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Assessing the tactical and strategic flexibility of farms

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Introduction

Climate change has the potential to increase the variability of water supply to farms. The impact of this on farmers will depend on their capacity to absorb greater variability, or adapt to it, with no material impact on farm financial performance.

The capacity of farmers to absorb an increase in the variability of water supply will depend in the first instance on the adequacy of the tactical responses available to them. Where this capacity is too low to match the increase in variability they will need to adapt to the increase. Farmers' capacity to adapt to an increase in the variability of water supply will depend on their ability to change strategy to suppress the effects of the increased variability.

The lower the capacity of farmers to absorb, or adapt to, an increase in the variability of water supplies, the greater the extent to which any increase in variability will translate into greater financial volatility. Greater financial volatility may, in turn, create pressure for government to intervene to assist farmers.

In this report we classify farms into types according to their capacity to absorb, or adapt to, greater variability in critical inputs like water supply. We then analyse the relative exposure of each type to increases in the variability of water supply. Finally, we identify logically-useful interventions that government might contemplate, consistent with maintaining the efficiency of Victorian agriculture.

Flexibility in farm systems

In this section we offer a framework for conceptualising the relationship between tactics and strategy that allows us to characterise different kinds of flexibility in farm systems.

There are two fundamental ways that farms can manage variability in critical inputs like water. One way is to substitute other inputs for the critical input. The other is to change the output mix in order to reduce reliance on the critical input. The capacity to substitute inputs in, or change the output mix of, farm systems is constrained in three ways.

First, the long production cycles characteristic of agriculture limit the opportunities available for farmers to make investment and management decisions. Consequently, opportunities to switch between inputs or change outputs are necessarily limited in themselves. This also implies that the timeliness of relevant information may be important. Second, asset fixity can cause considerable costs to arise when switching between investment paths (Leeuwis 2004). Third, technical constraints imposed by technology and the characteristics of location will constrain opportunities for substituting inputs, or changing output mix.

Farmers manage variability in critical inputs by using tactics to absorb the variability (Kaine and Cowan 2009). [1] Tactics are pre-programmed actions available to the farmer that do not involve having to make changes to the structure of the farm system (that is, the set of technologies and practices that constitute the farm system). Tactical flexibility refers to the portfolio of pre-programmed actions available for the farmer to activate as needed in response to a change in a critical input.

The tactical flexibility of a farm system depends on:

- the capacity of a tactic to match the variability in an input, and
- the number of tactics available.

The larger the portfolio of tactics available for an input, and the greater the capacity of a tactic to match the variability in an input, the greater is the tactical flexibility of the farm system. In a practical sense, farmers use tactics to substitute for variable inputs: the greater the capacity of the farm system to substitute inputs, the greater the farm's tactical flexibility and the greater its capacity to absorb variations in a critical input.

[1] For more information about the role of tactics, termed as system regulators, in the farm system to manage variability in environmental inputs (see Kaine and Cowan 2009).

Logically, a farmer may increase their tactical flexibility by expanding their portfolio of tactics to match the variability in an input. This would require some change in the technologies or practices used in the farm system. Consequently, expanding the portfolio of tactics would entail changing the structure of the farm system.

Strategy can be defined as a description of the objectives for the farm system and how these objectives will be pursued, given the operating environment. Hence, strategy involves choices about the mix of outputs to be produced from a farm system. In this context, the capacity of a farmer to vary the composition of their output mix in response to variations in the supply of a critical input is a measure of their strategic flexibility. The greater the capacity to alter the mix of outputs of the farm system, without changing the objectives for the system, the greater the strategic flexibility of the system. Practically speaking, when farmers cannot use tactics to sufficiently substitute for variable inputs then they must change the mix of outputs they produce to reduce their reliance on those inputs.

Tactics are subordinate to strategy. Hence, the portfolio of tactics available to a farmer is predetermined by their farm strategy. A change in strategy may involve a change in the mix of outputs or a change in the farm system that determines how output will, and can, be produced. For example, investments to expand tactical flexibility are strategic in nature.

When a farmer uses their portfolio of tactics to respond to a change in a critical input they are absorbing the change. When a farmer modifies their portfolio of tactics to better absorb a change in a critical input they are adapting their farm system because they are changing its structure. When a farmer exercises their strategic flexibility to change their output mix, or changes their strategy in order to increase their strategic or tactical flexibility, they are adapting their farm system because this necessarily involves changing the structure of the farm system.

The tactical and strategic flexibility that can actually be exercised depends on the timeliness of information (signals) from the environment. Information that is necessary to make a choice between alternative responses, and which arrives too late for an alternative to be implemented, effectively removes that alternative from consideration (Ashby 1956). Thus, untimely information reduces farm system flexibility.

A classification of farm flexibility

In this section we classify farms into types that characterise the different mix of tactical and strategic flexibility that might occur within farm systems (see figure 1). While we present four different ideal types of flexibility mixes, they should be considered as resting on two continuums.

Rigid farm systems

Farm systems that have low tactical flexibility and low strategic flexibility can be described as *rigid* systems. Rigid systems maintain system viability by using tactics to absorb variability in inputs (Feibleman and Friend 1969). Even so, the portfolio of tactics available to rigid systems tends to be relatively small. Put another way, farms that are rigid systems have a limited capacity to substitute inputs. If the portfolio of tactics is not sufficient then the farmer needs to make an adaptation to the system to expand the portfolio of tactics, to increase tactical flexibility. However, the low strategic flexibility of rigid systems implies a limited capacity to increase tactical flexibility. This is linked to the limited options to change output mixes. The financial consequences of input variability are expected to be greatest for rigid systems.

Examples of rigid systems could include specialist wheat or wool enterprises, specialist fruit or grape enterprises, and pasture-based dairy systems.

Robust farm systems

Farm systems that have high tactical flexibility and low strategic flexibility can be described as *robust*. A robust farm system attempts to maintain the current strategy by using a relatively broad portfolio of tactics to absorb variability.[2] This type of farm system has a greater capacity to substitute for variable inputs than does the rigid type. Hence, robust systems have more tactical flexibility than rigid systems. As with rigid systems, the types of adaptations available to robust systems are limited by low strategic flexibility. However, the greater tactical flexibility implies that the financial consequences of input variability are expected to be smaller for robust systems than they are for rigid systems.

An example of robust systems could be cut-and-carry dairy systems.

Elastic farm systems

Farm systems that have high strategic flexibility but low tactical flexibility can be described as *elastic* (Feibleman and Friend 1969). Elastic systems have some capacity to switch strategy and change output mix to manage variability, while maintaining system purpose. Farmers with this type of system will tend to change the mix of outputs so that they are less impacted by inputs whose variability has increased. The ability of the elastic type to switch between strategies requires that these systems have infrastructure that is less enterprise-specific overall, as infrastructure that is enterprise-specific impedes the ability to easily move between strategies. This feature of a farm's infrastructure is a function of both the demands of the specific outputs produced and the farmer's willingness to trade efficiency for flexibility.

Relatedly, even the most elastic systems have a low level of tactical flexibility, as tactical flexibility relies on investment in enterprise-specific infrastructure to obtain an increased portfolio of tactics. Such investment will be constrained, of course, by the variety of outputs produced on the farm.

Examples of elastic systems could include mixed livestock and cropping enterprises, and mixed vegetable enterprises.

[2] Feibleman and Friend (1969) termed this type of system 'tenacious'.

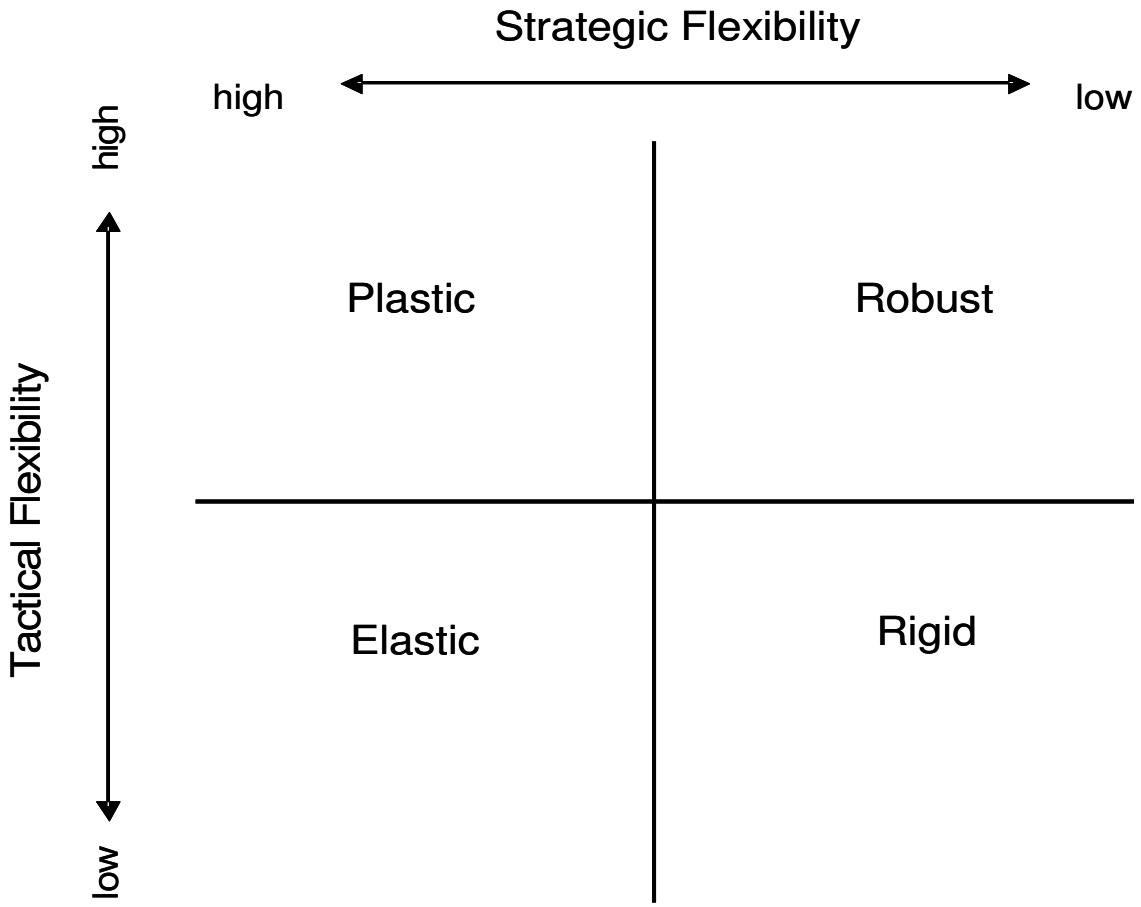

Figure 1 Characterising the flexibility mix in farm systems

Plastic farm systems

Farm systems that have high strategic flexibility and high tactical flexibility would be described as *plastic.* A plastic farm system has a broad portfolio of tactics to enable the system to substitute variable inputs. Additionally, plastic farm systems are able to change strategy and vary output mix while still maintaining the purpose of the system. Given the practical constraints on farming that we discussed earlier such as asset fixity, long production cycles and technical constraints, plastic systems are not currently likely in farming.

Illustrative examples

In this section we provide examples of rigid, robust and elastic farm systems. The examples are based on interviews with the managers of seven different farms covering horticulture, viticulture, mixed cropping and livestock, and dairying in the Shepparton Irrigation Region (see figure 2). In the interviews managers were questioned about the general characteristics of their farms, their management responses to dry seasonal conditions and low water allocations over the past few years, potential responses in the future, and the timeliness of information about allocations.

Rigid systems

Wine grapes

Sam and Sarah grow grapes on a 16 hectare property in the Goulburn Valley. The enterprise is a part of a family business that includes wine making and running a vineyard cafe. They produce premium wines for their own label using the grapes they grow as well as producing commercial clean skin wine for clients in Melbourne, using grapes from other sources. They are also process grapes on contract for other wineries.

Sam and Sarah bought the vineyard, with 10 hectares acres of vines on drip irrigation, in 2004. Since they process the grapes they grow for their premium wine label the emphasis in the management of the vineyard is on the quality not quantity of grapes.

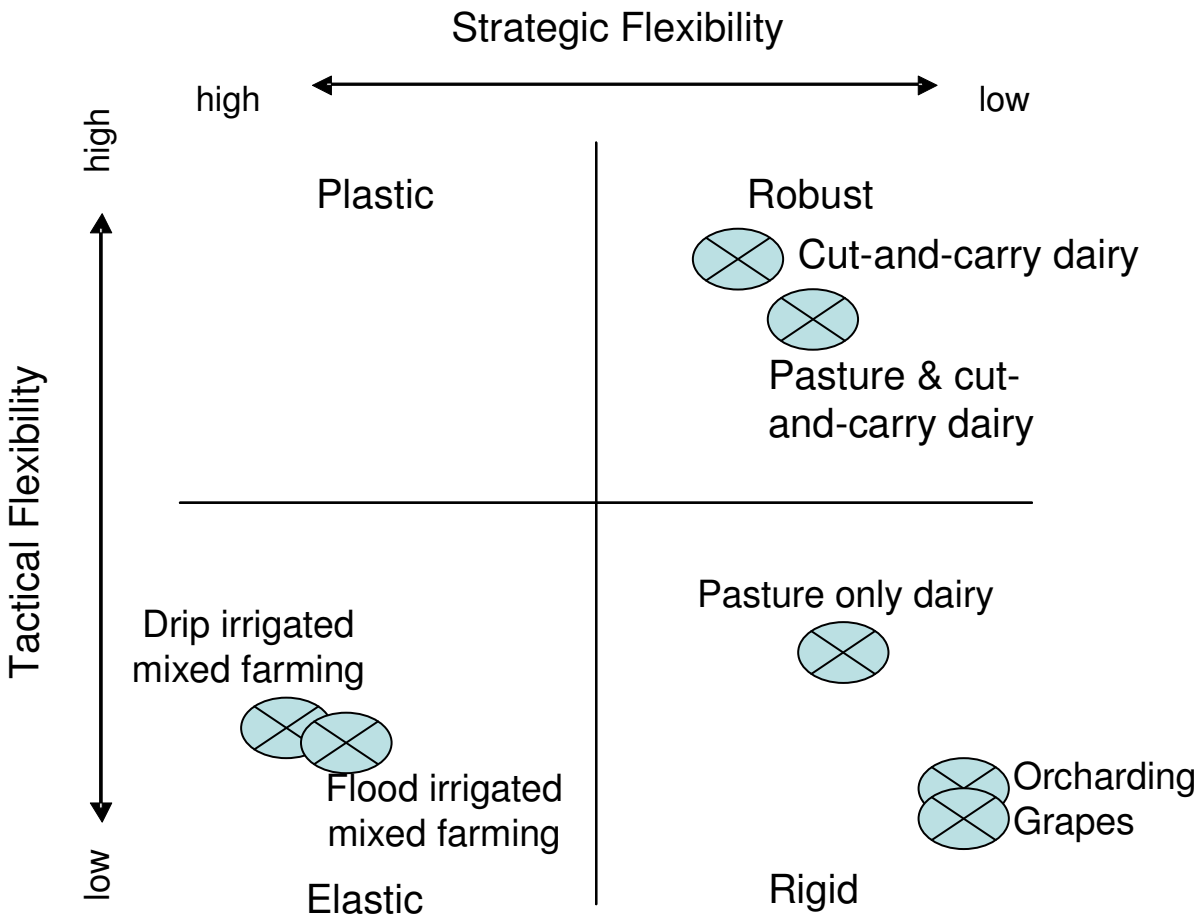

Figure 2 Examples of flexibility mix in farm systems

Sam and Sarah generally use between 12 and 16 ML of their 50 ML water right in a season, so a 30 per cent water allocation is sufficient to meet their needs in most years. Even so, water availability has been a problem for the past five years. They initially reduced water use by irrigating their vines with less water. The results were mixed. The health of the reds was unaffected but the health of the whites suffered. Consequently, they have had to increase water to their whites.

Sam and Sarah could prune their grapevines to reduce fruiting which, in turn, would reduce water use. As long as they retain the right ratio of leaf cover to fruit, they can increase or reduce fruit production year to year without harming the vines. However, pruning decisions are made in the winter before information is available on water allocations for the coming season.

This means Sam and Sarah have no choice but to prune according to the yields they want to achieve. During the growing season Sam and Sarah can adjust their trellises to alter canopy cover on the west-facing side of their vines to protect the fruit from intense afternoon sun. However, this has little impact on water use.

Sam and Sarah have had to buy water twice in the past five years, though only 3 or 4 ML in total each time. The cost of doing so was small compared to other business costs. They said that even if they had to go to the market to buy all of their water they would do so, as they could afford to buy whatever was needed to ensure production and make sure their vines are kept healthy.

For Sam and Sarah having timely information about what their water allocation will be, and when it will be available, is crucial to their decision-making. They would prefer having a larger allocation announced earlier, with fewer increments through the season, to having lots of piecemeal announcements throughout the season. Having enough water early in the season to irrigate early was particularly important. They described how, a couple of years ago, the weather was very hot early in the season, before the irrigation season started and, being unable to irrigate, the hot weather had an extremely detrimental impact on production that year.

Sam and Sarah were disappointed that, because their operation includes wine production, they were ineligible for a $20,000 grant to upgrade their irrigation and improve their water use efficiency.

Sam and Sarah do not have the capacity to vary their output mix hence their strategic flexibility is low. Their options in regard to tactical flexibility are limited as well: basically they can only buy in water and manage their canopy to protect the fruit from intense western sun exposure. This means that their tactical flexibility is low. Consequently, we classified their grape growing enterprise as a rigid farm system.

Pasture-only dairy

Ben runs a 55 hectare dairy farm with a 182 ML water entitlement. He has a groundwater licence for 268 ML and a 56 ML drainage diversion licence. Ben began using the groundwater as a supplement to irrigation water in 2001. The groundwater is typically around 1500 to 1800 EC so Ben shandies it with surface water to get it under EC 800 so he can use it on his sub-clover. Ben said that when he gets 100 per cent of his water allocation he can fully irrigate the entire property.

Ben purchased a 44 hectare block nearby in 1996 with a 170 ML water right. He used the block for grazing calves, heifers and bulls, as well as for growing hay. Ben used to transfer water from the block to the dairy property when needed. In 2008 Ben sold the block, with the water right, to pay off debt. He said that since his children were not interested in farming he wanted to scale back his operation. He reduced his herd from 120 to 90 cows. With the sale of the block he was debt free.

With the drought Ben said things have been ‘pretty ordinary’. In the past there was often excess water running down the drains. Since the drought, and with modernisation, there is very little water in the drains any more. In addition, the water-table has dropped and so the bore went dry about 16 months ago, shortly after Ben sold his out-block. Ben said that the loss of the groundwater, together with the low allocations for surface water, has really affected his production. He has had to reduce the number of paddocks he irrigates from 18 to only four or five. Consequently, he has had to buy extra fodder. He now puts the milking cows in dry paddocks with a couple of bales of hay during the day and

in the irrigated paddocks overnight. In addition to feeding out hay he gives the cows pellets in the dairy.

Buying feed can be very expensive. Last year cereal hay was $330 a tonne and pellets were $440 a tonne. At these prices Ben was paying twice as much to feed his cows as he was being paid for the milk he was producing. Even so, Ben said that buying water is more expensive than buying hay or pellets. For example, he put in some sorghum last year but, as it turned out, it was going to cost more to irrigate than to just buy in hay, so he decided not to irrigate it. It didn't help that there had been a 40 per cent decline in milk prices.

Irrigating early in the season to take advantage of spring pasture growth is critical to Ben. When it is a good season he starts irrigating in early August. In dry years he tries to delay to mid-September. He generally uses shandied groundwater for the first watering. One year, when there wasn't any surface water allocation, he ended up putting the groundwater straight onto his paddocks. He knew it would slow pasture growth, but any growth was good at that time. To increase his pasture production Ben has over-sown his permanent pasture with winter- and spring-growing annuals. These grow well when the perennial pasture is dormant and will increase feed production through to November when his cows have peaked.

Ben has two options in the longer term. One option is to replace his diesel pump with a stronger turbine pump, giving him access to deeper groundwater. The problem is that to be able to use the groundwater he needs reasonable surface allocations so that he can shandy the groundwater. Also, power will become a major cost.

The other option is to shift to focusing on winter milking so that he is less reliant on summer production and higher water allocations. To do this he would change some of his perennial pasture into annual pastures of rye and clover. Annuals take less water, at the most three irrigations, and they grow at their maximum over winter.

In moving to winter milking Ben would shift his joining and calving back two months so that his cows peak in milk production over winter, when

feed is more plentiful. For example, currently each cow produces 7-8 litres per day over winter, but with winter milking they would produce 30 litres per day. Ben said there is also the 'winter milking incentive', which means he is paid more per litre of milk.

The change to winter milking does have some disadvantages. Bad weather can be a problem for calf survival in winter and cows can develop feet problems in the wet. As well, lactation is shorter with winter calving (down from 300 days to 260 days). The laneways can be damaged by the movement of cows which means that Ben would have to improve his laneways. The paddocks themselves can also be damaged by pugging. Altogether, this means there is a greater financial cost and labour effort with winter milking.

The winter milking option is really only worthwhile if the surface allocation stays relatively low. But Ben is really hoping that some good seasons are coming which will recharge the groundwater and get things back to normal: 'Nothing wrong with the pump and once the water table rises things will be working again.' This year Ben is expecting to break even. The price of hay has dropped from $330 to $180 and pellets have dropped to $217 from $440. He is also fairly certain that the price of milk is going to rise.

Ben does not have the capacity to vary his output mix hence his strategic flexibility is low. His options in regard to tactical flexibility are limited as well: basically he can only buy water (through the market or by investing in groundwater), or reduce total pasture and milk production (by reducing herd size or shifting to winter milk production). This means that his tactical flexibility is relatively low unless he moves into a cut-and-carry system. Consequently, we classified his dairy enterprise as a rigid farm system.

Orcharding

Wajid manages 600 hectares of orchards across a number of properties. He produces a mix of pome and stone fruit on 500 hectares and pomegranates on 100 hectares. The pomegranates are grown on a new property that was purchased two years ago. He makes the

management decisions on all of the properties even though some are jointly owned.

Wajid has an 1100 ML water right and uses a minimum of 1600 ML a year. He regularly buys temporary water and transfers water between properties. He pays whatever the price of water is on the temporary market at the time he needs it, as he has a permanent crop that would die without water.

Over the last ten years, since water has been scarce, Wajid has worked to ensure that water is not wasted. Any new planting is irrigated with micro-jet or drip tape systems and he has converted the old orchards from flood irrigation to micro-jet. He uses different types of soil moisture measuring devices to help him decide the frequency and duration of waterings.

Even with his efforts to ensure efficient use of water, Wajid had found that the drier conditions have increased the stress on his trees. When the sub-soil is dry it is difficult to get water to penetrate through the entire root zone and to maintain moisture in the root zone. This reduces the response of trees to irrigation and fertiliser which, in turn, reduces the productive potential of his trees.

To Wajid, success is determined by obtaining the productivity potential of the trees desired for market. When water was less of an issue Wajid was less concerned about getting his fertiliser application precise. If he was a bit hit and miss at times, it didn't matter. Since the increase in drier conditions, because the trees are struggling, fertiliser is more important. If he doesn't get the fertiliser right then it can affect the performance of his trees and therefore the productivity of his businesses.

In addition to fertiliser, pruning is an important practice for managing productivity. Wajid prunes over winter and makes decisions about how many buds to leave for the coming season based on the condition of the trees and his expectations for the year ahead. He can't base his pruning decisions on water allocations, as he doesn't know what the allocations will be until it rains in spring. Wajid identified the lack of

information regarding initial allocations in the coming season as a big stress for him.

Wajid's biggest crop is late season apples which require irrigation until mid-May. Wajid would have to consider putting in dams to store water so that he could irrigate late in the season if the irrigation season was shortened in the long term.

If it stays dry Wajid said he will have to reconsider if his business will continue to be viable: whether he is getting enough of a margin to justify continuing. This isn't just about water, but also about markets. Dealing with the markets is a challenge according to Wajid as he has to make decisions about what market preferences for his product will be in 20 years time.

For Wajid market forces are the biggest consideration when deciding what varieties of trees to plant. Wajid is always pulling out older varieties that have characteristics the market doesn't want any more. He doesn't pull out any varieties because of limited water. While Wajid can change his output mix, such changes have long lead times. He is not able to change outputs depending on what is happening with water.

Wajid does not have the capacity to vary his output mix to cope with variability in water availability. Hence, his strategic flexibility is low. His options in regard to tactical flexibility are limited as well: basically he can only buy water and transfer water between his properties. He can use pruning to marginally reduce his water requirements. This means that his tactical flexibility is relatively low. Wajid has very little, if any, strategic flexibility. Consequently, we classified his orchard enterprise as a rigid farm system.

Robust systems

Pasture and cut-and-carry dairy

Jane and John bought their 135 hectare dairy farm five years ago. They were new to Australia and decided to buy an irrigated property in northern Victoria because it was a secure area with regard to water.

They milk 250 cows at present but could milk up to 300 cows given they can produce 12 tonnes of dry matter per hectare and need 5.5 tonnes of dry matter per cow.

They have a 400 ML surface water right and a groundwater bore but, because the groundwater is reasonably poor quality, they have had to shandy it with surface water. Even with the groundwater Jane and John need very high allocations to be able to fully irrigate the farm. Since they purchased the property the supply of water has been poor with allocations well below 100 per cent. In addition, the water table has dropped below the intake of the bore. Water prices have been so high that Jane and John have not been able to afford to buy enough water to irrigate the whole property. Consequently, they have had to move to a cut-and-carry system to remain in business.

They could invest in drilling deeper and buying new pumps if they wanted to continue using the groundwater. However, they think this is unwise as, given the need to shandy it, they would have to receive reasonable allocations of surface water to make the investment worthwhile.

In short, Jane and John buy in feed because they cannot afford to buy water. To them it is all about buying mega-joules of energy, whether it comes from water through pasture, or from grain off the back of a truck. It all comes down to which method offers the best value and this is a constant balancing act. In fact, over the last two or three years they sold some water and bought feed, as this was cheaper than growing their own.

For the last two years Jane and John have rented some nearby land for dryland cereal cropping. A contractor plants and harvests the crop then they use it for silage. Having a feed source within 5 kilometres of the farm has really brought the cost of feed down.

Jane and John have put in a simple rock-based feed pad and troughs. This has reduced feed waste by 10 to 12 per cent. The pad paid for itself within a season. They have also been soil testing and changing

their fertiliser use because buying feed and bringing it onto the farm adds nutrients to the soil.

For Jane and John being able to irrigate early in the season is vital. A good consistent diet is important for their cows, between calving in August and joining in October, to ensure high fertility. This means water is worth more to them early in the season. Also, pasture growth is a lot higher in the spring so they get more feed produced for water applied. This means the value of water changes through the year for Jane and John. Consequently, when their water allocation is low they irrigate as much of their pasture as possible early in the season. They then take paddocks out of production over the two to three months of summer, feeding the cows on the feed pad. They aim to re-sow dry paddocks every autumn to annual grasses, which means that having some water available around August can also be important so they can re-establish pastures.

Jane and John are expecting carryover water to be an effective tool for ensuring they have water available early in the season. They said that they have secured 6-7 months worth of feed for next season by carrying over water from this season. They think that having carryover will put pressure of Goulburn-Murray Water to ensure the season opens on time. They feel this pressure is important because they fear the Authority will try to shorten the season by pushing the start of the season back a couple of weeks into September. This could badly affect their ability to get good pasture growth in early spring.

Jane and John do not have the capacity to vary their output mix and their strategic flexibility is thus low. However, they do have some flexibility in their tactical options: they can substitute purchased feed and grow dryland cereals for irrigation water and pasture production. This allows them to buy and sell water depending on the relative prices of water and grain, and the allocation for the season. This means that their tactical flexibility is relatively high. Consequently, we classified their dairy enterprise as a robust farm system.

Cut-and-carry dairy

Alfonso and three partners bought a 200 hectare dairy farm two years ago. The property came with 800 cows and a large feed shed. It can carry up to 1600 cows. The farm is milking 950 cows at the moment, and Alfonso hopes to build up to 1000-1100. The farm has a 300 ML water right, an 80 ML dam and Alfonso buys temporary water. Alfonso makes all of the management decisions for the farm.

When Alfonso and his partners purchased the property they thought the drought was ending. Instead, water became even scarcer. At $1000 per ML it became too expensive to buy water and Alfonso had to rely on purchased feed for 12 months. Alfonso said that things have improved now.

Alfonso recently discovered that changes to the irrigation system, as a part of a government modernisation initiative, meant that his farm would no longer be on the public channel system. This meant that he had to reconnect to continue irrigating. Alfonso and his partners bought 650 hectares of land around their original property with a 500ML water entitlement. Alfonso has negotiated to sell the entitlement to the Water for Rivers program. This will result in the closure of 18 kilometres of channels across these properties. In exchange, Alfonso is receiving funding for a three kilometre pipe from the public channel to his home property.

Alfonso is setting up the farm now to grow more feed to reduce his reliance on bought feed. He aims to grow as many cereal proteins as he can. Consequently, 570 hectares of the new land is being used for dryland cropping of maize, wheat and oats to cut and carry. The sowing of crops is all done by the farm manager and contractors do all of the harvesting. The other 80 hectares is on the public channel and can be irrigated. Alfonso has sown this to lucerne, which he described as a good, nutritious cut-and-carry option. Alfonso's irrigated pasture is an annual rye and shaftal mix. He resows his pasture each autumn by spraying and then direct-drilling. When water is expensive he reduces the amount of pasture he irrigates, letting some die back to be resown in the autumn.

Alfonso believes he will always have to buy in some feed for energy, such as orange peel. He is also stockpiling feed to ensure that he has 12 months' supply of feed available so that he doesn't have to buy feed at exorbitant prices.

The cost of feed is the major consideration for Alfonso. He needs to keep the cost below $160 per ton of dry matter if the farm is to be viable. He compares the cost of buying water to grow a crop to the cost of buying feed. For example, if Alfonso can get water for under $200 per ML then it is worth putting in a crop of maize or lucerne. As well, having some pasture is important as Alfonso doesn't believe that they can make a profit when exclusively feeding out of the shed. Even so, the cows cannot be walked too far to graze as this reduces their milk production and increases the chance of mastitis. This means that the pasture needs to be near the feed shed. In a 'typical' year Alfonso said the cows strip graze in paddocks for eight hours a day for half of the year and the other half year they are in the feed shed.

Alfonso breaks his cows up into four herds (heifers, fresh cows, dry cows, and A2 milkers) so that he can feed them the right mix and manage their different needs. Getting the correct feed mix for the cows is crucial as getting it wrong will affect milk production levels and farm income for the rest of the season. For example, his fresh cows need to get a mix that helps maximise milk production because they are producing up to 39 litres a day. To ensure the most efficient mixing and feeding of the right feed mix to the right cows, Alfonso is in the process of putting in a stationary feed mixer near the feed shed. Silos for storage near the stationary mixer are also being installed. The less feed is moved around the farm and the fewer the number of trucks that enter the property, the greater Alfonso's profits.

Alfonso starts irrigating on the first day of the season and ends on the last day of the season. He needs to irrigate in spring because that is when the pasture grows fastest. He is concerned that the water authority seems to be starting the season later because they only announce a 5% allocation even though the allocation is going to be increased to 20% later on. Irrigating at the end of season is also important as that is when he sows his pasture.

Alfonso does not have the capacity to vary his output mix hence his strategic flexibility is low. However, he does have some flexibility in his tactical options: he can substitute purchased feed and grow dryland cereals for irrigation water and pasture production. This allows him to buy and sell water depending on the relative prices of water and grain, and the allocation for the season. For instance, Alfonso can purchase water to increase irrigated pasture production provided the price is less than $200 ML. This means that his tactical flexibility is relatively high. Consequently, we classified his dairy enterprise as a robust farm system.

Elastic systems

Drip irrigated mixed farming

Andy has been farming for over thirty years. His farm covers 254 hectares across three locations. The farm business includes a 16 hectare orchard planted to peaches, apples and pears. Andy's brother manages the orchard independently of the irrigated mixed enterprise business managed by Andy. Andy has a 758 ML water right. His water use varies from 900 ML to 1200 ML per year, depending on summer rains.

The farm started as a flood-irrigated cattle grazing enterprise. Andy moved into growing tomatoes not long after he started farming because it offered high profits. However, Andy stopped growing tomatoes this year because it is no longer as profitable as other crops.

Tomatoes can only be grown on the same site for a year or two before problems arise with soil disease and organic matter. To avoid these problems Andy used to move the tomato enterprise regularly to a fresh location on the property and replant to pasture for cattle production. Initially, Andy grew tomatoes using short-row furrow irrigation. He then moved to long-row furrow irrigation using siphons and then eventually installed subsurface drip tape.

The need to move the tomato enterprise regularly to a fresh location meant that it was common practice to lift and shift the drip tape every

two years. Since this was particularly costly Andy decided to try leaving the drip tape in place and follow the tomatoes with a crop rotation. This meant gradually expanding the area of sub-surface drip tape to maintain tomato production. Andy now has 200 hectares of sub-surface drip. His only problems with the tape have been damage from insects and mice, mechanical damage and root intrusion, all of which he can control through management.

Andy estimates that he saves 2 ML/Ha by using the drip tape. Electricity use is his biggest cost as it requires considerable energy to get the pressure needed for the system to function effectively.

Andy now grows a variety of crops including lucerne, maize, clovers and cereals such as wheat and chickpeas. This season Andy has decided to fatten lambs on his irrigated lucerne as he thinks he will get a better price for lambs. He has run beef cattle in the past and provided agistment for dairy farmers. He decides what he wants to grow each season depending on the relative prices of crops, livestock and water.

Andy tries not to over-capitalise in machinery purchases. He only buys machinery if he expects he is going to be using it for the next five years. Otherwise, he uses contractors for planting and harvesting.

Andy is always able to buy some temporary water so dry weather doesn't worry him. Drier conditions are actually better for his business as a lower allocation means there is greater demand, are fewer competitors, for his products.

Andy said that knowing likely allocations at the beginning of the season is particularly important for some farmers so they can make sensible decisions, such as when ordering tomato seedlings in August for planting in October. Andy said that mechanisms such as carryover do not really affect his decision making. He will buy (or sell) water depending on the price of water relative to crop prices.

Andy finds it difficult to keep up with water reform, as the water rules seem to keep changing all of the time.

Andy has a high level of strategic flexibility because he is able to vary his output mix easily by switching between crops and livestock production. He minimises his switching costs by using contractors and leasing machinery. His options in regard to tactical flexibility are limited though; fundamentally his only option is to buy water if he needs more. Consequently, we classified Andy's irrigated mixed farm as an elastic farm system.

Flood irrigated mixed farming

Patricia has a 300 hectare mixed production property that has been in her family for over 90 years. The farm began as a sheep (prime and wool), horse, cropping and dairy business. It currently produces prime veal, prime lamb, cereal crops (wheat, oats and barley), and lucerne (fodder and seed). Patricia runs the farm as a combination of irrigated pasture for stock and dryland cropping.

The farm has a 850 ML surface water entitlement. A few years ago Patricia put in a groundwater bore. The bore water is shandied 1:5 with water when used on the paddocks. Patricia generally uses bore water on weekends during the irrigation season when electricity prices are lower. Patricia has a 50 ML reuse dam on her property and she sometimes buys temporary water to irrigate her annual and perennial pasture.

Patricia has a mixed farm business because diversifying helps her to maximise productivity. She is constantly thinking about the output mix and changes the mix regularly depending on the price she will get for the product, how it will fit in with her rotation, and the affect on her soil.

Patricia's decision-making has been greatly affected by low water allocations over the last ten years. When water is scarce she can change her production system to increase dryland cropping and reduce irrigated pasture. For example, in 2005 Patricia converted 50 hectares of permanent pasture into crops because of limited water. Her plan is to convert back into pasture or lucerne when water allocations increase.

When switching between pasture and cropping Patricia highlighted a few considerations. She needs to decide by early February if she is

going to convert pasture to crops otherwise the soil will be too dry to remove the pasture. Rye grass is not used in the paddocks as this requires spraying when converting to cropping. Switching back to irrigated pasture from cropping is a bit more difficult and requires confidence that there will be enough water to get it established. Patricia has converted a couple of cropping paddocks back to lucerne which is the first step to going back into pasture.

Patricia can also change her mix of stock when water is scarce, or market prices change. For example, lack of water in 2004/2005 led her to increase her sheep and reduce her cattle as sheep could be run on poorer quality pasture than vealer cattle. Patricia is considering growing sorghum for hay and silage if water stays scarce, as it is compatible with her equipment. She has also thought about growing more barley, a short-season crop that requires a lot less water. She saw someone irrigating barley on bore water last year with fairly good results.

Patricia is in the process of upgrading her on-farm irrigation system to include more pipes and risers, which will reduce channel maintenance requirements and provide water savings. Over 95 per cent of the cost of the infrastructure upgrade is being covered through the government initiative in exchange for 100 ML of her water right.

Patricia has a high level of strategic flexibility because she is able to vary her output mix easily by switching between crops and livestock production. As well, she has the capacity to shift emphasis within her pasture-based stocking enterprises between vealer cattle and fat lambs. She minimises her switching costs by using contractors and leasing machinery. Patricia has limited tactical flexibility; she can use bore water, or buy temporary water. Patricia is improving her tactical flexibility to a limited degree by installing pipes and risers. Consequently, we classified Patricia's irrigated mixed farm as an elastic farm system.

Implications for farm management

The framework we have described for characterising the tactical and strategic flexibility of farm systems has a number of important implications for the management of farm systems generally and their responses to changes in the supply of critical inputs in particular. These flow from the application of Porter's analysis (Porter 1985) to the strategic flexibility identified for farm systems.

First, productive efficiency is the key determinant of business performance in rigid and robust farm systems. The more efficient these types of systems are in transforming inputs into outputs, the greater their profitability and the greater their capacity as businesses to absorb variations in input supply.

Second, allocative efficiency is the key determinant of business performance in elastic farm systems. The more efficient these systems are in choosing which output(s) to produce, given the combination of inputs that are available, the greater their profitability and the greater their capacity as businesses to adapt to variations in input supply. Productive efficiency is a secondary consideration for this type of farm system as efforts to promote productive efficiency (Villano et al. 2010) may increase switching costs between enterprises, reducing the ease with which inputs can be allocated between outputs, thereby undermining the flexibility the strategy seeks.

Third, farmers with rigid or robust systems can respond to changes in the variability of critical inputs like water by using their tactical flexibility to absorb the change, acquiring priority access to the input, or enduring variable financial performance. The capacity of rigid systems to use their tactical flexibility to absorb variability in critical inputs is more limited than is the capacity of robust systems. Rigid and robust systems can only adapt to increased variability in a critical input if technological innovation creates opportunities to change the portfolio of tactics available.

Fourth, farmers with elastic systems can respond to changes in the variability of critical inputs by, first, using their tactical flexibility to absorb small changes in the variability of a critical input. Where this is

insufficient this type of system can employ their strategic flexibility to reduce their dependence on the critical input by altering output mix. As with other types, elastic systems can adapt to increased variability in a critical input if technological innovation creates opportunities to change the portfolio of tactics available or it creates greater opportunity to modify output mix.

The impact on farms of input variability depends on the cumulative effect on profit. In the case of water, particularly, reductions in availability often occur in a series over consecutive years (Productivity Commission 2009). The cumulative financial impact can be severe and enduring. The relatively limited capacity of rigid farm systems to avert the consequences of input variability means that they are likely to be most heavily, and promptly, impacted by cumulative profit reductions.

Implications for policy

The greater impact of water supply variability will be on farms focusing on productive efficiency, that is, rigid and robust farm types. Their response to increased variability in water supplies is limited to available tactical responses. If farmers with rigid systems are constrained by a small portfolio of tactics which offer limited flexibility, there may be little, if anything, these farmers can do in response to increased variability in water supplies (apart from acquiring more water).

This is most apparent in the case of the pasture-only dairy farm. The managers of this rigid farm system are wrestling with the choice of exiting the industry or making a tactical change by reducing output and switching the output emphasis to winter milking in order to reduce water demand.

How quickly farmers with robust systems respond to increased variability in water supplies will depend on the cost of implementing the relevant tactics from the portfolio available. The higher the switching costs incurred in implementing tactical responses, the longer farmers will wait to confirm the persistence of change in the variability of water.

Since strategic change usually entails switching costs, farmers with the elastic farm systems will also wait as long as they believe they must to gauge the persistence and magnitude of changes in the variability of water supplies before committing themselves.

When increased variability in water supply can be anticipated, this rational delay by farmers in responding means that the value of information increases. For government this means that resources could usefully be directed to enhancing the accuracy, useful presentation and timeliness of information about projected and real water supplies for farmers, including projections of the likely distribution of input supplies over time. This will enhance dynamic efficiency by minimising delays in appropriate responses and minimising the reduction of flexibility due to untimely information.

A second category of relevant policy will be research and development to expand the sets of tactical options available to farmers. Of particular value would be new ways of reducing water demand on-farm. Research that modifies real options by reducing switching costs amongst tactics would also be useful.

Targeting of such research and development effort will be enhanced by audits of sets of tactical responses available to various farmers. These audits would also indicate the capacity of various farms to absorb, or adapt to, increased variability thereby indicating its impacts.

A third category of policy will be to continue to facilitate the ability of farmers with rigid and, to a lesser degree, robust systems to express the intensity of their need for water in water markets. This is exemplified by the differentiation of water in terms of security of access.

A fourth, and related, category of policy is to identify and review mechanisms that impede the operation of water markets and so constrain the capacity of farmers with rigid or robust systems to acquire water (and constrain the capacity of farmers with elastic systems to sell surplus water). In the same vein, policy decisions that impede tactical or strategic flexibility need to be identified and reviewed. For example, instances of ineligibility for farming grants, seemingly in contradiction of

policy objectives, were discovered during the interviews with farm managers.

Increased variability in water supplies will inevitably flow through to farm financial performance, increasing its variability. To maintain existing levels of assistance in, for example, net revenue smoothing, this greater variability implies increases in the absorptive capacity of buffering schemes made available by governments, the major contributor of which is the federal government.

Finally, to project adjustment pressures on farmers, research into the physical bounds to tactical responses to absorb input variability will be required to infer minimal financial impacts and to examine cumulative financial impacts arising from declining equity (ABARE 2008).

References

ABARE, 2008, Australian Farm Survey Results, 2005-06 to 2007-08, Canberra.

Ashby, WR, 1956, *An Introduction to Cybernetics*, Chapman & Hall Ltd, London.

Feibleman, J and Friend, JW, 1969, 'The Structure and Function of Organization', in F Emery (ed.), *Systems thinking*, Richard Clay (The Chaucer Press) Ltd, Suffolk, pp 30-55.

Kaine, G. and L. Cowan, 2009, 'Towards Building Adaptive Capacity in Farm Systems', Practice Change Research Working Paper 01/09, Department of Primary Industries, Victoria.

Leeuwis, C, 2004, *Communication for Rural Innovation - Rethinking Agricultural Extension*, Blackwell Publishing.

Porter, ME,1985, *Competitive Advantage: Creating and Sustaining Superior Performance*, Free Press, New York.

Productivity Commission, 2009, Government Drought Support, Report No. 46, Final Inquiry Report, Melbourne.

Villano, R., E. Fleming, et al, 2010, 'Evidence of farm-level synergies in mixed-farming systems in the Australian Wheat-Sheep Zone', *Agricultural Systems* vol. 103, no. 3, pp. 146-152