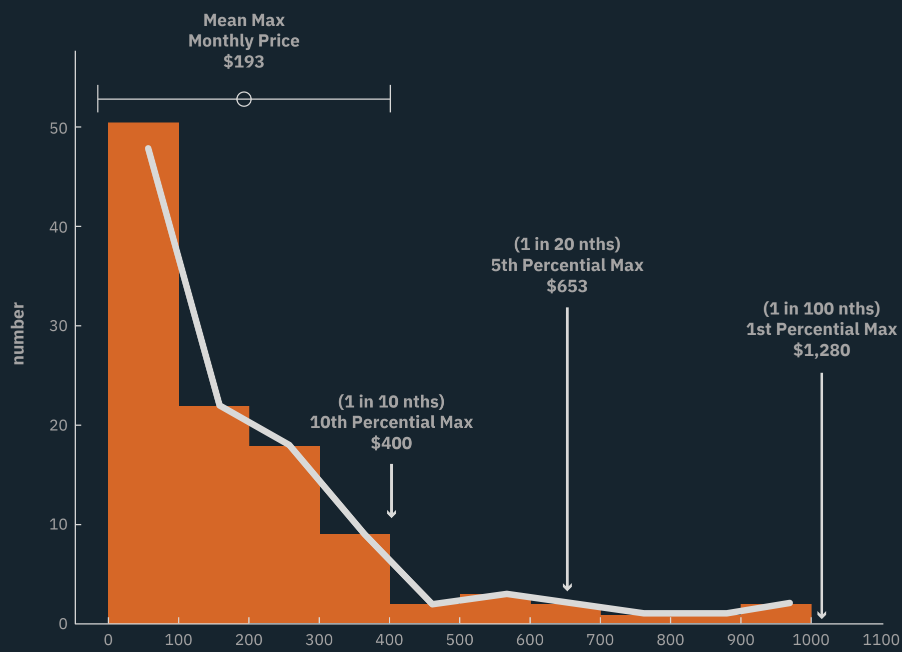


Figure 17: Frequency histogram plot of water prices in NSW for the last 10 years.

In essence, **wVaR** merely represents the total annual cost that a farmer must pay to purchase water from the temporary water market to make up the shortfall in water required to operate the farm given a specific level of probability. Here we assume the annual 10th percentile.

Quantity risk enters through the reduction in the availability of water, thus increasing the amount that needs to be purchased from the allocation market. Price risk enters through the increase in price the farmer must pay for water on the allocation markets.

In order to estimate the **wVaR** at a farm level, only the following data points are required:

- Quantity of annual water entitlement rights available
- Any existing temporary water allocations + rollover allocation
- Total quantity of on farm water storage and levels
- Estimated average annual drawdown (for a typical year) from on-farm storage
- Estimated average annual replenishment rate (for a typical year)
- Estimated annual rainfall (farm data if available)
- Annual estimated water demand requirements for growing crops.

When on farm data is unavailable, average and regional estimates can be used instead.

The next step to developing the **wVaR** methodology would be to estimate water risk on a small sample of farms. Unfortunately, this was outside the scope of the present research and left as further research.

Once tested with real data, this methodology could be developed into an online tool where bankers or farmers or anyone from the public could enter farm characteristics and associated water availability metrics and the tool would estimate, based on the location of the farm and the price of water for the basin where the farm is located, the estimated **wVaR** for the farm for different levels of probability.

This would be valuable information for a farm as it would provide a dollar estimate on the risk that is being taken on by the farmer and provide risk weighted value for the premium that would need to be invested to enable better water management.

For example, if a farm had a **wVaR** of $50,000 and the expected annual marginal return for the farm n that year was only $40,000 then the farm would be at risk of default if no further financial capital was available to cover the expected $10,000 shortfall.

7 CONCLUSIONS

As part of this research, a range of methods have been carried out to better understand on-farm water risk management and the financial decision making processes for agribusiness bankers and farmers.

Ten semi-structured interviews were held with existing agribusiness bankers and farmers.

Water scarcity was shown to be a real risk factor for farmers and can have a significant effect on the profitability of a farm and therefore its ability to service any loan obligations. Our findings from these interviews confirmed that water risk assessments are not presently undertaken as part of a formal loan application process. Importantly, questions about water risk do not even appear on agrubusiness loan application forms.

Both price and quantity risk are shown to be important in the assessment of water risk. To this end, a new method was derived to estimate the water value at risk for a farm (wVaR). In developing this new framework, historical changes in price and quantity are used to determine the on-farm wVaR to future water scarcity.

The model incorporates on-farm resources (e.g. dams, reservoirs, etc.), predicted rain availability, water allocation entitlements and market spot prices. The model then estimates at the 10th percentile (e.g. 1 in 10-year event) the wVaR exposure for a particular farm.

If the wVaR is higher than the annual projected profit (e.g. from selling produce at market prices for a given yield), then the farm will not be able to service its mortgage and will be in financial stress. A key output of this water risk framework is that it identifies opportunities for how to mitigate on-farm water risk and provides advice to improve the overall financial performance of the farm. (e.g. is it better for farmers to grow crops or sell their water allocation rights on the open market).

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APPENDIX A

Academic literature was sourced from the Web of Science Core Collection database.

The literature search was conducted using a keyword search in the article titles using different combinations of the terms ‘farm’, ‘water’, ‘irrigation’, ‘risk’, ‘drought’, ‘financial’, ‘management’, and ‘decision’ (see Table 1)

TABLE 3: SUMMARY OF SEARCH QUERIES AND RESULTING MATCHES.

An EndNote database was established, comprising about 30 articles for further initial review. From this initial review, 13 articles emerged as relevant to this research project and were further scrutinised.

This section summarises critical insights regarding the scope and context of risks; theories and methods used; and the relevance of these studies for the current project and its associated risk modelling activities.

No.	Search query	Results
1	*TITLE: (farm* AND water AND risk*)*	*32*
2	*TITLE: (farm* AND drought AND risk*)*	*20*
3	*TITLE: (farm* AND financ* AND risk*)*	*18*
4	*TITLE: (farm* AND risk* AND managem*)*	*168*
5	*TITLE: (farm* AND financ* AND managem*)*	*40*
6	*TITLE: (farm* AND decision* AND water*)*	*23*
7	*TITLE: (farm* AND irrigation* AND decision*)*	*11*

A.1 SCOPE & CONTEXT OF RISK

Based on the targeted literature review conducted, three broad categories of literature can be distinguished:

1. studies that focus on on-farm water availability, either at the individual farm level or in a river basin context;
2. studies that focus on water availability risks (water security) of drought and flooding which includes research on the perceived impacts of drought, flooding and climate change on water availability; and,
3. studies focussed on financial and business asset risks.

For example, Schenk et al. (2014) studied annual changes in the availability of irrigation water in Australia's Coleambally Irrigation Areas (NSW) and found that farmers reduce their cropped areas when faced with reduced water availability. Schenk et al. (2014) also found that the relative reduction in expected income from an optimal farm operated by a risk-averse farmer compared to a risk-neutral farmer was approximately 9%.

Also working in the Coleambally Irrigation Area in NSW, as well as in South East South Australia, Jackson et al. (2011) modelled the risk/uncertainty and sensitivity of linked water/energy consumption at the farm scale. This study takes a risk-based approach that comprises both surface water and groundwater sources for irrigation.

Key findings of this study identify risks profiles associated with different surface vs groundwater sourcing for irrigated agriculture. The study proposes a conceptual framework for building a climate-resilient farm, covering such risk factors as irrigation and pump efficiency; suction and discharge head; and soil water availability.

Similarly, Fernandez et al. (2016), studied how water availability might affect small-scale farmers under future climate change in Chili. This study explores the link between basin (catchment) scale with the farm scale, with findings that suggest a relationship between farm scale and impacts. Specifically, the results from this study indicate that at the aggregated (basin-scale) level, there will be minor economic impacts of climate change on small-scale agriculture, with small decreases in both expected utility and wealth.

However, when economic impacts are broken down into specific areas, substantial differences in the economic effects of wealthy and poor small-scale farmers are found. Changes in water availability reduce land reallocation options to increase farmer's expected utility, with the poor smaller-scale farmers being the most negatively affected.

A study, undertaken in the UK (Gloucestershire), by Hamilton-Webb et al. (2017), surveyed 200 farmers, asking farmers about their experiences of flooding. Using quantitative results from the

...absence of information and advice likely to be the main barriers to action.

survey, this investigation aimed to establish statistical relationships between climate change-related risk experience and farmers response through on-farm mitigation and adaptation.

Statistical analysis of survey results found the experience of flooding to be significantly associated with a heightened concern for climate change. Although also finding an association between experience and behavioural response, the sample most likely took adaptive behaviour as part of standard practice, with factors such as lack of overall concern for climate change risk and absence of information and advice likely to be the main barriers to action.

van Duinen et al. (2015) also present a study that focussed on water security. These authors studied the adaptive behaviour of farms to impacts of drought, using a quantitative survey among farmers located in the Dutch Province of Zeeland. They found that behavioural factors explain the actual level of farmers' adaptation motivation and that farmers' threat and coping appraisal influences adoption decisions across different drought adaptation measures.

Nartea and Webster (2008), albeit without an explicit focus on water availability, studied on-farm risks from the perspective of risk to financial assets. The focus of this research was on the potential risk reductions that can be achieved through diversification of farm asset portfolios (shares, bonds, bills, land, and so on).

Within the geographical context of their study (New Zealand), they conclude that bonds are the main contributors to portfolios maximising utility for mildly risk-adverse farmers. Uzea et al. (2014), also without an explicit focus on water risk, present an approach for achieving farm risk balancing. They studied how Canadian firms (farming enterprises) balance their financial and business risks through investment and borrowing decisions. The results from this study are mixed. First, Canadian business risk management payments were found to reduce business risk for beef farms but not for field crops farms. Second, risk balancing holds particularly for the larger farms, and third business risk management programs overall were found to have no significant effect on the likelihood of increased debt for either sector (beef or crops), on average.

However, participation in the Canadian Agricultural Income Stabilization Program/AgriStability was found to increases the probability that farms take on more debt than they would take otherwise for both beef and crops farms.

However, participation in the Canadian Agricultural Income Stabilization Program/AgriStability was found to increases the probability that farms take on more debt than they would take otherwise for both beef and crops farms.

A.2

THEORY AND METHODS

There was a range of both theory and methods used in the studies selected for review, from semi-quantitative surveys and subsequent statistical analysis to integrated, multi-scale stochastic models.

Hamilton-Webb et al. (2017) employed survey techniques and statistical analysis to investigate the relationship between risk experience and risk response. A farmer postal survey, undertaken in 2013 and mailed to 1,400 farm addresses used closed questions to determine how farmers respond to risk from their previous experience. The final sample was based on 200 completed surveys (response rate 15.2%). Data analysis (descriptive and multivariate) was then undertaken using statistical analysis software (SPSS) to find differences between flood and non-flood groups.

Zhou et al. (2008) employed farm household interviews (N=240) applying a logit model to analyse factors affecting farmer decisions related to the adoption of water-saving technology. A logit model was used to estimate the probability of farmers' adoption of such technology, using a binary variable U to simulate adoption (either adoption or not). Variables used in the logit model included: age of farm manager; gender of farm manager; farm size; the number of workers in a household; literacy; participation in off-farm employment by the farm manager; previous adoption experience; household membership in extension service; income level of household; and soil type.

Another example where a survey design has been used can be found in van Duinen et al. (2015). This study adopted Protection Motivation Theory (PMT), which incorporates both risk perception and coping evaluation as determinants of protective behaviour. The study employed a survey methodology, using a potential sample of 1,474 members of a Dutch agricultural organisation to elicit farmers' risk perceptions and adaptive behaviour. Two types of statistical analysis were performed: analysis of the level of farmers' drought-risk preparedness; and analysis of differences in the explanatory power of PMT variables regarding the adoption of adaptive responses in three different scale categories. Another example of the application of PMT to farmers' decision-making is in Gebrehiwot and van der Veen (2015).

Stochastic analysis is commonly used in irrigation system planning, resource allocation, water quality planning, flood inundation, reservoir management and technology adoption. Similarly, but with emphasis on farmers' decisions, stochastic analysis is used to study the risks inherent in uncertain water allocations.

These types of studies also cover the economics of risks, uncertainty and learning in the adoption of new technology (see e.g. Marra et al., 2003). Schenk et al. (2014) used a stochastic dominance approach to assess how farmers react to a reduction in water availability. The procedure consisted of undertaking regression analysis, where the area of the various crops (both aggregate season total and individual crops) was regressed against water availability (the independent variable).

Fernandez et al. (2016) employed a hydro-economic modelling framework, linking a farm risk-based economic optimisation model to a hydrological simulation model called SWAT. The latter model is a conceptual physically based, semi-spatially distributed model of hydrology and water quality designed to route water, sediments and contaminants from individual catchments through a larger-scale river basin.

The risk-based economic model integrates risk into a positive mathematical programming (PMP) model, formulated as a non-linear mean-variance specification. The specification assumes a logarithmic function to simulate a decreasing absolute risk aversion coefficient as a concave function of wealth.

The most influential factors affecting farmers' decisions are crop prices, production costs, and yields.

Farmer behaviour is characterised by farm types based on crop pattern; farm size; irrigated areas; and geographical location. The risk-based economic model estimates optimal crop area distribution by satisfying all constraints while optimising the expected utility of stochastic income.

Another example of a study linking basin-level water management and farm-level decision-making is Ng et al. (2011). This study employs agent-based modelling and sensitivity analysis to find the most influential factors affecting farmers' decisions. The agent-based model is linked to a hydro-agronomic model at catchment level. The results from this research show that the most influential factors affecting farmers' decisions are crop prices, production costs, and yields.

Different farmer behavioural profiles were found to lead to different predictions of farmer decisions. The farmers who are predicted to be more likely to adopt new practices are those who interact more with other farmers, are less risk-averse, quick to adjust their expectations, and slow to reduce their forecast confidence.

Farmers' decisions were found to have direct water quality consequences, especially those relating to the adoption of the second-generation biofuel crop, which is estimated to lead to reductions in stream nitrate load. In this study, these results remained empirically untested.

Jackson et al. (2011) used stochastic analysis to model risks, uncertainty and sensitivity associated with linked water-energy consumption at the farm scale. This study made use of available accounting methods for water, energy and greenhouse emissions in Australia. These were applied to farms in selected irrigation areas to determine current water and energy use and current greenhouse gas emission levels. Furthermore, water and energy use and greenhouse gas emissions with alternative irrigation systems were estimated. These results were then modelled stochastically, employing @Risk software to quantify the uncertainty and sensitivity of outputs.

Results from this analysis showed that conversions from gravity to pressurised irrigation methods reduced water application while increasing energy consumption in surface irrigation areas. In groundwater irrigated areas the opposite was found; pressurised irrigation can reduce water application and energy consumption by enhancing water use efficiency. Flood irrigation systems were generally perceived with more doubt than pressurised systems.

Modelling suggests that where surface water is used, well-designed and managed flood irrigation systems minimise the operating energy and carbon equivalent emissions. Where groundwater is the dominant use, the optimum system would be a well-designed and managed pressurised system operating at the lowest discharge pressure possible that will still allow for efficient irrigation.

Another example of stochastic analysis is in Nartea and Webster (2008). These authors used stochastic efficiency analysis to investigate alternative portfolios of farmers' assets (shares, bonds, bills and farmland). The approach consisted of modelling the distribution of returns of different asset classes based on historical data, premised on the idea that historical information possibly captures benefits foregone in the past and therefore points to new strategies for portfolio optimisation.

Flood irrigation systems were generally perceived with more doubt than pressurised systems.

In a similar vein, Uzea et al. (2014) offer a potentially useful conceptual framework in their study of farm support payments and risk balancing. The premise of this study is that the sources of total risk facing a business equate to the sum of operational risk and financial risk. Business risk is defined in this study as the inherent variability in the operating performance of the firm, independent of financing. Financial risk is defined here as the added variability of net returns to the owners of equity that results from the use of debt.

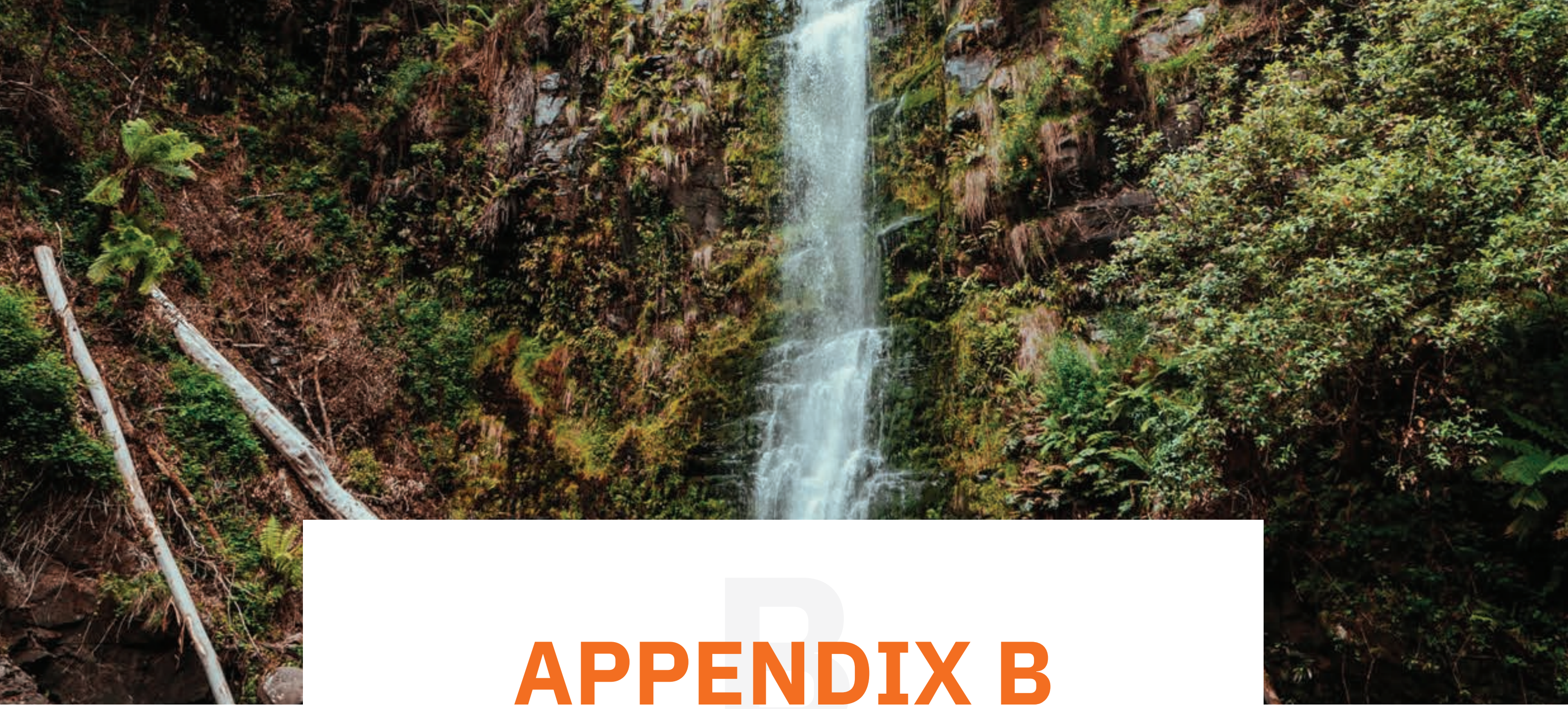
Risk balancing emerges from the hypothesis that any exogenous shocks that affect a firm's business risk could induce the firm to make offsetting adjustments in its financial leverage position: a decrease in leverage could offset any increase in business. Conversely, upward adjustments in optimal leverage levels could be warranted whenever the level of business risk decreases.

SUMMARY OF SELECTED ARTICLES

Reference	Keywords	Scope of Risk	Context	Theory & Method	Key Findings	Relevance	Comments
De Wit & Crookes 2013. Sth Afric J Sci.	*system dynamics; agriculture; groundwater; economics; Sandveld*	*Ag production using groundwater resources*	*South Africa, Sandveld region, Western Cape*	*Systems dynamics model, capturing land-use change, agricultural production, and groundwater abstraction and recharge*	*highest risks are associated with the financial viability of agriculture, in its present form, in the region*	*	*No explicit focus on risk.*
Fernandez et al, 2016. Water Res Mgt	*Hydro-economic model . Small-scale farmers . Risk .Water variability . Climate change*	*Water availability under future climate change*	*Chili – Southern Agreste Pernambucano small-scale farmers with narrow profit margins*	*hydro-economic modelling framework, linking a farm risk-based economic optimisation model to a hydrologic simulation model*	*At aggregated level minor economic impacts on small-scale agriculture; large differences in economic impacts between wealthy and poor small-scale farmers*	****	*Links basin scale with farm scale.*
Gebrehiwot & Van der Veen 2015. Env Mgt	*Drought ; Risk perception ; Protection motivation theory ; Transtheoretical model ; Adaptation*	*Drought risk*	*developing countries cultural context ; northern Ethiopia*	*Protection Motivation Theory; trans-theoretical stage model; farmer survey*	*statistically significant association between farmer's behavioral intention to undertake farm-level risk-reduction measures & key protection motivation model variables*	*	
Hamilton-Webb et al. 2017. J. Risk Research	*experience; response; risk; climate change; flooding; farmer*	*experience of flooding; relationship between CC risk experience & response through on-farm mitigation & adaptation*	*UK - Gloucestershire*	*quant survey with 200 farmers; statistical analysis*	*experience of flooding to be significantly associated with a heightened concern for climate change*	***	*use of quant survey could inform our survey*
Jackson et al. 2011 Ag Systems	*Climate change Uncertainty Sensitivity Irrigation method Simulation Carbon*	*risk based approach; water, energy and emissions; irrigated agriculture*	*Australia – Colleambally Irrigation Area (NSW) and South East of SA*	*Modelling the risk/uncertainty and sensitivity of linked water/energy consumption at farm scale; Sensitivity analysis*	*Key findings relate to surface vs groundwater sourcing for irrigated ag.*	*****	*See Fig 1. Conceptual Framework for building a climate resilient farm; Risk factors include irrigation eff; pump eff; suction head; discharge head; soil water availability- C*
Nartea & Webster 2008. Au J Ag & Res Econ	*financial assets, NZ farmland, risk management, stochastic efficiency analysis.*	*Potential risk reduction through diversification of farm asset portfolio*	*New Zealand*	*Stochastic efficiency analysis; analysis of alt portfolios of shares, bonds, bills & farmland*	*Bonds are the main contributors to portfolios maximising utility for individuals classified as 'somewhat' risk averse*	**	
Ng et al. 2011. Water Resour Res	*N/A*	*Farmer decision-making and water quality impacts; interactions among farmers re new technologies & market opportunities*	*USA - Salt Creek Watershed in Central Illinois (semi-hypothetical)*	*Agent-based model of farmers' crop & BMP decisions; linked to hydrologic-agronomic watershed model; Bayesian inference; sensitivity analysis*	*Most influential factors affecting farmers' decisions are crop prices, production costs, and yields*	****	*Another paper linking farm-level decisions w/watershed level. Link to risk, water availability??*

SUMMARY OF SELECTED ARTICLES *(continued)*

Reference	Keywords	Scope of Risk	Context	Theory & Method	Key Findings	Relevance	Comments
Prokopy et al. 2015.Env Mgt	*Climate change Farmers Beliefs Risk perceptions Surveys Agriculture*	*Climate change*	*Trans-national - Scotland, Midwestern United States, California, Australia, and two locations in New Zealand*	*Survey*	*In all locations, a majority of farmers believe that climate change is not a threat to local agriculture.*	*	
Schenk et al. 2014. Agr Water Mgt	*Irrigation Reliability Farm income Stochastic dominance Utility Risk aversion*	*Annual changes in the availability of irrigation water*	*Australia – Coleambally Irrigation Areas*	*Stochastic dominance approach; stochastic efficiency*	*Farmers reduce area cropped when faced with reduced water availability*	****	
Tavares et al. 2011. IN PORTUGESE	*linear programming, Monte Carlo method, net present value*	*Analysis of cropping patterns on a farm, aiming to optimize the use of water resources and maximization of financial return*		*Linear programming (using MSExcel) ; risk simulation (using @Risk software) and sensitivity analysis*	*Max total NPV were positive and closed for the two cropping patterns, demonstrating absence of financial failure*	**	*Only abstract is in English*
Uzea at al. 2014. Can J Ag Econ.	*N/A*	*Risk balancing; business risk & financial risk balancing by firms through their investment & borrowing decisions*	*Canada*	*Deriving of risk balancing hypothesis; two quant approaches/models*		***	*Looks potentially useful; study needs further scrutiny*
Van Duinen et al. 2015. Reg Env Change	*Drought Adaptation Agriculture Protection motivation theory The Netherlands*	*farmers' adaptive behaviour to drought*	*Netherlands – Province of Zeeland*	*Protection motivation theory, incorporating both risk perception and coping evaluation as determinants of protective behaviour; Farmer survey (potential sample of 1,474 members of LTO*	*behavioural factors explain actual level of farmers' adaptation motivation; components of threat and coping appraisal influence adoption decisions differently across drought adaptation measures*	***	*Focus on risk perception and adaptation*
Zhou et al.	*N/A*	*Farmer household adoption of water-saving technology (GCRPS)*	*China*	*Farm household interviews (N=240); logit model; determinants of adoption; simulation of impacts of change*		*	



APPENDIX B

INTERVIEW SUMMARY SHEET – FINANCIAL SECTOR

INTERVIEW SUMMARY SHEET:

ENVIRONMENTAL & FINANCIAL RISK IN THE AUSTRALIAN AGRIBUSINESS SECTOR

What is the project all about?

The Institute for Sustainable Futures (ISF) has been commissioned to undertake research that will improve the decision-making processes of financial professionals and farmers in Australia. The study aims to explore how on the ground financial decisions are made, and how that information might be improved for the assessment of water risk and irrigation. Outputs from this research will be combined with innovative sensor technology developed by The Yield to provide bank professionals and farmers with reliable sources of information to improve decision making and reduce risk.

What does the research mean for participants?

Your participation will involve one interview of up to 40 minutes. The interviews are being kept brief and will use teleconference or Internet-based technology (phone or Skype) where possible to minimise the time and costs. Participants are free to withdraw from the research project at any time without giving a reason.

How will responses be used?

Information provided during the interview may be used within publicly available reports and academic papers. All input received from interviews will remain de-identified and confidential (ISF will only use summary or anonymised data in published documents).

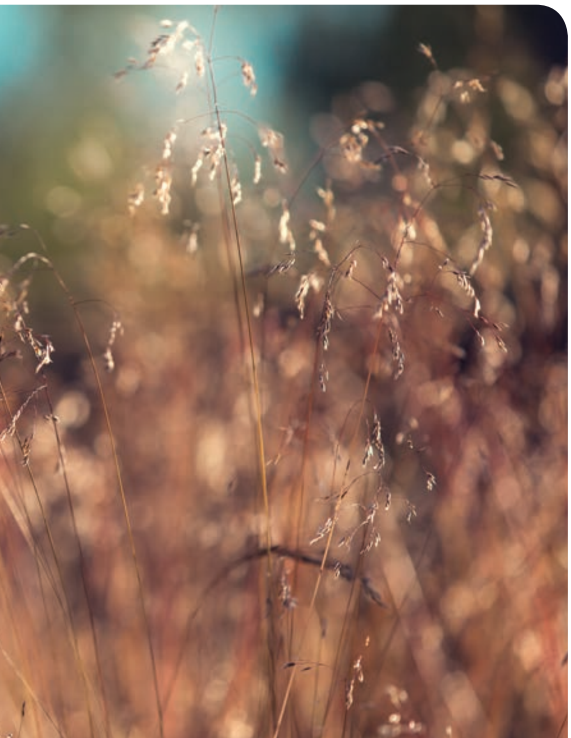
Where interviewees might be identifiable from demographic perspectives, institutional perspective or experiences on particular projects – this will be minimised by aggregating data and keeping the information general in nature. All care will be taken to avoid misattributing quotes unless specifically requested. If using a particular quote which can be attributed by virtue of the connection to an easily identified source, we would only use it with the interviewees' explicit permission.

NAB and the Yield will provide written, and verbal comments to ISF on the draft reports. The final reports and academic papers will be made available to the general public at the conclusion of the project and via potential media releases.

Who can I contact if I have questions or concerns?

If you have any concerns, questions or comments about the research you can contact Dr Scott Kelly at the Institute for Sustainable Futures on +61 2 9514 4881 or Scott.Kelly@uts.edu.au. You may also raise concerns, questions or comments with your interviewer. Studies undertaken by the Institute for Sustainable Futures have been approved in principle by the University of Technology Sydney, Human Research Ethics Committee.

If you have any complaints or reservations about any aspect of your participation in this research you may contact the ISF Ethics Coordinator, Dr Keren Winterford (02 9514 4972) or the ISF Deputy Director, Professor Cynthia Mitchell (02 9514 4953). You may also contact the UTS Ethics Committee through the Research Ethics Officer (02 9514 9615). Any complaint you make will be treated in confidence and investigated fully and you will be informed of the outcome.



Background

According to Gustafson (1989) agricultural lenders use the five Cs of credit when evaluating a loan application (e.g. capacity, capital, collateral, character, and conditions). Previous research has shown that lenders judge these attributes using information obtained from previous experience with the borrower in conjunction with financial statements, references, and other documentation. The decision making framework for offering a loan can be split into two parts. (i) the process which is followed by a bank for assessing and approving loan applications, and (ii) the information that is provided or used by agribusiness bankers to support the assessment and approval for the loan. Both the process and the information that is considered may vary from banker to banker. Understand the process of approving a loan may prove valuable to know at what at what points interventions or additional information could be provided to add most value to farmers and/or bankers and what type of information could be provided to improve decision making processes and improve risk management.

QUESTIONS FOR FRONTLINE AGRIBUSINESS BANKERS

Below is a draft set of questions that will be asked to frontline bankers. The comments in red explain the underlying purpose of the question and the type of information said questions are trying to elicit and why the questions are potentially relevant for this study.

1. Can you describe the process you follow in assessing a loan?

    a. *Does the process you follow change under different circumstances (e.g. changing environmental conditions, size of the loan, what the loan is being used for etc.,)*

The purpose of this question is to understand the process that bankers use to assess and award loans. Understanding the loan application process, and how the process may vary from banker to banker will enable us to determine at what points in the process it is best to intervene with additional information, who should be provided that data, e.g. farmers and/or to the bankers. If the process is fairly standard across all bankers and regions, then this question might become redundant and can be reconsidered. The follow-up question aims to understand how the process may change depending on other relevant factors such as changing environmental conditions (e.g. drought).

2. What factors do you consider most important when assessing a loan application (e.g. the four Cs and how much emphasis is placed on each characteristic)?

    a. *Do you rank any of the 4Cs - Character - Capacity - Collateral – Capital higher than the other?*

    b. *Does the information you use to assess a loan change under different circumstances? (e.g. in a drought do you require additional information about how a farm is managing water risk?).*

The purpose of this question is to consider what factors are actively used to assess a loan application and in particular, we want to understand if these factors vary significantly between bankers, loan purpose, region, crop type, farm size etc.? Is water an essential risk driver?

3. What are the characteristics of poor customers i.e. behaviours, assets, operational practices?

This question may provide additional insight into warning signs, problem areas that are potential red flags to bankers in providing a loan.

4. What information do you need to assess a loan?

    a. *Which of these are provided by the customer and / or your own data to make an assessment?*

    b. *Does any of the information collected link directly to water consumption?*

The purpose of this question is to understand what information is required to make an assessment and relative importance of the data collected from a customer compared to information collected from the banker to verify or cross-check the customer's application or to provide additional supporting information.

QUESTION 5 CONTINGENT ON RESPONSES TO ABOVE – THE ABILITY TO ACCESS DATA FROM FARMERS:

If they have mentioned on-farm tech:

5. What additional information would you like to improve your internal decision-making process to improve efficiency or mitigate the risk of a loan application?

    a. *Are you aware of farmers using micro-climate sensors or weather stations to inform decision making processes?*

If they haven't mentioned on-farm tech:

6. "are you aware of farmers using on-farm technology like environmental sensors and weather stations to help them better manage their crops"

This question aims to extract information that is presently missing, or hard to get that would assist frontline bankers in making decisions. The follow-up question relates specifically to new technology that enables the collection of further information. Water risk may be water shortage or lack of water availability.

7. How do you currently assess the importance of water risk (energy?) requirements of a farm business in your credit assessments? If so, how do you presently assess water risk?

This question aims to elicit the relative importance of water risk in making credit assessments and what information they collect to assess water risk.

8. If water risk is viewed as an important risk factor, what strategies are employed or recommended to mitigate water risk in Lending Submissions?

    a. *Are some customers superior water managers to others?*

    b. *Do they receive better lending terms? If so how?*

This question aims to understand what strategies are presently being employed by farmers to mitigate water risk and what approaches are favoured by agribusiness bankers.

9. Do you presently check a customer's water usage and their requirements against their water availability or water allocation rights?

    a. *Do you consider or forecast the market price of water in this assessment?*

This question aims to understand the extent to which customers' demand for water may exceed their supply and the extent to which this is considered. The second part of this question relates to water allocation rights and the price of water should the farmer need to purchase water from the market.

10. Do you presently provide finance for projects that may mitigate water risk?

    a. *If so how do you fund and price these loans?*

This question aims to understand if finance is presently provided to mitigate water risk and how these loans are funded and priced. Other bank data sources may be able to provide information on the proportion of loans that are presently used on projects that mitigate water risk.

11. Do you consider that projects that mitigate water risk also reduce the overall riskiness for the farm?

    a. *If so, is the lower risk score reflected in the customer's credit risk score (eCRS)?*

This question considers the mitigation of water risk as a potential driver for de-risking a farm, and whether this lower risk is priced-in to other loan products.

12. Do you have any customers you could pass on our information to ask to interview?

BIBLIOGRAPHY

Gustafson, C.R., 1989. Credit Evaluation: Monitoring the Financial Health of Agriculture. Am. J. Agric. Econ. 71, 1145–1151. doi:10.2307/1243097

APPENDIX C

INTERVIEW SUMMARY SHEET: FARMERS

INTERVIEW SUMMARY SHEET:

ENVIRONMENTAL & FINANCIAL RISK IN THE AUSTRALIAN AGRIBUSINESS SECTOR

What is the project all about?

The Institute for Sustainable Futures (ISF) has been commissioned to undertake research that will improve the decision-making processes of financial professionals and farmers in Australia. The study aims to explore how on the ground financial decisions are made, and how that information might be improved for the assessment of water risk and irrigation. Outputs from this research will be combined with innovative sensor technology developed by The Yield to provide bank professionals and farmers with reliable sources of information to improve decision making and reduce risk.

What does the research mean for participants?

Your participation will involve one interview of up to 40 minutes. The interviews are being kept brief and will use teleconference or Internet-based technology (phone or Skype) where possible to minimise the time and costs. Participants are free to withdraw from the research project at any time without giving a reason.

How will responses be used?

Information provided during the interview may be used within publicly available reports and academic papers. All input received from interviews will remain de-identified and confidential (ISF will only use summary or anonymised data in published documents).

Where interviewees might be identifiable from demographic perspectives, institutional perspective or experiences on particular projects – this will be minimised by aggregating data and keeping information general. All care will be taken to avoid misattributing quotes unless specifically requested. If using a particular quote which can be attributed by virtue of the connection to an easily identified source, we would only use it with the interviewees' explicit permission.

NAB and the Yield will provide written, and verbal comments to ISF on the draft reports. The final reports and academic papers will be made available to the general public at the conclusion of the project and via potential media releases.

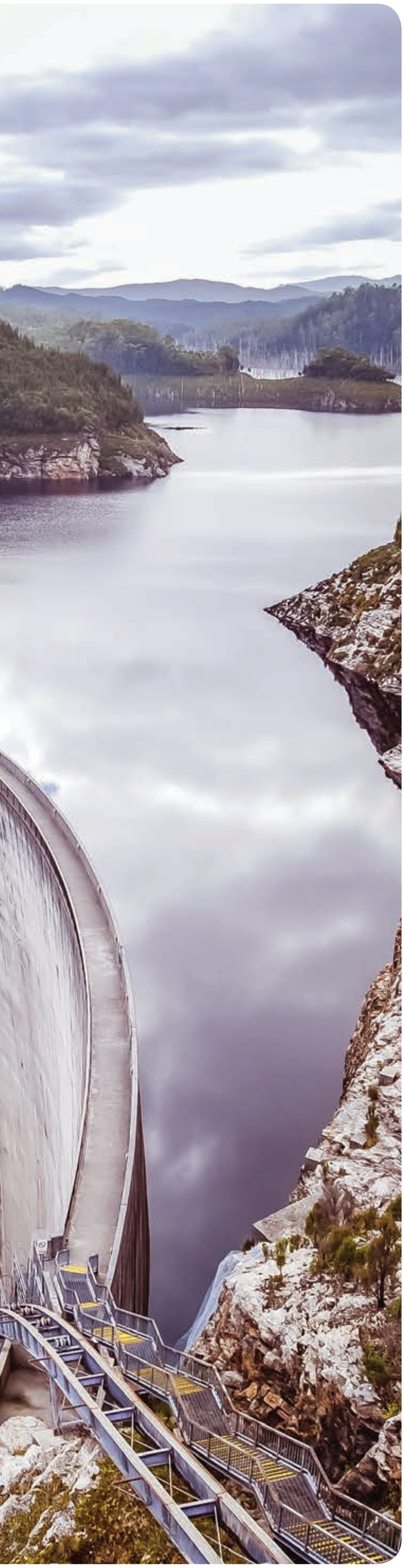
Who can I contact if I have questions or concerns?

If you have any concerns, questions or comments about the research you can contact Dr Scott Kelly at the Institute for Sustainable Futures on +61 2 9514 4881 or Scott.Kelly@uts.edu.au. You may also raise concerns, questions or comments with your interviewer.

Studies undertaken by the Institute for Sustainable Futures have been approved in principle by the University of Technology Sydney, Human Research Ethics Committee.

If you have any complaints or reservations about any aspect of your participation in this research you may contact the ISF Ethics Coordinator, Dr Keren Winterford (02 9514 4972) or the ISF Deputy Director, Professor Cynthia Mitchell (02 9514 4953).

You may also contact the UTS Ethics Committee through the Research Ethics Officer (02 9514 9615). Any complaint you make will be treated in confidence and investigated fully and you will be informed of the outcome.



QUESTIONS FOR FARMERS

Below is a draft set of questions that will be asked to farmers. The comments in red explain the underlying purpose of the question and the type of information the questions are trying to elicit and why the question is potentially relevant for this study.

1. Can you describe the process you follow when assessing when and what to plant in any particular season?

   a. *What factors or circumstances might affect the process that you follow?*

   a. *How does the process you follow change under different circumstances (e.g. changing environmental conditions, availability of finance etc.,)*

The purpose of this question is to understand the process that farmers undertake when assessing what to plant in any given season. Understanding the on-farm decision-making process and how the process may vary from grower to grower will enable us to determine at what points in the process it is best to intervene with additional information, who should be provided that data, e.g. farmers and/or to the bankers. The follow-up question aims to understand how the process may change depending on other relevant factors such as changing environmental conditions (e.g. drought).

1. What factors do you consider most important when deciding to seek additional finance for on farm activities?

   a. *Does the information you use to prepare your loan application change under different circumstances? (e.g. in a drought do you provide additional information and evidence about how your farm is managing water risk?).*

   b. *Does the Bank require different/additional information under different circumstances (e.g., have you been asked for additional information during drought about how they are managing water risk?)*

The purpose of this question is to consider what factors are actively used to assess on-farm finance decisions. In particular, we want to understand if these factors vary significantly between farmers, the purpose of the loan, and so on. Is water a critical risk driver?

2. How would you define water risk for your farm (e.g water shortage, water price, etc)

3. What information do you need to make good on farm decisions relating to water risk?

   a. *How do you collect and store this information?*

   b. *What information do you provide to the bank? Do you provide your own data and/or publicly* *available data in making your application?*

c. *Does any of the information collected link directly to water consumption or projected water consumption?*

The purpose of this question is to understand what information is required in making an application from the farmers perspective, and the relative importance of the data collected Question 5 contingent on responses to the above – the ability to access data from farmers (n.b if they have mentioned on-farm tech)

4. What weather forecasts do you currently use? What information do you find relevant (e.g., weather forecasts, long range, short range, seasonal etc)?

    a. *Do you currently use micro-climate sensors or weather stations to inform decision making processes?*

    b. *If yes – what format / analysis do you use? Eg., soil moister, wind direction etc.*

If they haven't mentioned on-farm tech:

c. *"are you aware of farmers using on-farm technology like environmental sensors and weather stations to help them better manage their crops"*

d. *Are there reasons why you aren't using on farm tech? (e.g., technical barrier, cost etc)*

5. What additional information would you like to have to improve your internal decision-making processes for either improving farm efficiency or for improving the likelihood of making a successful loan application?

This question aims to extract information that is presently missing, or hard to get that would assist farmers in making decisions. The follow-up question relates specifically to new technology that enables the collection of further information. Water risk may be water shortage or lack of water availability.

6. Do you currently take into account water risk (or energy risk?) in the /cash flow/forecasts for your farm business? If so, how and when do you presently assess water risk?

This question aims to elicit the relative importance of water risk in making credit assessments and what information they collect to assess water risk.

7. If water risk is viewed as an important risk factor, what strategies do you presently employ to mitigate water risk?

a. *What factors do you think makes someone a superior water manager?*

- *Are there important timing decisions? Crop choices? Water assets (ownership of entitlements versus acquisition of temporary water etc)*

b. *Does this lead to better outcomes (e.g. successful loan applications, better lending terms and lower interest rates, if so how?*

This question aims to understand what strategies are presently being employed by farmers to mitigate water risk and what approaches they perceive to be favoured by agribusiness bankers.

8. Do you presently check your water usage and requirements against water availability or water allocation rights?

a. *Do you consider or forecast the market price of water in this assessment?*

This question aims to understand the extent to which customers' demand for water may exceed their supply and the extent to which this is considered. The second part of this question relates to water allocation rights and the price of water should the farmer need to purchase water from the market.

9. Have you previously prepared an application for a loan to pay for a project that may mitigate water risk? If not, do you think you will prepare an application for a loan to mitigate water risk in the future?

a. *Have you nad issues obtaining finance for water risk mitigation?*

b. *How do you presently fund water risk management strategies? e.g., self-fund, loans, Government schemes?*

This question aims to understand if finance is presently sought to mitigate water risk.

10. Do you believe that projects that mitigate water risk also reduce the overall riskiness for the farm?

This question considers the mitigation of water risk as a potential driver for de-risking a farm.

WATER SCARCITY RISK FOR AUSTRALIAN FARMS & THE IMPLICATIONS FOR THE FINANCIAL SECTOR

UTS Institute for Sustainable Futures

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University of Technology Sydney