

Irrigation essentials

for North Coast farmers in NSW



by **Richard Swinton and Gary Creighton**

NSW Department of Primary Industries



Water is a precious resource with a growing number of users, rural and urban, competing with the need to maintain environmental water to protect the health of the rivers.

Crunch decisions again

Drought grips 76 per cent of NSW

82 per cent of NSW now in drought

THE continuing dry weather and heavy frosts have resulted in an increase in the area of the State experiencing drought conditions.

The latest information from the Land Protection Boards shows that 82 per cent of the State is now in drought. Moderate show August on the N lands and Nor welcome but it needed to turn things heavy frosts have been in the north with

Drought:

Big dry extends across two thirds of State

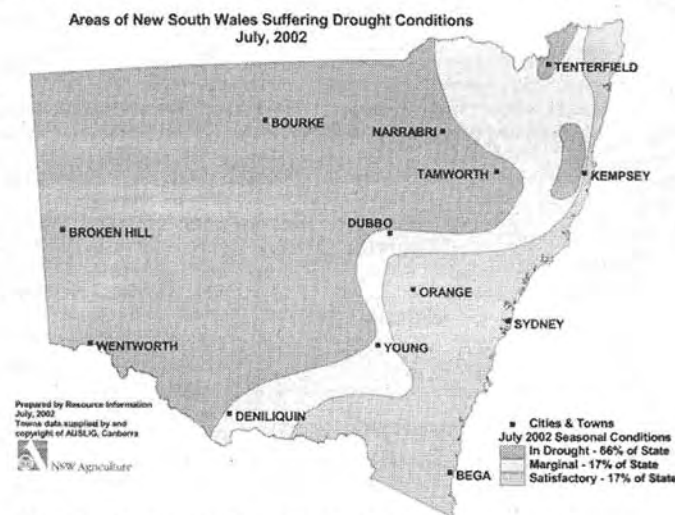
SEVERE winter frosts and continuing dry conditions have resulted in an increase in the area of the State in drought.

The drought-affected area has increased to 66 per cent of the State while another 17 per cent is considered marginal.

New drought areas are located in the south west slopes, with an increase in the marginal area in the northern tablelands and east towards the coast.

In the north only about one third of the winter cereal crop has been sown due to lack of soil moisture, and it now looks like the window of opportunity for sowing in that area has passed.

Frosts as low as minus 14C over the tablelands and slopes in the latter part of June have had a severe impact on livestock condition and pasture quality.



Stock water remains a critical issue in most areas of the state, with no significant rainfall occurring to improve water storage levels.

New Director-General of

Agriculture, Richard Sheldrake, has reported on the current situation and provided the State Government with a range of options to assist landholders.

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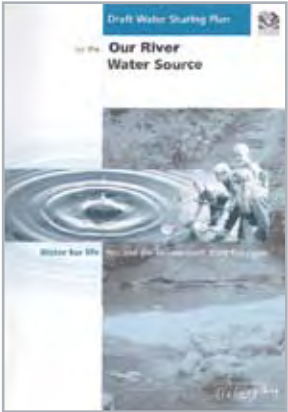
Access to water is becoming more problematic as drought, climate variability, and possibly climate change take hold.

Introduction

So you have an irrigation farm – or you’re thinking of irrigating? This booklet has been prepared to provide important information for all irrigators – experienced or newcomers.

Throughout Australia governments are developing plans and rules to try to ensure that humans, their enterprises, and the environment, get a fair share of available water. The old days of pumping water when you want it are gone. Irrigators now have to plan ahead and justify their requirements.

Irrigation Essentials outlines principles for useful, profitable and efficient irrigation. It also examines irrigators’ legal responsibilities and explores options when water access is limited. It is not designed to be an almanac of everything to do with irrigation, but it will point out the critical things you need to know.



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Why should I irrigate?



Even in relatively high and reliable rainfall areas like the north coast of NSW, natural rainfall patterns do not match the water requirements of many of our commercial crops.

North coast spring seasons tend to be dry, but this is the season when many crops need water to guarantee crop yield and quality. Small showers are not effective because most of the water evaporates quickly from the soil surface.

Without irrigation, a fruit crop, for example, may yield half the weight and, equally importantly, the fruit may be too small or the quality too poor to sell at a profitable price.

As one north coast horticulturist told a Government water official while holding up two very different size peaches;

“This peach was not irrigated – it’s too small and yields no profit after costs; THIS much larger peach was treated identically except that it was irrigated – result, a healthy profit!”



North Coast irrigated dairy pasture provides quality feed compared to the unirrigated fields behind.

Efficient irrigation



This portable pump unit, situated low on the Clarence River bank for maximum efficiency, provides water for a broad area cropping system and can be easily moved away from flood damage.

Efficient use of irrigation water means more crop can be grown for a given volume of water, an important factor now that water supplies are becoming limited and expensive. Increased competition for water now means that the whole community is looking carefully at how irrigators use their water.

Efficient irrigation reduces operating costs because less water has to be pumped for a given yield. It also means that on-farm dams can be smaller because less water is needed, an important consideration now that irrigators face restricted access to rivers.

Inefficient irrigation can lead to water and nutrients draining through the root zone, which is a waste of water and fertilisers and leads to rising and contaminated water tables. Inefficient water use can also mean unnecessary pumping from rivers.

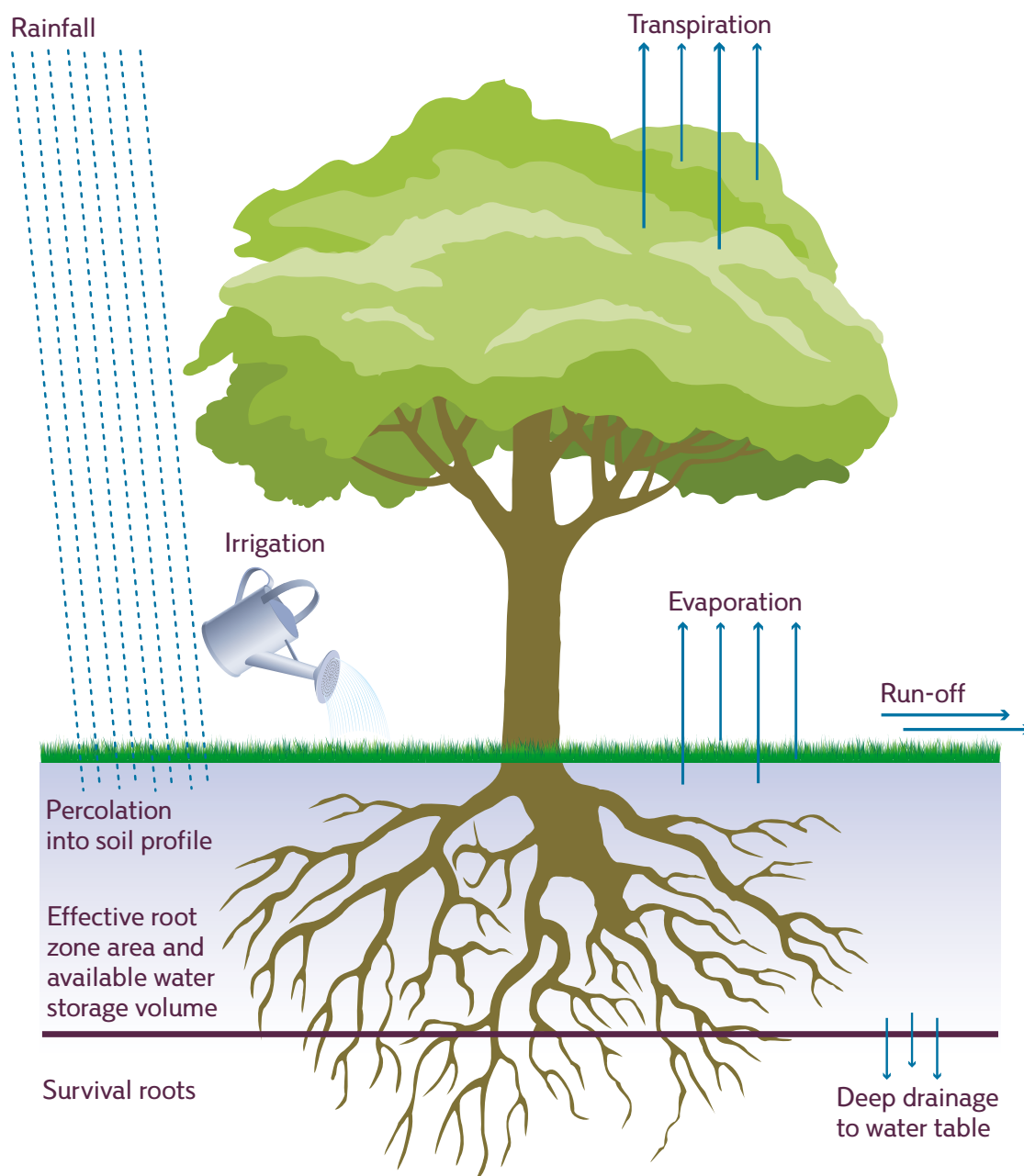
What determines my irrigation needs?

Since most of our crop plants get their water through their roots, the amount of water available to a plant is determined by the capacity of the soil in the rootzone to hold water. This is measured as millimetres of water per metre depth of soil. Sandy soil may hold as little as 25mm, and clay soil as much as 60mm, but the clay holds onto the water very tightly, so only a portion of the 60mm is actually available to the plant. A well structured healthy loamy/silty soil has the most **Plant-Available Water**.

Irrigation Water Balance Model

Water inputs

Water losses



Root depth

The total amount of water is also controlled by the root depth since a shallow-rooted crop will have less water available than a deep-rooted crop. Most crops have an effective root zone below which roots still exist, but they use so much energy to draw the water up from depth that the plant moves into survival mode and ceases to produce – in fact it may become so stressed that it aborts whatever produce it has developed. These deep survival roots are why crops don't die when the readily available water is used. That is useful strategy for a bush plant, but not for a profit-making crop!

Plant water use

The rate at which a crop extracts water is determined by the evaporation rate. Most water used by a plant (90%) is pumped up from the roots and transpired from the leaves to keep the plant cool. Plants transpire (evaporate) water faster on sunny windy days, ie the days when washing dries most quickly. Dry, hot, windy conditions increase their demand for water. Cool, humid, still conditions lower their demand.

Readily Available Water

Different crops have different abilities to extract water before they stress. A lettuce or strawberry crop, for example, may start to wilt and degrade soon after irrigation, while a cereal crop can extract more water from the soil before it stresses. So Plant Available Water has to be corrected to Readily Available Water for different crops.

Plant growth stage

Root zones also change as plants grow and mature. Seedlings, with shallower and developing roots, run out of water much sooner than mature plants even though the mature plants cover a larger area and have more leaves to evaporate the water.

GENERIC CROP FACTORS

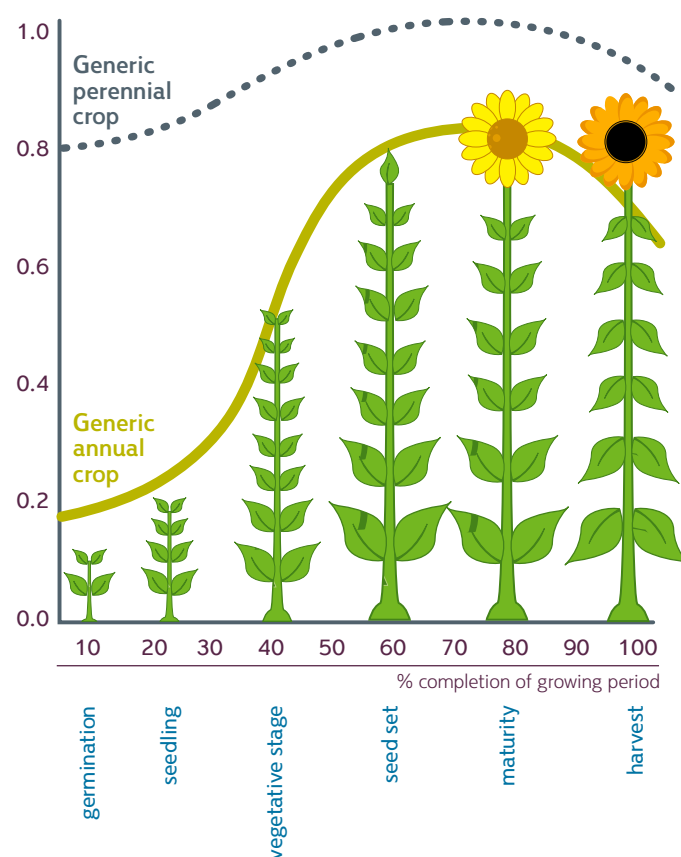


TABLE 1: READILY AVAILABLE WATER HELD BY DIFFERENT SOIL TYPES

Note: The following table allows for 4 classes of plant sensitivities – very sensitive to very tough. The volumes listed are for a metre depth of soil. Where plant roots are less than this, the water volume available to the plant is proportionately reduced. The red kraznozom soils on the north coast would sit as a medium to heavy clay.

	A: Water-sensitive crops such as vegetables and some tropical fruits	B: Most fruit crops and table grapes, most tropical fruits	C: Lucerne, most pasture, crops (maize, soybeans, grapes)	D: Annual pastures and hardy crops (cotton, sorghum, winter cereals)
Soil Texture	Readily Available Water (RAW) mm/m			
Sand	35	35	35	40
Sandy loam	45	60	65	70
Loam	50	70	85	90
Clay loam	30	55	65	80
Light clay	25	45	55	70
Medium to heavy clay	25	45	55	65

How do I know when to irrigate?

Timing of crop irrigation depends on the crop, the soil, and the extraction rate.

Type of crop

You need to understand your crop.

- How deep is the root zone?
- Is the crop sensitive to moisture stress?
- How does water demand change with stages of growth?
- Are there critical periods in the plant's growth where moisture stress must be avoided?

Answers to these questions are readily available in crop irrigation manuals, from industry organisations and from the internet (see 'Resources' appendix).

Type of soil

You need to know how much plant-available water can be held in the effective rootzone. You can learn to classify your soil types and from this you can estimate the soil water available to plants, or you can employ a soil consultant to prepare a soil map showing plant available water levels. A good irrigation designer cannot prepare a design without this information.

Extraction rate

You need to know how quickly the plant is extracting the water from the rootzone. You can directly measure the remaining soil moisture with sensors which are located in the rootzone or you can directly measure the stress on the plant (usually a high tech method reserved for research). You can also quite easily and accurately estimate the plant's water use by monitoring weather conditions. This is the most commonly used technique.



Farmers in a soil pit explore the depth of different soil layers so they can estimate the soil water capacity. The pit can also reveal such things as waterlogging or restricted root growth caused by impenetrable layers.

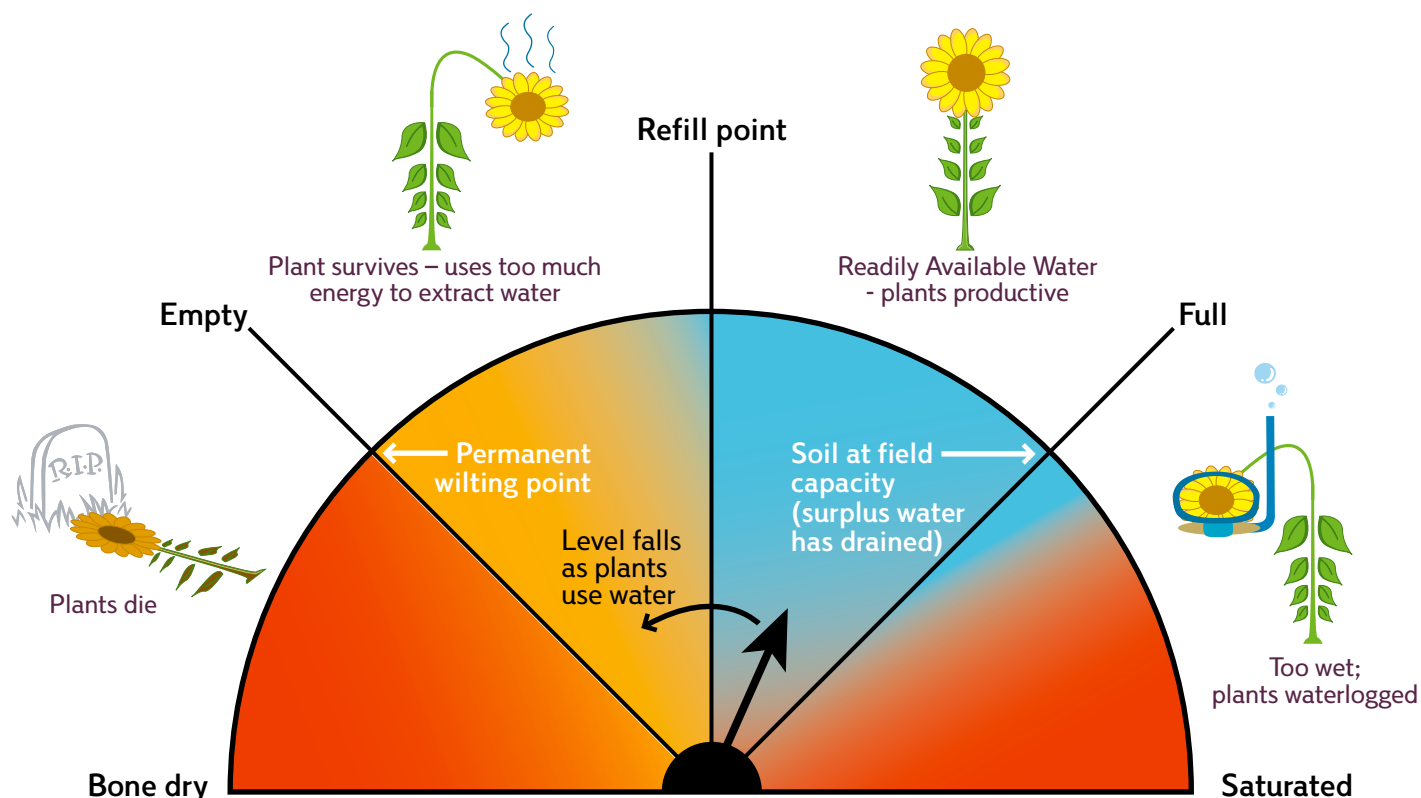
Since most of plant water use is for cooling by transpiration which is determined by the evaporation rate, a measure of cumulative daily evaporation with some corrections applied, minus the effective rainfall that may have fallen since the last irrigation, can be used to estimate plant water use.

The irrigation system can then be used to refill the rootzone with the correct amount of water. If this calculation is done regularly, the volume of irrigation applied can be kept to a minimum and the crop never allowed to stress. This process is called 'scheduling' and will help maximise your return per hectare and minimise the impact on the environment.

PART OF AN IRRIGATION SCHEDULING SHEET

	A	B	C	D	E
			$A \times B$		$E \text{ from the day before} - C + D$
Date	ET_o	K_c	ET_{crop}	Effective rain or irrigation (mm)	Remaining RAW Rootzone is at field capacity after one day of heavy rain
2 Dec	8.1	0.8	6.5		$12 - 6.5 + 0 = 5.5$
3 Dec	9.5	0.8	7.6	3 hour irrigation 15 mm	$5.5 - 7.6 + 15 = 12.9$
4 Dec	10.2	0.8	8.2	3 hour irrigation 15 mm	$12 - 8.2 + 15 = 18.8$

SOIL MOISTURE "FUEL GAUGE"



Strategic irrigation

Strategic irrigation is used when water availability is very restricted. Crops are irrigated only at very sensitive and critical times to get maximum benefit from the water. This won't give the highest yields per hectare, but will maximise your return when water is the limiting factor. Different crops will require different strategies depending on their sensitivity to water stress at critical times.

Evenness of application

An irrigation system needs to apply water evenly to the crop rootzone. Tree crops can adapt their root zones to extract water from where it is applied, but if the water is applied to only part of the root zone area, this limits the total volume of soil water available to the tree requiring more frequent irrigations. An evenly spread application can be more effective. For field crops such as pasture and cereals, evenness of application is very important. If watering is uneven, some areas will not receive enough water, which restricts crop yield, while other areas will get too much, which wastes water and nutrients below the root zone and may stress the crop through waterlogging.



An example of a badly designed sprinkler system. A well designed system would have each wetting pattern overlapping to provide an even application.

Rate of application

An irrigation system must apply water at a rate which suits the soil's capacity to absorb it. If the water is applied too fast it will run off the surface, lead to uneven application, and may cause erosion.

The golden rule for effective, efficient and profitable irrigation is applying 'the right amount at the right time in the right place'.



What irrigation system should I use?

Irrigation systems can be classified into three main groups.

Irrigation types

1. **Surface irrigation** floods water across the soil surface. This is rarely used on the north coast. It tends to have low efficiencies compared with other systems, and most only be used on suitable, low permeability soils.
2. **Spray irrigation** sprinkles water onto the soil surface. This technique covers a wide range of types from high pressure big gun travelling irrigators, through lateral move and centre pivots, to fixed solid set systems, and finally microjet and micro sprinklers often used in home gardens.
3. **Drip irrigation** applies water very slowly to the soil surface, or into the rootzone below the surface. Drip systems include drippers, porous tubes and subsurface pipes. Drip systems can be very efficient, and can utilise water of low quality if carefully managed. They can be used on individual plants or trees or even on broad area crops such as potatoes or lucerne.



Surface irrigation by furrows on a grape crop in southern NSW.



A fixed (solid set) sprinkler system used on a dairy pasture.



A buried subsurface drip system used to irrigate potatoes near Dorrigo.

Choosing a system

Each system is suited to different crops and soil and management conditions, and efficiency may have to be compromised to suit the site and enterprise. For example, a bike shift irrigation system has a higher

labour requirement and relatively poor evenness of application compared with a centre pivot, but it is very flexible and can be used in paddocks with trees where a pivot system is impractical.



Bike shift: a farmer uses a quad bike to shift sprinklers quickly on a regular pattern.



Hand shift: the irrigator shifts the system by hand on a regular basis - very labour intensive but low capital cost and flexible.



The centre pivot system is a high capital investment but has excellent irrigation characteristics and requires little labour. It can be moved to other paddocks but usually only seasonally for a new crop.



Irrigators examine the results of soil moisture probes and weather data to make better irrigation decisions. This process can be automated to directly control the irrigation system.

The irrigation system you choose will be a compromise between capital and operating costs, efficiency, labour and management requirements, and suitability for the crop.

It is well worth employing an expert irrigation consultant to design a system that will meet your enterprise's requirements.

While this may represent an upfront cost, it will be repaid many times over through increased yield, reduced operating costs, and easier management. Incorrect choice of pump, for example, can double operating costs and still give below standard performance!

With valuable crops, it is possible to automate the irrigation systems so that a computer monitors the soil moisture, calculates crop needs, and turns on and off the irrigation system to supply the water.



An irrigation farmer and his designer discuss his proposed layout.

How do I maintain my system?



A poorly maintained hand shift irrigation system leaks water badly. This leads to waterlogging, wasted water, and increased pumping costs. It may also lead to reduced effectiveness of the sprinklers because of low pressures.

All irrigation systems need to be maintained regularly. A monitoring program is a critical element of a good irrigation scheme to ensure that pressures and volumes are correct, that blockages do not occur and that leakages do not waste water and ruin system performance.

Pumps and sprinkler nozzles can wear, especially with turbid water, and wear reduces water pressure, leading to uneven application and reduced efficiency.

Modifications

If you intend to alter or extend an existing irrigation system, seek advice from a qualified consultant. Many systems have been severely compromised by inexpert alterations or changed management of the irrigation program which alters the area being irrigated at one time, and the usual result is much lower efficiency, increased operating costs and, often, reduced productivity.



A badly eroded pump impeller. This can be caused through turbidity or through operating the pump outside its effective limits. It will increase energy costs and severely reduce capacity.

What are my rights and responsibilities as an irrigator?



A typical stock and domestic windmill.

In Australia all water is vested in the Crown. The Crown, through State Governments, grants rights and licences to extract and use some of the water. In NSW, a deemed 10% of the annual rainfall runoff from your land can be captured in a dam or dams constructed on a 'minor stream' and used as you wish without the need for a licence. This is known as your 'harvestable right' but is usually not enough for commercial irrigation. For details, see the Department of Water and Energy (DWE) website at www.dwe.nsw.gov.au or contact your local DWE office.

Landholders with stream frontage properties have a basic landholder right to extract water for domestic needs (limited to 'reasonable use' and no commercial gain), and for livestock needs (ordinary grazing livestock, not intensive stock such as chicken sheds or feedlots).

All other water extraction from streams or surface runoff must be licensed. All groundwater extraction must be licensed irrespective of what purpose you use the water.



A farm dam which collects runoff water and stores it for irrigation.

The licence for stock and domestic bores is so DWE can warn you if groundwater contamination problems are found in your area.



Drilling to establish a groundwater bore to irrigate avocados.

Most water extraction works used for irrigation such as a pump on a creek or river, or a dam, must have a 'works approval' from DWE.



A skid mounted electric pump for irrigation from a river which floods.

How much water will I need?



A high pressure, “big gun” irrigator operating on dairy pasture. These are expensive to operate with high energy costs, but have low capital cost and are very flexible.

In unregulated rivers where there are no large dams to even out the flow, irrigation is limited more by the volume you can extract on a daily basis than by your annual licensed entitlement. On the north coast, most rivers are unregulated which means that when river flow is low, irrigation demand is usually greatest. Daily restrictions are often imposed to ensure that every licence-holder has equitable access and that riverine ecosystems are protected.

The volume you need each year depends on the quantity and timing of rainfall. In a wet year you may not need to irrigate at all, and in a dry year the crop may be entirely dependent on irrigation. How much risk you are prepared to take will also alter the volume you need to have available.

Irrigation water entitlement requirements for typical north coast crops

These are the volumes of entitlements needed that were calculated to provide enough irrigation water to supplement rainfall in all but the driest 1 in 10 year. It allows for the annual rainfall patterns of the north coast area and the growing season of the crop.

TABLE 2: ANNUAL ENTITLEMENT VOLUME REQUIRED PER HECTARE

Crop Type	Megalitres
Winter cereal	4.0
Summer cereal	2.0
Citrus	3.5
Vines	1.5
Winter oil seeds	4.0
Summer oil seeds	2.0
Pulses	4.5
Perennial pasture - beef	4.0
Perennial pasture - dairy	6.0
Lucerne	4.5
Annual (winter) pasture	3.0
Vegetables	6.5
Orchards	5.5
Nuts	5.5

Notes:

Climate change may alter these volumes over time, with drier winters and springs leading to increased crop demand for crops that grow in that period. Access restrictions may impact on irrigation water availability.

Climate change and seasonal variability



An irrigation dam filled from runoff in a new coffee plantation.

The north coast has a more reliable rainfall than most of NSW, but rainfall volume and timing can vary greatly from year to year. This variability is likely to increase due to water sharing plans, and changing climate. Modelling by the Department of Environment and Climate Change suggests that our summers will eventually be wetter with more rain coming as bigger storms, and our springs and winters will be drier, especially since evaporation will increase with warmer winter temperatures.

All these indicators suggest that it may be a good strategy to look at storing some of your irrigation entitlement in an off-stream dam for use in drier times. DWE has rules about licensing dams, so consult with them before committing yourself to a project. A few water sharing plans allow you to surrender some, or all, of your access to low river flows in exchange for a higher entitlement for extraction from high flows in the river. This may be a useful way of compensating for the inevitable extra losses through evaporation and seepage from the dam as well as to increase production to help pay for the dam.



A new irrigation dam under construction. The design should be prepared by a qualified person and should be based on proper soil tests, especially for the dam embankment. Bypass capacity must be high enough to cope with extreme storms.

So do you still want to irrigate?

Even with our current climate, irrigation secures a much higher and more reliable return from expensive to establish, valuable crops. Better yields and crop quality are the benefits from the investment of time, money and management in irrigation.

Doing it properly right from the beginning can make irrigation a positive and important component of your business.



A potato farmer near Dorrigo is very happy with the performance of his subsurface drip irrigated crop.

Resources

Websites

NSW DPI

www.dpi.nsw.gov.au/agriculture/resources/water

This site contains much useful information for irrigators.

Irrigation Australia Limited

www.irrigation.org.au

This site has information on accreditation, designers, irrigation courses and other useful material.



A group of farmers at an irrigation course measure the output of a sprinkler irrigation system.

Training courses

Irrigation training courses are occasionally run by NSW Department of Primary Industries, and there are many books and websites on efficient irrigation principles and practices including those available through Irrigation Australia Limited. This body has an accreditation scheme for irrigation designers, and NSW DPI would recommend that you use these designers.

Irrigation designers

A good irrigation designer will work with you to achieve what you want in the best possible way. The designer should also provide a comprehensive set of instructions on how best to use the systems they design.



Irrigation course attendees compete with the chickens to measure the evenness of irrigation application.



A travelling irrigator can be converted to a more efficient, less energy-intensive, boom system.

So you're an irrigator?

irrigate *v.tr* supply water to (land) by means of channels, or of a stream [based on Latin *irrigatus* 'watered']

Do you...



Apply the right amount of water at the right time to get maximum growth from your crop or pasture?

You need to monitor the rate at which plants use the moisture available in the soil, and then apply just enough to refill the profile. Apply too much and it drains away below the crop and leaches out some of your expensive fertiliser, as well as waterlogging the crop unnecessarily; too little or too late and your crop may stress. How can you do this? There are many ways to keep track of plant needs, some simple to use and some very sophisticated.



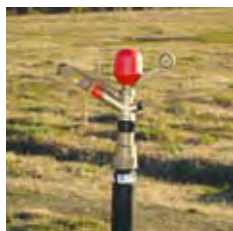
Maintain and manage your irrigation system to minimise wastage and leaks?

There doesn't seem to be much point using expensive energy to pump water from a water source and then let it go to waste because of leaks in the system. Leaks can also reduce the operating pressure of a system so it doesn't apply the water evenly leading to patchy crops.



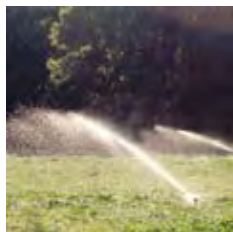
Check your pump to ensure it still operates at the correct pressure?

Like all machinery, pumps wear out and corrode. The fine clearances inside erode and the pump can no longer operate at its most efficient. This means more power is used and less water delivered at lower pressure. Your irrigation system no longer does what it was designed to do. This increases costs and reduces crop yields. Check your operating pressure and flows regularly.



Check your sprinkler performance?

Sprinkler nozzles also wear with use, especially if there is sediment in the water. Enlarged nozzles will lower pressure and performance.



Plan ahead for possible restrictions in access to water when you need it?

Even if weather patterns return to 'normal', many irrigators suffer restrictions at critical times. If you depend on irrigation, you should explore how you can best minimise these impacts. There are many alternatives which may suit you.

For more information – NSW DPI Irrigation Officers:

Richmond 02 4588 2107

Tamworth 02 6763 1262

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www.northern.cma.nsw.gov.au