Drought Proofing the Low Rainfall Agricultural Zones of WA

Alternative farming systems for low rainfall, semi arid agricultural regions of Western Australia

A report for

by Cameron Tubby

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Foreword

My Nuffield journey began in the middle of 2008. Until then a Nuffield Scholarship was something that other more fortunate and better equipped farmers than myself undertook. This all changed for me when in the middle of May 2008 the season looked as if we were about to head into the third year of severe drought following a run of other droughts and dry seasons before that.

On one particular day that May I was watching the neighbours dry seeding a paddock as the temperature of the day rose and the little moisture we had left evaporated, it dawned on me that the practices we were employing were possibly the highest risk in agriculture in the world. Why would you commit financially and mentally everything on the hope that it will rain, given at the point of sowing there is no moisture in the soil, you had just endured two of the worst droughts on record and there was no forecast of rain anytime soon. There had to be a better way.

Coincidently, on that same day the brochure for the Nuffield Scholarship arrived in the mail. After consulting with my wife, Teresa and parents it was decided that I should have a go to see if I could find some alternatives to the high risk farming systems we were practicing. I will be forever grateful to Nuffield and all those who aided me in receiving the scholarship because it has been a life changing experience not only for myself but my wife, children and ultimately the farm.

My Nuffield experience exploded with the Global Focus Program. This is a once in a lifetime opportunity that only a very few are fortunate enough to experience. I was blessed to be able to undertake this trip with a great bunch of blokes (kiwi's included!) who really made the trip. This intense whirlwind trip around the world certainly opened my eyes to global agriculture. It was also responsible for reinforcing the need for our area to adopt safer, less risky farming systems.

The second leg of my Nuffield journey was the individual study tour. This is where a Nuffield Scholar is really tested as to whether they are up to it or not. There is no one to hold your hand in organising and achieving the travel. This alone will change your life. My aim of this part of the scholarship was to visit countries with modern farming systems that operate agricultural research facilities in climates similar to, or dryer than ours. With the time available I was able to visit South Africa, Syria, Israel and the United States.

My focus in South Africa was their dryland grain growing regions and livestock. The greatest benefit from South Africa was their livestock breeds. South Africans are decades ahead of Australia and the rest of the world in the breeding of livestock for harsh climates.

The International Centre for Agricultural Research in the Dry Areas (ICARDA) was my target in Syria. I was also able to take the opportunity to see the other side of agriculture where it is not necessarily a business but a means of survival for farming families. Culturally Syria was unbelievable, something I was not expecting to experience.

Israel offered a number of opportunities in modern agriculture. With the countries focus on being self sufficient in food production in an arid climate and the generous funding from international sources they are able to attempt things in agriculture that the rest of the world are not. Alternative crops, aquaculture and water harvesting were areas I gained knowledge in.

The United States allowed me to look at some of the cutting edge technology and new ideas that can assist in drought proofing farming. These included Genetic Modification (GM), farm management systems, aquaculture and alternative crops. This is also where my family were able to join me and experience a little of the Nuffield Scholarship journey.

Acknowledgments

- My wife Teresa and children who kept the home fires burning. Without Teresa's assistance in planning and preparation I may never have got on my way. It was only with my families blessing that I was ever able to attempt a Nuffield Scholarship
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- My Parents and Brother in-law for keeping the farm running in my absence
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- Ross Jones and Rod Madden, my referees for all their advice
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- To all the people around Australia who offered me advice and help organise contacts around the world, thank you
- Finally to the numerous farmers, business people and researchers I met around the world that were also very generous with their time and knowledge, thank you.

Contents

Executive Summary

This report is about looking at options to drought proof farming operations in the low rainfall zones of the Western Australian wheatbelt by complementing traditional farming systems with alternative farming systems that are more adapted to dry conditions making them more sustainable. Our traditional cropping and livestock systems will always be a part of farming operations in this environment; therefore options that can help these enterprises in drought conditions are also investigated.

The last decade in many areas of the low rainfall zone of WA and indeed Australia wide has seen a series of dry and drought years (see appendix 1 and 8). When these years are experienced in a low rainfall zone there are very few options available to turn to that can see you through the droughts. A fundamental flaw in our farming systems is that they have evolved from traditional European and North American systems that were established in environments very different to much of the low rainfall zones in Australia.

Compounding this is that during the droughts research was withdrawn from these areas. This is exactly the wrong time to withdraw research as it gave the opportunity to look at alternatives to the normal for dealing with drought conditions. Some of this withdrawal was due to lack of funding, lack of personnel, but more than anything I think is was due to the lack of incentive because of the way research funding is allocated now. A failed, unattractive trial site on the edge of the wheatbelt is not all that appealing to a private sponsor who is aiming to get as much exposure to their company as possible. Unfortunately this type of funding in many cases is the only option available to research organisations.

Background

The need for this report was the result of my farm and many farming operations in my local community enduring a series of droughts since 2000. The result of this was the loss of many farming families, the loss of local services and people in town and for those who managed to stay extreme financial and mental stress. Because we were farming with systems that could not cope with drought we were left in a position of being unable to trade our way out until normal type seasons returned and the old farming practices could operate again. We were stuck in a situation where only a return to the old climate could save the area. What if this

dryer climate is our new climate? We need to adapt and do it now before the next round of droughts which are inevitable in our environment.

Findings

The most outstanding finding I made was how savage our droughts were compared to what other similar areas in the world considered a drought to be. The most sobering thought was what we were attempting to do in these conditions and almost getting away with it. To receive below 200mm of rainfall in a growing season in regions that dry land cropped was regarded as a severe drought. In some areas farmers only had the confidence to dryland crop because they have the backing of government if there was a failure or they rely on it for their survival.

When referring to our rainfall figures and yield results as indicated in appendix 1, most farmers and researchers around the world shrugged their shoulders and said it was not possible in their environment. To me this is a testament to Australian farmers, researchers and agronomist as to what we have been able to achieve in our extreme climate. Unfortunately our abilities could not match the droughts we have experienced lately.

Many of my findings may be a little confronting to the more traditional farmers in the area. *I make no apologies for this!* I am not in the business of telling people what they want to hear. My objective was to find real alternatives that will require a change in mind set.

Some of the options presented are more a case of 'what's old is new again'. There are some old plants being regenerated such as the cactus as well as a call to go back to some of the lost genetics from livestock and crops. Modern breeding has focused too much on a single trait resulting in the loss of many features the older crops and livestock had that enabled these species to survive. There are now cases of monoculture crops beginning to fail around the world because a single environmental factor has wiped them out.

A number of the options are livestock or related to livestock. The fundamental reason for this is risk reduction. Throughout the world in similar climates to ours livestock are a critical component of dryland farming. Nowhere did I see 100% cropping operations.

A key to my findings is to utilise the resources we have in our environment now. This includes native plants, utilising our saline land more effectively and increasing water use efficiency when it falls.

Implications

There will be implications for farmers, researchers, Government departments, commercial businesses and consumers if we are to drought proof ourselves using the options I have presented here. Most of this will come in the form of changing our mind set on what is normal. We cannot keep working against the environment if it is changing along with a worsening economic environment.

Ultimately the implications of changing to suit a drying climate and worsening economic environment is that it will have a less risky and more sustainable farming system for both ourselves and future generations. Even if our climate returns to normal this will still hold true and at the very least we will have the confidence of how to farm in a harsher climate.

Introduction

This report covers but just the tip of the iceberg of all the information provided to me over the length of my journey. What I was able to learn was also just a snap shot of what may be out there in the world, although I do believe I was able to capture the most relevant to our situation at this given point of time. To discover all the answers of what I set out to learn could be a lifetime quest.

As previously eluded to this is not a set of rules that all farmers in my area should adhere to, rather it is a comprehensive list of potential options that both farmers and researchers could look at to help drought proof their operations.

The report is presented in a way where all the options are grouped together in eight broad chapters. Within these chapters I have further grouped them into options that could be implemented within the short, medium or long term based on when I think they could be implemented into my farming operation. This would vary from farmer to farmer, but judgement was based on how much is already known and how much research will need to be done before they are a reality.

Cropping/Pasture/Rotations

Finding better ways of cropping, running pastures or utilising both in rotations proved to be difficult in the countries that I visited. The areas that I visited in similar climatic conditions to the low rainfall zones of WA indicated that cropping practices are nowhere near as advanced as dryland agriculture in Australia.

The concept of no-till farming is in its early stages in South Africa where as in Syria and Israel it is virtually non-existent. Stubble retention again is a young idea in South Africa and is unlikely to ever be a reality in Middle Eastern countries due to the monetary value placed on crop residues as either straw hay or grazing. Traditional practices in the Middle East are to utilise as much of the stubble residue for hay then what's left is grazed by the nomadic Bedouin people.

Many areas in the US that are in similar rainfall zones simply do not attempt dry land cropping. I visited farm lands in California, Arizona, New Mexico and Idaho where their

annual rainfall is between 225mm and 400mm. The majority of agriculture in this area was irrigated or grazing, it wasn't until I got into rainfall zones getting close to 400mm that I saw any attempt of dry land cropping. The biggest percentage of land I saw in this zone had been put into the Conservation Reserve Program (CRP) some time ago and has only recently been opened to restricted grazing every three years.

Having said all that I was still able to pick up some very good ideas that can be put into practice in our environment to improve what we are doing with cropping, pastures and rotations in a dryer environment.

Short Term Opportunities

Drought Tolerant Barley

My understanding of Barley in the WA agricultural environment is that it is generally regarded as a medium to high rainfall zone crop. This maybe because of the focus on malt barley varieties, where in most years, the best results come from the higher rainfall zones. Because of the focus on malt varieties in the higher rainfall zones I believe there has been no attention paid to the drought tolerance of barley. Certainly what we witnessed in our area during the droughts and dry years is that our local barley varieties performed poorly compared to triticale and wheat and only slightly better than oats.

South Africa

I first became aware of the ability of barley to withstand dry periods better than wheat while in the Swartland wheat growing region of the Western Capes. At one of the Western Capes Department of Agricultural research stations they were experiencing a dry period where the wheat had thinned out and run up into head while the barley was still in the late tillering stage showing little signs of moisture stress. This same result was evident at Human Hiedelberg's property in the same area where his wheat had also run into head with an estimated yield between 0.6 – 0.8t/ha where as the barley in the adjoining paddock was still in the tillering stage showing little signs of stress.

Both researchers and farmers in South Africa acknowledge that barley is a more hardy cereal than wheat in dry conditions. Dr Mark Hardy, a senior Scientist at the Western Capes

Department of Agriculture states that "The general experience is that barley can handle dry periods better than wheat, especially at the beginning of the season. Barley seedlings and young plants always look better than wheat planted under the same dry conditions. However, I cannot say that barley will necessarily provide better yields than wheat in dry seasons despite the barley plants "looking" better than the wheat" (personal communication, July 2009)

ICARDA Syria

Barley is identified at ICARDA and throughout the Middle East as a very hardy cereal compared to wheat. While visiting the ICARDA's Breda Research station which is the driest of their research stations I observed trial sites where the barley yielded 1.2t/ha while the wheat alongside yielded 0.36t/ha with 247mm rainfall for the growing season.

A well known Genetic Resource Scientist at ICARDA, Dr Ken Street, made the following quote while visiting him *"In my collection missions I have been to some very dry places and I've noticed that barley and triticale will produce grain next to wheat fields where the wheat has fallen over the barley and triticale are still going on to produce grain"* (personal communication, 4th August 2009). This is evident in the traditional farming practices of the local Syrian farmers where barley is grown in the most marginal cropping areas to ensure that they get some production for grain and residual stubbles for animal fodder. Wheat is not considered in these areas because it fails in such marginal conditions. Figure 1 gives a good indication of the farming systems in Syria for certain rainfall zones. This clearly indicates the importance of barley in the lowest rainfall zones where this is not the case in similar areas of WA.

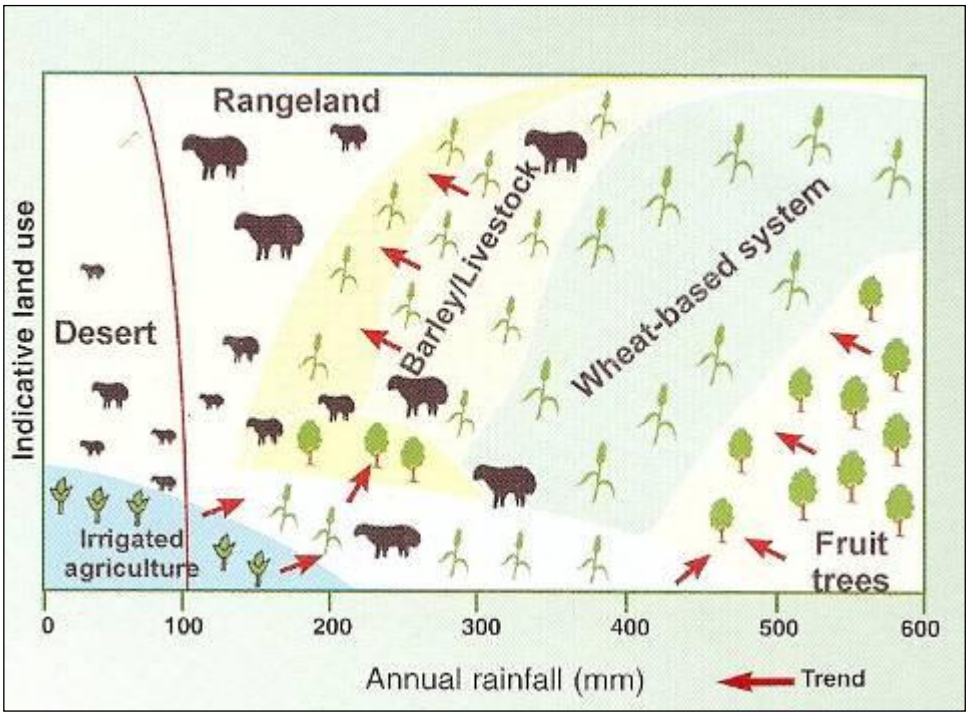

Figure 1. Graphical representation of the Syrian farming system

("Barley Improvement at ICARDA", n.d)

ICARDA has been actively breeding drought tolerant varieties since the late 1980's. During the severe droughts of 1999 and 2000 in Syria a new line of barley called 'Arta' was identified as having significant drought tolerance (Nour, 2002, p 54). There was only 120mm growing season rainfall for 2000 yet the variety Arta was able to yield 0.5t/ha where as the regular varieties failed to produce any grain. This was one of the driest years on record in the Middle East since 1960 and a period that saw massive crop failures throughout Central and West Asia and North Africa (CWANA). Barley harvests in Syria alone dropped 65 percent during this timeframe (Varma, 2002).

In general, it takes at least 200 mm of rainfall to grow a barley crop in non-irrigated areas, but 'farmer researchers' in Syria have produced crops on much less using lines developed by ICARDA. In some locations, farmers managed to harvest a crop from just 87 mm of rain. Yield was measured in kilograms, not tonnes, but in such years of drought, a harvest of barley grain and stubble for livestock can mean the difference between survival and selling off livestock or a piece of the family farm (Ceccarelli, Addass. n.d)

These new lines of drought tolerant barley were developed using a new way of selection. The new way ICARDA have developed for plant breeding is known as Participatory Plant

Breeding (PPB). This is where farmers (women included) choose the lines with the traits they want and that work well in their own particular environment instead of the traditional plant breeding programs that routinely select lines with wide adaptation, discarding those that perform well only in poor conditions – and would thus be potentially suitable for marginal areas ("Barley Improvement at ICARDA", n.d)

The PPB could be a plant breeding technique that should be looked at in Australia to help develop varieties that are more suited to certain areas. It appears that Australia's barley varieties have lost, or never had the drought tolerance trait that other barley varieties from around the world have.

Grasspea (Lathyrus sativus L.)

Grasspea is a pulse crop belonging to the Leguminosae family that is grown in dry, poor regions of the world that need a legume that they can rely on to feed them in a drought. Typically grasspea is the last plant standing in times of drought when all other crops have failed ("Healthy Food for the Poor", 2000) Grasspea is capable of withstanding a myriad of assaults, not only drought, but water-logging, cold, and pests and disease attack. As a fodder crop it is both palatable and extremely nutritious, either by direct grazing or by harvesting for grain or hay. It is rich in protein (30%), and for sheep its high lysine content promotes improved wool quality. Grasspea is easily cultivated, with little need for costly inputs ("Grasspea – a Tough choice". n.d)

Grasspea's popularity stems from its ability to grow in areas that receive as little as 200mm of annual rainfall. "Even hardy dryland crops such as lentils and barley require 200-300mm of water to produce a viable crop," says John H. Dodds, ICARDA's assistant director general ("Famine victims in Ethiopia, India" 2000) ICARDA has developed lines of Grasspea that can produce 1.5 t/ha of seed in slightly less than 200mm of rainfall ("Healthy Food for the Poor", 2000). Dr Shiv Kumar Agrawal, lentil breeder ICARDA suggested to me that Grasspea has the ability to produce a useful amount of seed and biomass with as little as 150mm rainfall (personal communication, 4th August 2009)

Figure 2. Grasspea in pod

Grasspea has been trialed in WA with a local variety released called Ceora but it was never promoted as a potential crop for low rainfall areas or as having the ability to withstand drought. In the WA Department of Agriculture farmnote *"Growing Ceora Grasspea (Lathyrus sativus) in Western Australia"* grasspea is recommended for the medium to high rainfall zones and promoted as having good tolerance to water logging. Nowhere in the document is it mentioned that it may be very useful in the low rainfall zones.

From what I have seen and heard from around the world that this could be a very useful legume to introduce into a low rainfall cropping system. During the droughts almost all legume crops and pastures have been removed from low rainfall cropping systems due to the high risk of these crops. I see Grasspea particularly useful for mixed cropping and livestock enterprises because of its low cost, high nutritional grazing value, ability to produce in droughts and all the other benefits that go with growing legumes. It appears to have little value in the grain because of limited or no world trade in the seed therefore may have less value to continuous cropping enterprises but may be useful as a green manuring crop. However it is looked at, it is potentially the low risk, low cost legume crop or pasture that is required back in the low rainfall cropping systems.

Mixed Populations of Cereal Varieties

One of the survival techniques for the cereal growers in the subsistent farming areas of the world is the utilisation of landrace species. Landraces are ancient seeds grown is the same area for centuries that have adapted to the harshest of conditions. Within these landrace

species are a huge range of gene diversity. Dr Ken Street, ICARDA, comments on the use and benefits of landraces by local farmers in the documentary "Seed Hunter"

"If one season comes along and it's quite a dry season you might have individuals within this population that can handle that, so he still gets a crop, or there might be a disease that comes through here and some plants get effected but others don't. The landraces can evolve. are robust and stable. Not necessarily high yielding perhaps, but the farmer can rely on it to produce in almost all conditions"

This gives a subsistent farmer the ability to feed his family and possibly generate some income in the worst of years.

In the last 50 years the modern crops have been bred predominately for yield and have lost a lot of their genetic hardiness. This has seen many of these varieties fail as changes in the climate are experienced around the world (Ingleton, 2008)

It is possibly time to re-assess our monoculture, singular genetic population cropping systems currently used in Australian agriculture. In order to protect ourselves against an event that can wipe out a crop the potential of mixing different varieties with the same qualities but different traits should be looked at. I cannot see any reason the new varieties of wheat that are promoted as drought tolerant but not necessarily high yielding could not be mixed with a very high yielding variety of the same quality. This would protect against very low yields in dry season yet reach high yields in the good seasons. Obviously this would need to be trialled to see what the net result is, but could give us some protection against complete failures in droughts in a similar way the subsistent farmers have achieved.

Medium Term Opportunities

Low Rainfall Lucerne

The use of lucerne in the dryland cropping regions of the Western Capes, South Africa plays a significant part in their rotations. Almost all farmers in the areas I visited still maintained a significant flock of sheep for the reason of reducing their exposure to risk with cropping.

The area around Swellendam (about 220km east of Cape Town and 50km from the south coast) is a 300 - 400mm rainfall zone with 60 percent falling in winter. The standard practice

in the area is to have a 50:50 cropping/lucerne pasture rotation. Even in the 300mm rainfall the farms had excellent stands of lucerne on shallow soils.

The rotations work on five years of cropping and five years of lucerne production. Over the five year period the low rainfall areas are able to maintain significant stands of lucerne with heavy short periods of rotational grazing practiced on them (one week in / five weeks out). At the time I was in Swellendam the area was experiencing a significant dry period, yet I saw an example of an established lucerne stand being put under significant grazing pressure over a number of weeks still looking relatively healthy while a neighbouring crop of Triticale had not performed well and the farmer had placed sheep on it to get some grazing value out of it (see figure 3)

Figure 3. Heavily grazed lucerne stand growing next to a failed Triticale crop

This was the first indication that there may be room in our system to introduce a lucerne rotation into certain areas of our cropping land. Having observed how the system works in South Africa I think we would need to target possibly our best land with the ability to absorb any summer rainfall or retain winter moisture into the summer. It would be site specific and on a relatively low scale compared to the 50/50 rotation in South Africa. Once established it appears that lucerne is capable of surviving droughts, especially on the better soil types.

The new varieties released by the South Australian Research and Development Institute, SARDI 7 and 10 could be worth looking at in the low rainfall area of WA. For this to play much of a role in WA it will take a few years of reasonable seasons to give farmers the confidence to re-invest in pasture again.

Growth Promotion Products

While at Monsanto's Davis Research centre, California it was suggested to me that I may want to look at the use of growth promotion products to help with crops early drought resistance. The active ingredient recommended was Harpin which is a naturally occurring protein which has been formulated by a number of companies as a seed treatment for uses in garden plants through to broadacre crops. The benefits of harpin are:

- Increases root mass and uniformity in germination
- Stimulates a plant's defense and growth mechanisms
- Boosts overall growth, vigor and production
- Aids in the management of disease
- Improves the plant's ability to grow and protect itself from stresses caused by adverse environmental conditions.

Acceleron™

Monsanto has recently registered a product using harpin called Acceleron™. This product will be sold in conjunction with a number of their other products as a pre-treated GM seed. These products include Roundup Ready 2 Yield® soybean, SmartStax™ corn in 2010 and Deltapine® cotton in 2011.

At this stage Monsanto do not produce Acceleron as a stand alone product that farmers can use to treat their own seed, but they did indicate that they would be willing to trial it in wheat in Australia.

Invinsa™

Invinsa is a new product released by Agrofresh and Syngenta designed to mitigate yield loss under heat and drought stress. Crops respond to stress by producing ethylene, a natural plant hormone. The active ingredient in Invinsa technology, 1-Methylcyclopropene (1-MCP), works by binding to ethylene receptors and preventing the ethylene signal from triggering stress responses in field crops. Invinsa technology enables crops to maintain active photosynthesis and healthy leaf function, which allows them to optimize growth during periods of stress. In wheat it prevents premature flag leaf senescence, reduces stress induced

grain abortion and increases grain size under heat stress conditions ("Invinsa Crop Stress", 2009).

These two products may be one of the many snake oil products we have seen released on the market claiming all sorts of benefits but they may be worth looking at.

Long Term Opportunities

Genetically Modified Drought Tolerant Wheat

Put simply we cannot expect Genetically Modified (GM) drought tolerant wheat on the market for about 10 years. In Monsanto's case they are only now beginning the process of looking at GM because of the lack of support coming from the wheat industry in the past. It wasn't until May this year that a joint statement between the wheat growing associations of Canada, USA and Australia was released supporting the use of GM technology in the wheat industry (Appendix 2). Following this joint statement companies such as Monsanto now have the confidence to go ahead with the technology knowing there is an end user for the product.

Monsanto is not the only institute investigating the GM technology for drought tolerance in wheat around the world. On the Global Focus Program (GFP) earlier in the year we saw GM drought tolerant wheat growing in the laboratories at CIMMYT, Mexico. ICARDA are in the process of building their Biotech Labs ready for operation early next year as well as companies such as Syngenta, BASF and the Bioscience Research Centre in Victoria, Australia has also begun the research into GM drought tolerant wheat. However, given the general resistance to GM wheat by both consumers and producers most of the research has slowed considerably until now.

Figure 4. Genetically modified drought tolerant wheat in the laboratories CIMMYT Mexico

Although GM drought tolerant wheat is some way off the GM drought tolerance technology is very much a reality. Monsanto in collaboration with BASF are due to release their lead drought tolerant corn project in 2012. This is now in stage 4, the last stage before commercialisation, and is showing yield improvements above the control (conventional variety without GM trait) of between 6.7% and 13.4% consistently for the last five years. Monsanto set a targeted yield advantage of between 6% and 10% over the conventional varieties for the historically dry land farms of the Western Great Plains of the US (Crews, 2009, slide 14).

Monsanto and BASF also have a second generation drought tolerant corn that is now in the second phase of development. This variety is utilizing a different gene to that of the first generation and will have a broader area of adaptation. This variety is also showing consistent yield advantages over the control in moisture stressed conditions of between 9% and 15% for the last three years. Again Monsanto's target yield advantage was 6 – 10% over the conventional varieties (Crews, 2009, slide 20).

According to Jill Deikman, Monsanto's Biotech Corn Drought Yield Project Manager the third generation in Drought Tolerant corn will be the combination of the genes in generation one and two. The outcome of this and time line for such a project are unknown at this stage. There are three possibilities as to the outcome of combining the genes. First is the yield benefits will remain the same as stage one and two of around 10%. The second likely

outcome is a combined yield benefit of around 20%. The third and most desirable outcome is a synergetic effect between the genes and the yield benefit is greater than 20%. Unfortunately it will be many years before we know this outcome and even longer for such a result in wheat.

The positive things that we can look forward to in GM drought tolerant wheat is that the research has now begun in earnest, the majority of the industry is in agreement on the need for such technology and the technology exists and is well advanced in corn. Hopefully by the time the first GM drought tolerant wheat varieties are commercially available the market place and industry in Australia and worldwide are in a position to take advantage of it.

Livestock

Wherever I visited in the world with a climate similar or dryer than the climate in the low rainfall zone of WA livestock, in particular sheep played a big part in the farming systems. At no stage did I meet a farmer who continuously cropped; neither did I speak with any researchers who advocated removing livestock from the system and concentrate only on cropping.

The reasons for this are varied across the world but in general they remain an important part of a low rainfall farming system because it reduces risk, and in some areas secures food supply. Even in areas of South Africa that are favourable and safe for continuous cropping, no farmers I met were prepared to take livestock out of the system, rather just adjust the numbers they were running.

In New Mexico, USA, I meet a farmer who had taken cropping out of prime dry land arable acres to return it to grazing land. This included Conservation Reserve Program (CRP) land that was due to go back into crop production, instead it was left in its natural perennial pasture phase. It was indicated to me that this was becoming more common in the area simply to reduce farmer's exposure to risk with high input cropping systems.

Despite the obvious detrimental effects sheep had on the stubble residues on the cropping land in Syria and Israel the local farmers and communities saw more benefits in having sheep in the system than taking them out. Not all management practices I observed would be regarded as good practice but with careful, smart management, livestock will play a very important part in farming systems in the low rainfall zones of WA.

Australia and the world is fortunate that South Africa saw the advantages of improving the local fat tail sheep breeds and developing new hardy breeds of sheep over the last century. There are now numerous options available to the world of animals that can produce good lambing percentages, quality meat, low maintenance and input requirements all in harsh, dry climates.

Short Term Opportunities

Sheep Breeds

Within the sheep breeds in South Africa there are many that are capable of surviving and thriving in harsh conditions. Having seen just about all of them and spending many hours talking to farmers in South Africa that produce the different breeds I have narrowed down two that I think best fit into my farming environment and possibly the low rainfall region in general. It should be noted here that my opinion may be influenced by the fact that I have run Damaras and Dorpers in our business for the past ten years. This is because I believe that these breeds have been the best option for our environment and therefore think my conclusion is based on some experience of what works in our environment.

Van Rooy Breed

The Van Rooy presents itself as an excellent breed of sheep suited to dry climates. The breed was started in 1906 by Senator J. C. van Rooy. His aim was to develop a breed with excellent conformation suitable for the British market that could withstand regular droughts while being fertile enough to maintain a high percentage of production. Although the Van Rooy is classified as a fat tail sheep significant breeding has gone into getting a good conformation with as little fat localization on the body and only a reasonable accumulation on the rump (Pretorius, 1990).

I was fortunate to meet a few farmers in the Koroo and Kalahari regions of the South African veld who run Van Rooys alongside other breeds. All of these farmers identified the Van Rooy as a superior breed over the other breeds for many reasons. Two of the farmers use performance testing figures on both their Van Rooy and Dorper breeds to verify the claims. Appendix 3 lists the advantages of the Van Rooy identified by myself and the local farmers.

Figure 5. Van Rooy Ram

Figure 6. Van Rooy and Van Rooy x White Dorper 2 month old lambs

The only drawback to the Van Rooy is the fact that it is still a fat tail sheep with localized fat on the rump. This is not well accepted in the domestic market and receives a penalty at the abattoirs but they are highly sought after by the live trade. In order to maintain all the excellent traits of the animal but have a product that is accepted by the market a White Dorper ram can be put over the Van Rooy ewes to produce a prime lamb that has no localized fat, excellent body conformation and superior growth rates. This is a strategy used by many South African Van Rooy farmers who are chasing the premiums in the domestic market.

Meatmaster

Meatmasters are a new composite breed of sheep that was registered in 2007. The origins of the breed are a cross between a Damara and White Dorper. The aim of the Meatmaster is to combine the desirable traits of both breeds to produce a superior animal (see appendix 4). The Damara was used for its durability and fertility and the White Dorper for its body conformation. Clynton Collett, one of the founding farmers in the development of the breed, describes it as a "Supped up Damara not a downgraded Dorper"

The need for the breed was identified in 1995 when a group of South African farmers recognized that the Damara breed had a number of excellent traits for production in arid climates but lacked two vital components preventing them becoming highly sought after economic meat producers. That was fat localization with poor distribution and lack of muscling leading to flat sidedness and late maturity. The trialling then began on crossing other breeds with the Damara to establish the now recognised and registered Meatmaster.

Figure 7. Meatmaster ewe with lambs at foot

Figure 8. Meatmaster Ram

The Meatmaster is designed to be a robust, no messing about breed. It has simple breed standards (see appendix 5) which ignore many of the petty conformation issues that other breeds have become bogged down in. The main focus of the breed is on economic factors which are low cost, maximum income.

With the new improved conformation of the Meatmaster I believe it will be equally acceptable to the Australian domestic market as any of the current breeds that are accepted in that market. If not, as with the van Rooy, a White Dorper could be put over top to produce a prime lamb. The only disadvantage is that the breed is still coloured similar to the Damaras. In my experience colour can be discriminated against in the domestic market even though it has no outcome on the carcass quality. This will need a little educating of the buyers to overcome this.

Both the Van Rooy and Meatmaster offer an excellent alternative livestock option for the low rainfall zone of WA. They have similar desirable characteristics (see appendix 3 & 5) and are bred for the environment. This adaptability to the environment can only improve as animals are further bred and adapted to local conditions in WA.

Other Possible Alternative Livestock

Afrino Sheep

The Afrino breed would make a good alternative livestock for someone who is looking for a dual purpose animal. It is a breed made up of 25% Merino, 25% Afrikaner and 50% SAMM, therefore it has some of the hardiness qualities of the fat tail Afrikaner and wool qualities of the merino. According the Clynton Collett, a breeder of the Afrino, it is the only good wool producing, dual purpose animal in the world with fat tail blood in it, giving it the advantage over other wool breeds in regards to hardiness in arid conditions.

Overall I do not think it would be as suitable as the Van Rooy and Meatmaster. Appendix 4, graph 3 you will see that the overall income for Afrinos in South Africa is slightly behind Meatmasters with considerably more inputs and labour required due to the wool production. It should also be noted that wool prices in South Africa are better than Australia's with the costs of labour, in particular shearing, being well below the costs in Australia.

Dorper Sheep

The Dorper is a well known, excellent meat breed in Australia. It was breed in the 1950s after it was identified that a new breed was required that could produce a superior carcass in the arid lands of South Africa. The original breed was a cross between the Black Head Persian and the Horned Dorset. This cross gave the original breed the body conformation required from the Horned Dorset and the hardiness from the Persian (Lategan, n.d, p 7).

There are two fundamental flaws in the Dorper that do not make it as suitable to the low rainfall zones of WA. Firstly, is the annoying trait the breed has of fence breaking. Universally throughout Australia and South Africa farmers have been frustrated by this trait.

Secondly, is that the original hardiness of the Dorper appears to have been bred out of the breed over time. This is recognized by many farmers in South Africa who have left the breed to go to other hardier animals. It is a factor that we have noticed on our property also by running Dorpers with Damaras.

Clynton Collett, a Meatmaster and Afrino Stud producer and ex-Dorper stud producer made this comment about the direction of Dorper breeding in South Africa *"Studs have been making Dorpers and other breeds more pretty to the eye, more desirable by the market, not*

breeding sheep that make money for the farmers. Breeding has gone the wrong way by forcing a breed to be the best at some uneconomical trait" (personal communication, July 2009)

This comment was re-enforced by Jaco Van Rensberg who is a South African Van Rooy and Dorper stud breeder who performance tests all his animals. Joco stated *"The biggest and fattest ewes win the shows but they are the ones that only produce one lamb in two years. The genetics from this animal is then used and the industry takes a step backwards"* (personal communication, July 2009)

Goats

The obvious alternative livestock option for low rainfall zones is goats. I saw many goat operations throughout the world and after talking to Stud Goat breeders in South Africa I do not believe there are many options available that would be better than the Van Rooy and Meatmaster. Jaco van Rensburg breeds both Boer and Kalahari Red goats alongside the Van Rooy's and Dorpers. In Jacos' opinion both goat breeds are not as hardy as the Van Rooy. This comment is supported by Clynton Collett, who has also had experience with the two breeds of goats.

Other factors that make goats not a preferred option are the generally low prices and fickle nature of the WA goat market. Goat markets and prices in South Africa are a lot stronger than Australia because of the strong domestic demand for goat meat. It was also suggested to me by Clynton Collett that in his opinion the best option would be to improve the feral goat we have in our pastoral areas as they would be a more robust animal than trying to improve the population with the Boer or Kalahari breeds.

Summary on Livestock

To best sum up the future use of livestock in the low rainfall zones would be to use some quotes from Dr Q Campbell's (1998) book *"Making Money with Mutton Sheep"* Here he states *"In order to be successful with whatever breed of sheep, cattle or goat a breeder farms with it must be well adapted to that particular habitat. No breeding venture can be successful if the breeder farms with a breed which is not adapted to that area"*

"Instead of changing the environment to suit the breed, breeders should change to breeds that are hardy and well adapted to the environment" (Campbell, 1989, p 4-10)

Marginal Land Perennial Pastures

A consequence of the drought in the low rainfall zones in WA, in particular where we farm is that the areas of land we regard as marginal are no longer capable of producing a viable income. In other words to attempt to crop or establish annual pasture on them costs more than the returns made. Marginal land in this chapter is referring to shallow, wodjil gravels and heavy, iron stone type clays. Saline land is also regarded as marginal land but this is referred to in a later chapter.

The practice of removing these soil types from production results in the land sitting idle, non productive and prone to erosion which has the kick on effect of causing erosion to the productive land elsewhere in the landscape. There is the expensive option of trying to establish some type of annual ground cover on it each year or look at what types of commercial perennials can be established. Establishing a commercial perennial on these marginal lands may have a high, once off cost of establishment but over time would prove to be low maintenance, low cost and potentially economically profitable.

Wherever I went through the semi-arid rangelands of the world, any land not being irrigated was regarded as marginal. Not only was it marginal but in many places it was badly degraded, resembling what our marginal land looks like when left idle in drought years. Fortunately there is significant work being done on regenerating these areas with commercially viable options to keep the land in production. These options are potentially very useful to our area.

Figure 9. Marginal rangelands in Negev Desert Israel

Figure 10. Marginal Land on home farm Morawa, Western Australia

Short term Opportunities

Water Harvesting

Figures from ICARDAs research suggest that in degraded dry rangeland environments up to 90% of rainwater is lost by either evaporation or through runoff to salt sinks. Only 10% is then available to rangeland plants (Karrou. M, Oweis. T, 2008, p19-20). This process not only loses water but significantly increase the rate of erosion. Given that our marginal land resembles the arid rangelands when not in production, a season where we may have 325mm the plants trying to establish on these marginal soils only have 32mm to survive on.

The best method to restore this situation is through water harvesting techniques. Water harvesting is the technique of capturing the runoff water in either a micro or a macro environment. At macro level runoff water is collected in small reservoirs for irrigation during dry periods or allowed to seep into the soil to recharge aquifers. The micro level is where the water is trapped and stored in the soil profile directly supporting plants that have been established in that micro environment (Karrou. M, Oweis. T, 2008, p19-20).

Research at ICARDA shows that 40 – 50%, of water, that would otherwise be lost to runoff can be saved and used by the plants. This is a critical advantage to help restore and maintain marginal land at both the establishment phase and in drought periods (Karrou. M, Oweis. T, 2008, p19-20).

The micro water harvesting technique will be crucial to us converting our non-productive marginal lands back into productive land with the establishment of commercial perennial plants. I saw a myriad of examples of how to construct both micro and macro water harvesting structures in South Africa, Syria and Israel. They all worked but all required different levels of input to construct them. Given all the examples worked, the best method for individuals in Australia will be determined by the equipment and terrain available. Appendix 6 has a number of photos of the various construction techniques I saw around the world.

Prickly Pear Cactus (Opuntia spp.) Fodder

Of all the options looked at as alternatives that can help the low rainfall zones of WA drought proof itself, the use of the spineless prickly pear (Opuntia) has shown possibly the most potential. If nothing else it is the one idea that I have received the most support on from both farmers and researchers from around the world.

Some concerns were raised as to the Declared Plant status of prickly pear in WA, but as indicated in appendix 7 it is only a declared plant above the 26th parallel. This leaves the bottom half of the state free to grow the plant.

The potential for cactus in a low rainfall farming system is almost endless. My initial idea for the use of the plant is simply as a fodder plant to be grown on the marginal lands. This plant used in conjunction with the micro water harvesting technique could potentially turn our marginal land into very productive land. At the very least I anticipate cactus changing the marginal land into a drought fodder reserve and protect the soil from erosion in the better years.

On my travels I have seen the cactus used everywhere. In the veld regions of South Africa it was used as an extensive grazing fodder that animals could graze as they please or locked away for a fodder reserve in dry periods. I also saw extensive trials of it to be used as a combined fodder and fruit plantation. In Israel I came across a huge plantation used exclusively for fruit production. It is also used widely and expanding rapidly in the Middle East and northern Africa for combating desertification, animal fodder and fruit production.

Figure 11. Ad-lib grazed Cactus

Figure 12. Fruiting cactus in South African Plantation

Cactus is also used in the Salinas valley, California for large fruit plantations. I met with John Diener, Red Rock Ranch in the irrigation district of the San Joaquin Valley, California, who is now facing water allocation restrictions. John is in the early stages of trialing the Apuncia Cactus in an attempt to maximise his restricted water allocation. This is just what I have seen without going into Mexico and South America. Somewhere along the line we seem to have got left behind on this movement in Australia for reasons that are not clear to me.

Cactus Fodder Value

According to Herman Fouché, Research Scientist with the South African Agricultural Research Council, the cactus is a highly palatable plant but its nutritional value is generally not regarded as good enough to sustain an animal for peak production on its own. However, if the cactus was all that was available such as in droughts it is capable of maintaining livestock.

The nutritional quality of cactus varies considerably depending on the age of the plant, season and fertility of the soil. Typical values for the nutritional components of the plant are moisture content 85 – 90%, Crude protein 5 – 12% and energy 2.6 Mcal/kg. Cactus when planted in rows, fertilized and weeded can achieve between 6 – 10t/ha dry matter or 60 – 100 t/ha wet matter with crude protein levels of between 5 – 12%. When supplemented with protein and some trace elements and vitamins excellent growth and conception rates can be achieve with just Cactus. It has great potential for increasing production in average rainfall years as well as providing a critical reserve of forage for animals in severe drought years Felker, 2001, p 52 – 56)

Cactus has been referred to in the USA as "Hay in the Barn". It is a live, standing hay stack that does not deteriorate in quality with storage and can survive for 100 years. Even during drought periods in the summer or winter the plant remains green, full of vitamin A and water which means the animals are not required to walk great distances for water as almost all requirements can be met by the cactus plant (Felker, 2001, p 52 – 56)

Agronomic Ability of Cactus

Without question cactus is an extraordinary plant. It can survive in arid rainfall zones down to as low as 50mm. Annual rainfall of between 100 – 150mm corresponds to the minimum requirement to successfully establish a rain feed plantation. It has a rain use efficiency unsurpassed by just about any plant. Cactus can produce 40kg/DM/mm/yr compared to wheat of 13.3kg/DM/mm/yr (Kock, 2001, p102).

The cactus has a unique root system that gives it the ability to survive in shallow soils with minimal moisture. Eighty percent of a cactus root mass is located within 50mm of the soil surface. It also has the unique mechanism of producing rain roots within four hours of a rain event. These roots grow at a rate of 25mm per hour and last for 2 – 3 days allowing the plant

to absorb all the moisture available within a very short time (Fouché, personal communication, July 2009).

Fodder Management of Cactus

There are three easy ways of feeding out cactus cladodes (leaves) that could be implemented in our low rainfall systems. The first is simply grazing. The plantation can be opened up to the animal to graze as they wish. This is the least efficient way, and can lead to significant damage to the plant if not managed properly. It is also the cheapest and least labour intensive of the options.

Second is supplementary feeding with whole cladodes. This is where the cladode is removed from the plant and fed out to the animals as a supplementary feed. The management of the plant is more controlled and efficient in the use of the plant with this system but more labour intensive.

Finally is the shredding of the cladode. This is where the cladode is removed and run through a shredder to produce long strips of plant that are placed in feeding troughs. This gives maximum utilization of the plant but the costs and labour requirements are also the highest (Kock, 2001, p104).

Figure 13. Meatmasters supplementary fed with shredded cactus cladodes

As previously mentioned I can see a big role for this plant in helping to stabilise our farming systems in drought years. The possibilities with this plant are endless. Later in this report I

will be covering other uses of the Prickly Pear that can be value added, further increasing the value of this plant.

Fodder Shrubs

The use of fodder shrubs has been extensively researched, trialed and implemented by farmers throughout Australia for many years. The bulk of this work I have observed is the use of *Atriplex* (Saltbush) on saline land. Something I saw throughout the veld in South Africa and the arid lands of the Middle East in the use of saltbush plants on the shallow, marginal, degraded areas in these arid environments. Dr Karrou, ICARDA suggested that saltbush is a hardy, drought tolerant shrub that is native to the Mediterranean, arid climates. Until now I have seen little reference to saltbush been utilized on marginal land other than saline land in Australia.

Figure 14. Saltbush (Atriplex) established on degraded rangelands in Syria

Simple observations through the recent droughts showed that saltbush, in particular the native bluebush in our local environment was very capable of surviving in areas other than the saline areas. This observation along with the experience of farmers and researchers in other arid areas of the world suggests that the use of saltbush would be an excellent tool in returning our marginal land to productive grazing areas. The utilization of water harvesting would further enhance this process.

Medium Term Opportunities

Native Perennial Grasses

Possibly the most over looked asset we have in our local environment in the low rainfall zone of WA is the native grasses. These grasses have evolved and adapted to the local climate and soil conditions over millenniums. Fortunately many of these grasses still exist in remnant vegetation areas in the marginal lands that sheep have not been able to get to. Rather than trying to force a perennial grass or shrub into the area that is not acclimatised to the conditions we should be looking at the potential of the native grasses that already exist in the area.

Figure 15. Native Australian perennial grasses established in fenced off areas on the authors farm Morawa, Western Australia

The native grasses found locally need to be identified and the potential of each specie evaluated. From there the agronomic requirements and grazing management of these species would also need to be investigated. Some of this work may have been done in other areas that may help to speed the process up.

The Koroo and Kalahari veld regions of South Africa presented the best example of managing palative perennial native grasses I had observed around the world. The Worcester Natural

Veld Research Station, located on the edge of the Koroo region in a 210mm rainfall zone has done some excellent research into the identification and management techniques of native South African grasses. This work is used throughout the veld region of South Africa in re-establishing degraded areas of the rangelands.

Arid Land Perennial Grasses

Throughout the world a number of perennial grasses native to the arid lands have been identified as useful for grazing and re-establishing degraded areas. I have identified two that I think could be available and useful to the low rainfall zone of WA. These are the Desert Grass (*Panicum turgidum*) and Hartbeesgrass (*Chaetobromus dregeanus*)

Desert Grass

Desert grass is a warm season specie that grows in regions with annual rainfall of 200 – 250mm and sometimes even less. It is distributed from Mauritania and Senegal eastwards through the Sahara and Sahel to Sudan, Ethiopia, Eritrea and Somalia, and through northern Africa and western Asia to Pakistan and India.

Dr Mounir Louhaichi, ICARDA Range Ecology and Management Research Scientist, said that Desert grass is considered to be very palatable to sheep and goats when young or with fresh growth. It is regarded as a very drought resistant grass suitable for fodder and ICARDA are researching further the value of the plant for Human food and many other potential uses (Louhaichi, personal communication, August 2009).

Figure 16. Desert Grass ICARDA research centre Syria

Hartbeesgrass

Hartbeesgrass is native to the west coast of South Africa. It originally extended from the mouth of the Orange river to Cape Town and was especially prolific in the drier parts of the winter rainfall region. The Worcester Natural Veld Research Station regards this as one of the most productive native grasses in the lower Koroo region of the veld where the rainfall is predominately winter. They have done extensive research on the grass along with new mechanical harvesting and sowing techniques. This is also the only grass they have commercially available for sale throughout the world.

Figure 17. Hartbeesgrass, Worcester Natural Veld Research station South Africa

Figure 18. Native rangeland grass sowing equipment Worcester Natural Veld Research station South Africa

Mixed Perennial Populations

The ultimate perennial pasture for the marginal lands would be a mixed population of cactus, saltbush and perennial grasses. It is widely regarded that cactus is high yielding, highly palatable and a readily available source of carbohydrates but lacks crude protein and crude fibre, Therefore to get the best performance out of cactus it needs to be supplemented with a cheap source of fibre and protein (Nefzaoui, Salem, Salem, 2000, p512 – 516).

Trials conducted in Tunisia in the 1990's indicated that Cactus could be sufficiently supplemented with *Atriplex* and small amounts of hay and grain to achieve a daily weight gain in ewe lambs of 100g/day. The hay and grain can successfully be replaced with perennial grasses and Saltbush to achieve the desired levels of protein and fibre to achieve good growth rates in animals (Nefzaoui, Salem, Salem, 2000, p512 – 516.

In establishing the mixed perennial pastures considerable care would need to be taken when determining the ratios of each fodder plant in the population. In the above trial the Cactus was fed *ad libitum* while the consumption of the supplements was carefully controlled. In order to reduce the over grazing of the cactus in a mixed population the percentage of cactus in the population would possibly need to be a lot higher than the *Atriplex* while the perennial grasses would also need to be established in large volumes to avoid over grazing also.

Stewardship of Remnant and Marginal Land

It is generally accepted that if the climate is changing then the dryer arid lands of the world will experience even more and extended periods of droughts than they currently do. Outside the agricultural use of these areas they also provide vital environmental services to the general community in the form of nutrient cycling, water purification and supply regulation, pollution filtration, carbon sequestration, biodiversity protection and erosion control. The same conclusion could be made for the remnant vegetation and marginal lands of the Wheatbelt of WA. Even with new techniques, farming of these lands will continue to put environmental pressure on these areas.

One solution to this is being investigated by ICARDA in the form of payment for environmental services. I imagine this would be similar to the CRP in the US. Recipients of the natural environmental services pay farmers to conserve the rangelands, thus maintaining the environmental services. In the low rainfall zones of WA this scheme would protect our remnant vegetation and allow the marginal land to be re-habilitated and locked away for good. A scheme such as this would need to be evaluated by the community and government agencies. The loss of production would also need to be considered in the light of the fact there will be no more new agricultural land available in the future.

Saltland Utilisation

Salinity is a well know issue in the wheatbelt of WA. The problem is at its worst in the low rainfall zones of the wheatbelt where low rainfall with high evaporation combines to produce the ideal environment for salinity to develop. There has also been considerable work done on how to combat the further encroachment of salinity and attempt to reclaim saline areas. A part of combating salinity is the use of salt tolerant perennial plants for grazing. Until now the majority of the focus has been on the use of *Atriplex* (saltbush) in our environment. For saltbush to be utilized fully by livestock they require roughage that is free of salt.

During my travels I was fortunate enough to come across a number of halophyte fodders that could fulfill the role of the roughage or add to the grazing value of saline land. Better utilization of our saline land is an important part in helping stabilize our farming systems during dry and drought years. Saline areas are largely underutilized at the moment and have the capacity to serve as a fodder bank during droughts.

Medium Term Opportunities

Halophyte Fodders

Saltgrass (Distichlis spicata)

Saltgrass, also known as Desert Saltgrass, is an indigenous perennial specie found in the arid and semi-arid regions of the world. The plant is abundantly found under the worst salinity, sodicity and drought conditions in the western regions of the United States, as well on the seashores of several Middle Eastern, African and South and Central American countries. (Pessarakli, Marcum, Kopec, 2001).

According to Dr Amnon Bustan, Ben Gurion University, Saltgrass is regarded as a very good fodder for livestock (Bustan, personal communication, August 2009). Saltgrass is available commercially in Australia through NyPa Australia Ltd. It is sold under the brand name NyPa Forage. NyPa Forage is the result of 20 years of breeding for larger leaf size, softer growth, palatability and tolerance to high salt concentrations.

Puccinellia (Puccinellia ciliata)

Puccinellia is another perennial grass highly tolerant to salinity and water logging. This is also available commercially in Australia under the brand names Menemen or Restora Sweet Grass. Along with the NyPa Fodder it is the most salt-tolerant of all the commercially available grasses suitable for highly saline scalds ("Solution 6", n.d).

Puccinellia is highly palatable when plants are actively growing in the winter time. During summer the palatability drops off as the plant dries off. Puccinella stands commonly support 5dse/ha but with appropriate grazing and fertilizing dry matter yields can be doubled and stocking rates of 6-8dse/ha can be achieved. At these stocking rates live weight gains of 120kg/ha have been achieved over a season (Solution 6", n.d).

Puccinellia pastures have been widely adapted in the upper south east of South Australia with at least 200,000ha having being established to date. This level of adoption gives some indication of the suitability of this plant to saline environments. John Diener, Red Rock Ranch California, believes the Puccinellia to be the best of the salt tolerant perennial grass species, after many years of trialing all the various types on his property (Diener, personal communication, September 2009).

Figure 19. Dormant, heavily grazed Puccinellia plants in California growing in soil covered in white salt

Salicornia

Salicornia species are a small, usually less than 30cm tall, succulent herb. They grow in salt marshes, on beaches and among mangroves and are native to North America, Europe, South Africa and South Asia. Salicornia is been utilized and trialled all around the world for a variety of end uses. I saw extensive trials of salicornia in both Israel and the US utilizing all types of environments and water quality.

Dr Moshe Sagi, Ben Gurion University, made reference to salicornia being a very good fodder plant, especially in the production of milk in cattle (Sagi, personal communication, August 2009). A trial run in Kuwait using salicornia irrigated with seawater found that the salicornia forage can partially replace conventional forage as a source of roughage and energy for small ruminants (Abdsal, 2009, p1033).

Figure 20. Salicornia, University of Arizona

Other Halophyte Fodders

During my travels numerous types of halophytes were mentioned to me as having potential use for our environment. Of the species not referred to in this report there are two that may be worth looking at in the future for perennial salt tolerant grazing plants. These are *Ditchgrass* and *Paspalum vaginatum grasses*.

Saltwater Utilisation

As previously stated salinity is a well known issue that seriously affects the low rainfall zones of the Wheatbelt of WA. Salinity is generally regarded as a production inhibiting problem that needs ways to combat it and reverse the procedure. There is potentially more value in working with the saline land rather than trying to eradicate it.

With the technique of deep drainage, the salt water in the saline areas can be extracted and utilized as a resource rather than a byproduct of salt land reclamation. During the worst of the drought in 2006 - 07 the water in our drainage system did not stop flowing indicating that this water is available as a potential drought proofing resource. In some areas of the low rainfall zone the quality of the water is very similar to seawater in salt contents and ph. This then has potential for use in aquaculture ventures similar to those using seawater for marine organisms.

Short Term Opportunities

Brine Shrimp (*Artemia)*

Artemia, commonly known as Brine or Fairy Shrimp, are small filter-feeding crustaceans highly sought after by the aquarium industry as a live, fresh or frozen feed for fish. They are also used widely in the fish and prawn aquaculture sector as a live feed for larvae and juveniles. While *Artemia* are found naturally in brackish and saline water bodies throughout the world almost all that are used commercially are bred/hatched from drought resistant eggs or cysts imported from China and the United States. *Artemia* have the ability to thrive in salinity levels of between 36 – 200ppt (six times seawater salinity) (Sarre, 2008).

A pilot project for the production of Artemia has been underway on my property in conjunction with the Morawa Farm Improvement Group (MFIG) for more than eighteen months. Production trials being run at Fremantle Challenger TAFE using saline drainage water from the area and utilizing the production system being developed by TAFE have indicated equal or better production figures than using seawater (Michael, n.d). A Marketing report prepared by Dr Gavin Sarre indicates good demand for a locally produced Artemia product in the local Aquarium industry (Sarre, 2008). Subsequent contacts with potential consumers have shown considerably more demand than that indicated in the report.

Figure 21. Morawa Farm Improvement Group brine shrimp trail tanks

Figure 22. Adult Brine Shrimp (Artemia)

A similar size pilot project has been set up at the Red Rock Ranch (RRR) in Northern San Joaquin Valley, California. This project was established to see if it Brine shrimp was capable of removing toxic levels of selenium from saline drainage water from the irrigated agricultural regions. They have also identified the potential of a locally produced product for the aquarium industry (Diener, personal communication, September 2009).

Discussions with a number of Aquaculture specialists throughout Israel support the potential of a locally produced live and frozen artemia product. The would have had concerns that if we were attempting to produce just the Artemia cyst then we would have been at serious risk not being competitive against larger producers in China and other countries.

Medium Term Opportunities

Integrated Aquaculture Production Systems

An excellent option in the medium term is a system developed in Israel known as the integrated aquaculture production system. This is where the excretion and used water from an intensively raised organism such as fish is moved onto another cultured specie in a separate module to be utilised by the next organism. At the National Centre for Mariculture in Eilat, Israel they have developed an integrated system that starts with sea urchins and abalone tanks, then the intensive fishponds and finishes with a three stage *Ulva Lactuca* (seaweed) biofilter which cleans 50% of the water to be recirculated back into the fishponds. This system

significantly reduces costs by reducing the high rate of water exchange, or water treatment and recirculation that traditional aquaculture systems operate with (Schuenhoff, Shipigel, et al, 2002, p167-168).

I see this system being able to be used in a similar way with the Brine Shrimp production and the irrigation of a halophyte plant such as the salicornia. An additional trial run at the National Centre for Mariculture is using salicornia instead of the seaweed as the biofilter. The Kibbutz Mashabei Sade in conjunction with Ben Gurion University were also trialling removing ammonia from the waste water from their fish farm with salicornia then selling the salicornia for human consumption (value adding of salicornia is mentioned later in this report). Salicornia may not be the only halophyte plant that could be used to irrigate with the water brine shrimp water. It maybe that saltbush and the other halophyte grasses could be successfully irrigated to increase the volume of fodder produced.

Long Term Opportunities

There are a myriad of longer term opportunities available to the utilisation of inland saline water. Most of these will be determined by the future direction of the aquaculture industry in Australia and most importantly the level of expertise available to assist in the establishment of these ventures. The best of these options I have mentioned below.

Marine Ornamental Fish

There a number of examples of ornamental fish farms in Israel using salt water to grow marine ornamental fish. There is one particular farm that has been developed by the farmer that is extremely efficient to run once established. The main restriction to marine ornamental fish farming is the time commitment, labour requirements and level of expertise required by the operator.

Farmed Table Fish

According to Dr Gavin Sarre there is some potential for the production of small crops of marine fish that target niche and local markets and thus can obtain higher prices, particularly if value added. Pilot commercial production trials conducted at Northam, WA indicated that commercial scale fish farms using open saline ponds would require a break even production of 50t/fish/annum. For this to be achieved the operation would require a significant start up

capital investment and access to water volumes well in excess of those available in the local environment. Therefore large scale production of farmed table fish in unviable.

A fish that could be used on a small scale, low cost operation is the Tilapia. This is a very hardy fish that does not require such intensive management but is very productive at the same time. Around the world the Tilapia has the fastest rate of adoption in aquaculture production of any fish. It is a highly sought after product in Europe, the US and Mexico (Dr Edward Glen, University Arizona, personal communication, Sept 2009). Unfortunately, tilapia is a declared specie in Australia and cannot be imported for farming at this stage.

Disease Free Brood Stock of Shrimp

Dr Edward Glenn suggested that there may be in the future some potential to raise the brood stock for commercial shrimp farms. According to Dr Glenn the shrimp industry has significant problems in raising disease free brood stock to grow out. He suggested that a production facility independent of the ocean and other shrimp farms may be able to carry out these requirements. An obvious restriction on this is the access to shrimp farms in WA and the costs of producing a product for someone else in Australia or the world.

Water Treatment and Salt Recovery

A trial running in conjunction with the Brine Shrimp trial at the Red Rock Ranch, California, is the treatment of the saline water to extract the salts from it. Here they are looking at the methods and feasibility of extracting toxic trace elements from the saline drainage water and removing the salts into their individual elements so they can then be on sold for industrial use.

Chemicals such as Sodium Sulphate that can be extracted are used for textile dye as well as in the manufacturing of glass. Calcium Sulphate (gypsum) is used as an agricultural soil conditioner. There are other chemicals that can be mined such as calcium chloride, sodium chloride and boron compounds that all have commercial value. The secret to the success of this project is the ability to extract the chemicals economically and finding the expertise in Australia to oversee such a venture.

Agroforestry

Agroforestry is a well researched and in some cases a well established part of the farming system in the low rainfall zone of the WA wheatbelt. To date agroforestry in this area has been dominated by the oil mallees. Although the research into oil mallees has been extensive and plantations well established throughout the state there has been little advancement in the industry as a commercial venture.

Medium Term Opportunities

Native Tree Crops

As previously mentioned the oil mallee has already been identified and established for its potential commercial value in oil, biochar and carbon sequestration as well as environmental value in controlling salinity, wind and water erosion and providing habitats for native animals.

Other trees and shrubs that have potential as commercial crops in the low rainfall zones are the Broombrush and Sandalwood tree. There may be a myriad of other native trees that could also have commercial value in the future, especially those that come from the desert to produce desert fruits. These may have some way to go before they are established as viable options within agroforestry enterprises.

Alternative Tree Crops

The Ben Gurion University and the Arava Institute in Israel have undertaken a program of looking at alternative native trees from arid and semi-arid areas of the world that can be utilized as commercial crops. Dr Solowey, Arava Institute believes the indigenous fruit and nut trees are an undervalued resource, ignored and neglected for many years by the scientific and economic powers but often the mainstay and lifesavers for those with no money (Solowey, 2006, p1).

Dr Solowey has also questioned why indigenous fruit and nut trees in arid areas that survived with no cultivation and irrigation, were resistant to local pests and diseases and attuned to the local climate were cleared to make way for imported trees that required irrigation and high levels of maintenance such as apples and oranges (Solowey, 2006, p4). By raising these questions a number of new tree crops have been identified for the arid regions of the world.

From these I have selected three that I believe could suit our climate, fit within our farming systems and have a commercial value within Australia.

Pomegranate

The pomegranate is an ancient fruit originating in the Middle East region. Currently it is cultivated throughout the Mediterranean region of Asia, Africa and Europe. Israel is heavily involved in researching the fruit as an alternative crop for the Negev Desert with particular emphasis placed on its drought and salinity tolerance. According to Dr Lazarovitch, Ben Gurion University Israel, Pomegranate is a drought hardy plant but in a 300 – 400mm rainfall zone additional irrigation would be required for optimal fruit production

The pomegranate is a small tree growing 4 - 5 metres high that produces a large bright red fruit. The market for pomegranate is in fresh fruit and fruit juice. In recent times, the products of pomegranate have seen a dramatic increase in demand due to the growing evidence that it contains powerful agents against cancer (Portman, Johnston, n.d)

Figure 23. Pomegranate fruit

Marula Tree

The marula tree is indigenous to southern Africa. It is highly drought and salt tolerant which has made it ideally suited to Namibia, Botswana, Zambia and Zimbabwe where it is found in abundance from bushveld to woodlands (“The uses and properties”, n.d, p1)

The Marula trees are from the same family as the mango, cashew and pistachio nut. It has a plum size fruit covered in a soft, leathery, pale green exocarp which encloses the juicy white flesh. The tree is deciduous and grows to a height of 15 – 20m in its natural state (The uses and properties", n.d, p1).

The Marula has a number of very useful and potentially commercial uses identified by Dr Solowey from the Arava Institute, Israel. The fruit and leaves can be utilized as fodder for livestock, fresh fruit, nuts, oil, wood and the most well known use of the Marula trees is the fermentation of the fruit for the production of the popular liqueur, Amarula. A very important trait of the Marula tree for its potential adoption into Australia is that it is a non-invasive specie (Solowey, personal communication, August 2009)

Figure 24. Marula tree, Arava Institute Israel

Figure 25. Marula fruit, Arava Intitute Israel

The Arava Institute is developing and improving the breeding of the tree as another alternative tree crop for the Negev desert in Israel. Dr Solowey has identified that the Marula tree uses about 1/3 of the water that an average tree crop in the area utilizes, making it an important alternative crop in a water restricted desert climate.

Olive Trees

Olive trees are obviously nothing new to Australia; nether is its well known trait of being highly drought tolerant. However, having seen the tree grown in dry land environments in Syria with no irrigation and in the Negev desert with nothing else other than micro water catchment techniques the tree may have potential to fit in a low rainfall farming system in WA.

Figure 26. Extensive Olive plantation in Syria using micro water harvesting

The trees in Syria were generally grown in small plantations and well spread out to suit the area where the annual rainfall was between 250 – 300mm. The Olives in Israel were a trial run by the Ben Gurion University, where in an 80mm rainfall zone they had an olive plantation that survived on only water harvested from runoff water in a dry river bed. In Israeli terms this was not a viable plantation because the production was very low compared to the high tech irrigation plantations that is normal there, but in a less intensive situation, with less capital requirements and less requirements for high output this type of plantation may work in Australia.

Macro Water Harvesting

From the examples I have seen around the world agro-forestry plantations in a low rainfall zone can be greatly enhanced by the use of macro water harvesting. This can be either a

flooding of the plantation of the harvested water when the event occurs or capturing the water in a reservoir and supplement irrigating when required. Micro water harvesting could also be utilized by shaping the tree beds to capture and maximize any rainfall events.

Figure 27. Acacia Plantation in Negev Desert Israel using macro water harvesting techniques in an 80mm annual rainfall zone

Careful consideration of labour requirements, management techniques, costs, market availability and financial returns would be required of any agroforesty venture. Although the alternative tree crops I have mentioned look like they could be grown in a low rainfall zone of WA there would need to be considerable work done on trialling the plants and investigating the markets for the products before it could be determined as a viable alternative.

Value Adding

With dry and drought years our production will clearly be down on average type years. The obvious way to mitigate some of this loss in production is to maximize the value of what is produced. Value adding is a well recognized addition to farming in Australia, but in practice is rarely used in our traditional farming systems in the low rainfall zones. Having met with many farmers on our Global Focus Program around the world who have successfully added value to production from their properties, it became clear that it is possible and necessary in some cases for farmers in our area to seriously look at this.

Value adding is one step removed from farming that is time consuming and in many cases expensive to set up. I believe it will not be necessary for the individual farmers to try to attempt this process themselves rather they have a stake as possibly a silent partner or co-operative member in a localized value adding venture, either within the individual farming operation or the local community. This would free up the farmers time to get on with farming and at the same time offer an excellent opportunity for groups or individuals to set up additional businesses locally. This scenario would be great for local communities with all the flow on benefits from new businesses and employment opportunities.

Many of the options that have been presented in this report have very real opportunities for value adding into niche markets. I have seen examples of all the value adding options listed below in my travels so they are possible. With the use of local farmer markets to test the market, I believe these can be achieved.

Fat Tail Sheep

The very nature of the fat tail sheep allows opportunities for value adding. The characteristics of the animal needing very little human intervention can be used as a marketing tool, as well as the localized fat can attract good money when utilized in specialized products such as South African sausage products.

Cactus Fruit and Candy

A growing market around the world is the cactus fresh fruit. I saw some very good examples of where the fruit is further value added into other products such as candy and jellies. The Mexicans also use the young cladodes (leaves) as a vegetable known as nopalitos which could be an opportunity in Mexican restaurants.

Figure 28. Cactus Jelly, Arizona USA

Halophyte Plants

Both Atriplex plants and salicornia are picked and packed as fresh vegetable products throughout the world. The salicornia in particular is popular in Europe in cooking and in fresh salads as a garnish. It is cut and bunched similar to asparagus which may have a small niche market locally or in Asia.

Aquaculture Products

Marine organisms can be value added in many ways. The one that is the closest to reality in our environment is value adding the Brine shrimp. This can be done through the various methods of packaging the product as either live or frozen or nutrient enriching the Brine Shrimp to suit the requirements of individual customers.

Figure 29. Nutrient enriched brine shrimp, Israel

Management Systems

I was unable to come across a singular 'silver bullet' to drought proof a property in the low rainfall zone, rather a combination of many pieces that could possibly achieve this outcome. With the suggestion, that a combination of some of these may be needed as a way of drought proofing the need for control of the whole system will be required. For a farming operation to keep costs down and remain sustainable in this environment all the individual components within that farming system will need to work together, rather than acting as separate, stand alone operations.

What became clear to me as I traveled around the world was the most successful farmers I met were the ones who understood this and put it to practice in some form. To categorise this is to refer to it as a 'holistic view' of farm management. Nuffield Scholar, Tim Napier, broke this holistic management into three sections known as the 'Triple Bottom Line' consisting of economy, ecology and community.

Economy

Financial analysis of each aspect of the farming system will be critical. This is generally well understood and well done by most farmers. Unfortunately this is often the only focus of many businesses with financial profits being subsidized by the decline in the value of the natural ecology and/or the decline of the local community (Napier, 2006, p 11).

Ecology

We cannot afford to negatively impact on our environment in an attempt to make a profit using farming systems that are not sustainable in a dryer climate. This is amplified in a drought when these practices can devastate the environment. This is when we need the new, sustainable farming systems, suited to that type of climate to fall back on to carry us through the dry times without effecting the environment. The practice of 'mining' our delicate resources by depleting them and not renewing them is obviously incapable of being sustained in the long run (Napier, 2006, p 11).

Community

No farmer wants to be seen as the one responsible for the degradation of the environment or having a bad effect on the local community. We can challenge the community and question, what is the right way to farm within the community, without impacting adversely on others. As farmers, regardless of our enterprise, whether we like it or not, we are being required to maintain a 'social license' to manage the land for our personal profit. This community expectation of responsible environmental practices for community benefit is growing in influence both in the market place and in politics. Along with the right we have to exploit the land comes the responsibility to do it in such a way that we are not degrading it (Napier, 2006, p 12).

The implementation of the holistic view of farm management using the triple bottom line to measure the sustainability of the farming operation can be done so using one of two recognized management systems. These are **Holistic Management International** and **Biological Farming**. Both these systems appear to be excellent tools to implement the holistic view of farm management.

The secret to drought proofing our farming operations in the low rainfall zones will not be just the introduction of new, suitable farming systems but also how they are implemented into the

new environment. This is why I believe a management system such as the 'holistic view' will be critical in ensuring the new farming systems are integrated, sustainable, profitable and have a positive effect on the environment and community.

Recommendations

I have no intention of suggesting that everything I have presented in this report be implemented by all farmers. My recommendation is that farmers and researchers may wish to investigate these alternatives if they aim to drought proof their business going into the future. There will need to be extensive on farm demonstrations and small plot trialling of many of the ideas. There will also need to be work done on the marketing and processing potential of some of these options.

I also believe that if it is to become a reality that our area can drought proof itself there will need to be incentives from government. Implementing more suitable farming systems not only benefit the farmers but the wider community also. Therefore some consideration should be given as to how the community could assist agriculture to adapt for the good of all.

Conclusion

To quote Al Gore "There is no silver bullet, only silver buckshot". In other words there is no one single solution to drought proofing our properties in low rainfall, marginal areas rather a combination of options that can assist in drought proofing. Instead of persisting with one thing that may be unsustainable we will need to cast a wider net to adopt new ideas that are viable and sustainable moving into an uncertain climatic and economical environment.

To do this there will need to be change in mind set of all involved in agriculture. It is quite feasible that a sustainable farming enterprise in the future in the low rainfall areas will be very different to the ones we are used to today.

Ultimately the implications of changing, is that it will have a less risky and more sustainable farming system for both ourselves and future generations. Even if our climate returns to normal this will still hold true and at the very least we will have the confidence of how to farm in a harsher climate.

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Appendices

Appendices' are available at www.nuffieldinternational.org/append.html

Plain English Compendium Summary

Project Title:	Drought Proofing the Low Rainfall Agricultural Zones of Western Australia

Nuffield Australia Project No.:0905

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Objectives

- Identify alternative farming systems that could be adapted to suit a dryer climate in the Low rainfall zones of WA
- Identify alternative methods of existing farming systems already utilised that can cope with dryer conditions.
- Reinforce or change current plans we have put in place on our property to address our viability through dry years.
- Develop a farming operation where a normal budget would rely on less than 50% of traditional farming system to generate the income, therefore reducing exposure to financial risk in droughts.

Background

A series of droughts during the first decade of this century coupled with numerous warnings of a potential dryer climate and worsening economic conditions in agriculture lead me to the realisation that our traditional farming practices in the low rainfall agriculture zones of WA were possibly the most risky in the world.

Facing the potential of another drought at the beginning of 2008 the decision was made to look for alternative, less risky and more sustainable farming systems to carry us into the future

Research

The study consisted of the Global Focus Program visiting New Zealand, England, France, Belgium, Brazil, Mexico, Canada and the United States. Following this a further ten weeks of individual studies concentrating on countries with similar climates and a modern agricultural sector or internationally renowned research centres. This consisted of South Africa, Syria, Israel and the United States

Outcomes

No single answer was found rather a combination of numerous options. Many of the options are livestock or livestock related. There is a renewed focus on our natural resources along with the re-introduction of old plants and old, forgotten plant and animal genetics. There are options available to maximise the returns on production through value adding and improving the introduction of new systems with a 'Holistic Management' system.

Implications

Implications are going to be for farmers, researchers, Government Departments, commercial business and consumers. Among other things there will need to be 'change in mind set' for all these individuals. Ultimately changing to suit a dryer climate will lead to less risky, more sustainable farming systems for now and future generations.